



ARAB JOURNAL OF STI POLICIES

المجلة العربية لسياسات العلوم والتكنولوجيا والإبتكار

ISSN: 2682 - 4078 (ONLINE) - 2682 - 4310 (PRINT)

Received: 25 June 2025, Accepted: 14 August 2025

DOI: 10.21608/ARABSTI.2025.397377.1024

Original Article

Innovations to Curb Covid-19: Perspectives from AUDA NEPAD SANBio Network Countries

Tabisa Nomava Finiza¹, Zandile Nxumalo², Munyaradzi Tinarwo³, Pagal Agbanglanon^{4,5}, Seke Lukovi⁵ and Ereck Chakauya^{1,6}

¹African Union Development Agency (AUDA-NEPAD) Southern Africa Network for Biosciences (SANBio),
Meiring Naude Road, Brummeria, Pretoria, 0001

²Synthetic Nanobiotechnology and Biomachines Group, Synthetic Biology and Precision Medicine Centre,
Council for Scientific and Industrial Research, Pretoria 0001, South Africa.

³University of Cape Town, Department of Molecular and Cell biology, Chemistry Rd, Rondebosch, Cape
Town, 7700

⁴CeRADIS NGO, Abomey-Calavi, Benin Republic

⁵African Union Development Agency-NEPAD, 230 15th Rd, Randjespark, Midrand, 1685

⁶Food Security and Safety Focus Area, Faculty of Natural and Agricultural Sciences, North-West University,
Mmabatho 2735, South Africa

E-mails: ¹Echakauya@csir.co.za; ¹TFiniza@csir.co.za; ²ZNxumalo@csir.co.za; ³munyaradzi.tinarwo@gmail.com;
⁴godpagal@yahoo.fr; ⁵pagala@auda-nepad.org; lukovis@auda-nepad.org; ⁶Echakauya@csir.co.za

ABSTRACT

The COVID-19 pandemic posed a global health crisis, particularly in low to middle-income countries, due to low manufacturing and innovation capacity, poor health systems, and disrupted supply chains. It was predicted Africa would be the worst hit; however, the result was not as predicted. This paper contributes to understanding why it was not doom and gloom for the continent. The study explores

and reports on the dynamic and resourceful response of low to middle-income countries to COVID-19 within the AUDA NEPAD Southern Africa Network for Biosciences (SANBio) Networks. The specific objectives were: 1) to document how entities in the SANBio network responded to COVID-19 using available capacity, and 2) to conduct a survey to validate desktop research and produce case studies. Our analysis shows that amidst constrained resources and infrastructure, low- to middle-income countries displayed remarkable ingenuity in devising locally tailored strategies to combat the multifaceted impacts of the pandemic. In the healthcare sector, innovations emerged, including rapid and low-cost testing solutions, novel telemedicine platforms, and community-based health initiatives. These approaches enabled efficient detection, monitoring, and treatment of COVID-19 cases while alleviating the burden on strained healthcare systems. The innovations that surfaced stand as a testament to the resilience, adaptability, and determination of communities facing unparalleled challenges. Understanding the impact of local innovation on human life would go a long way toward advocating for local industrialization and grassroots innovation in solving African problems. Learning from these innovations contributes to the and offers insights for future crises.

Keyword: Innovation, COVID-19, Africa, SANBio network, research, resilience.

INTRODUCTION

Coronavirus disease (COVID-19) is the fifth recorded pandemic with a global impact relative to the 1918 Spanish Flu (H1N1) with approximately 50 million deaths recorded (LIU, KUO, & SHIH, 2020). It is an infectious disease caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) resulting in the devastating viral respiratory illness (ZHU, ZHANG, WANG, LI, & YANG, 2020). The SARS-CoV-2 discovered in Wuhan, China was extremely virulent and highly contagious. The disease was declared a global pandemic by the World Health Organization on 11 March 2020 (SADC-Secretariat, 2020). Lack of knowledge about how COVID-19 spreads led to a delay in preparedness efforts, resulting in an underestimation of its seriousness. In mid-March 2021, the total number of confirmed cases globally was estimated at 120 505 185, with 2 666 866 confirmed deaths and 97 050 315 recoveries (Statista, 2021). It wasn't until the World Health Organization (WHO) declared a public health emergency and health crisis that comprehensive measures for COVID-19 prevention were implemented (Oehler & Vega, 2022) (Tatar, *et al.*, 2022). This declaration marked the start of global concern and prompted the WHO to advocate for physical distancing and self-isolation (Tatar, *et al.*, 2022).

Covid-19 the runaway train' of Africa infection

The initial instances of COVID-19 in Africa primarily originated from Europe, because of the greater extent of business and tourism-related air travel between African nations and Europe (Kanyanda, 2021). According to a report published (Kim, 2021), South Africa recorded its initial cases of COVID-19 from nine adults who had returned from a vacation in Italy, a country with a high number of cases, on February 29, 2020, (Kim, 2021). These individuals began experiencing symptoms resembling the flu, and on March 5, 2020, they were confirmed to be COVID-19 positive through reverse transcription-polymerase chain reaction tests (Kanyanda, 2021) (Kim, 2021). Some of them displayed no symptoms but still tested positive. The number of new confirmed cases in Southern Africa was continuously increasing, as of 08 March 2021 an estimated 1 622 516 cases have been reported, with South Africa recording the highest cases of 1 521

706 (*Statista, 2021*). In response to these imported cases, the President of South Africa declared a national state of disaster to proactively address the potential impact of the COVID-19 pandemic (*Kim, 2021*). Other African countries followed suit and thereafter a cascade of interventions to limit spread were initiated, albeit uncoordinated across the continent.

As the number of COVID-19 cases continued to rise in the African continent and globally, and with no approved vaccines available at that time (*Kim, 2021*), the South African Department of Health, together with the ministerial advisory implemented stringent measures. In addition to following the recommendations of the World Health Organization (WHO) and the Africa CDC COVID-19 mitigation strategies and guidelines (*Pilkington, Keestra, & Hill, 2022*). These measures encompassed expanding the testing process, and imposing lockdown, except for “healthcare essential workers”. Furthermore, restrictions were imposed on travel restrictions both domestically, locally (between provinces), and internationally, prohibiting large gatherings such as music events, sports, religious gatherings, and social gatherings, as well as the sale of alcohol and cigarettes. Furthermore, campaigns promoting physical distancing, emphasizing good hygiene practices, establishing curfews, urging people to stay at home, and setting up communication protocols for reporting cases and closing units or departments in case of employee infections were all put into effect. Furthermore, to enhance their efforts in mitigating COVID-19, the healthcare system also carried out awareness campaigns, managed cases effectively, implemented infection prevention and control measures, conducted surveillance, engaged in risk communication, and bolstered human capacity by providing training in surveillance, epidemic response, and diagnostic testing kits.

Impact of COVID-19 Pandemic on the economy

COVID-19 negatively affected global economic growth, with major economies losing an estimated 2.4% of the value of gross domestic product (GDP). Global lockdown measures imposed by countries in response to the COVID-19 pandemic have led to severe economic consequences. The economic damage is evident of the largest economic shock the world has experienced in decades as most countries’ activities were near-standstill due to restrictions of movements to halt the spread of virus (*World-Bank, 2020*). As a result of the pandemic, the global economy is projected to grow by 5.8 percent in 2021 as economic activities are starting to normalize assisted by policy support (*IMF, World Economic Outlook: The great Lockdown. Washington DC: International Monetary Fund., 2020*). Hence, effective policies that target monetary, fiscal, and financial markets to prevent economic fallouts in different sectors are essential. Although the global economy is slowly normalizing, the pandemic has caused a heavy toll of deaths and illness, plunged millions into poverty and job loss, and may reduce economic activity and incomes for a prolonged period.

Over a longer period, the recessions triggered by the COVID-19 pandemic are expected to leave long-lasting shocks through lower investments, fragmentation of global trade and supply linkages, and destruction of human capital through lost work and school. Estimates indicated that over 110 million people around the world could experience extreme poverty and global trade could fall to an annual amount of 9.0% because of global economic downturn (*Global Economic Effects of Covid-19, 2021*). On the other hand, international oil prices fell drastically in the early stages of COVID-19 and partially regained their pre-pandemic price levels in late February 2021 due to slow economic activities across the globe. As economies are slowly reopening, oil product prices are partially recovering.

The economic fallout due to the COVID-19 pandemic lockdown was severe in most SADC countries, governments had to step in to prevent the countries from being bankrupt and more people losing jobs. Sub-Saharan African regional economy was projected to diminish by 3.2% in 2020 reflecting a weaker external environment and measures to contain the COVID-19 outbreak (*IMF, IMF financial data, 2020*). Economic growth is projected to recover approximately by 3.4% in 2021, thus policies should remain focused on supporting businesses hit hardest by the crisis, safeguarding public health, and facilitating the recovery.

On the other hand, different sectors in the region have been severely impacted by COVID-19, including tourism, manufacturing, finance services, education, aviation and maritime, real estate, automotive, and oil industries. Despite the strong global misinformed impression of COVID-19 transmission, the function of food processing and retail businesses has remained stable. This was due to the announcement by the World Food Organization that people are unlikely to contract COVID-19 from food or processing packages. As such, food processing and retail businesses experience a rise in demand for their goods.

COVID-19 a test for African ingenuity

The Oxford dictionary defines ingenuity as the quality of being clever, original and inventive. Indeed, when faced with crises, humans draw from their environment, their past and their networks to come up with solutions to the problem. Africa's adaptability was visible during the COVID-19 pandemic, which was evident in various areas and some of the key drivers of these developments and other technological innovations belong to the SANBio network. This section highlights some of Africa's adaptability during the pandemic, which included community-led initiatives across the African region, where developments and implementation of several solutions tailored to their specific needs, harnessing local knowledge and resources emerged. Research Technology organizations, academia, and non-state-actors across the African region turned to readily available technologies, which included digital innovations, whereby the use of mobile technology and digital platforms became vital for communication, contact tracing, and disseminating health information, further highlighting Africa's adaptability in the digital realm. Moreover, the shortage of medical supplies and personal protective equipment (PPE) led to local manufacturing efforts, illustrating the ability to adapt and produce essential items locally. Some African communities turned to their knowledge of indigenous traditional medicine and herbal remedies to treat the associated symptoms of the COVID-19 virus. Thus, allowing the African region to showcase their ability to draw upon indigenous knowledge for healthcare solutions. Furthermore, in response to disruptions in food supply chains, agricultural innovations emerged to ensure food security, exemplifying adaptability in the face of food-related challenges. During lockdowns and restrictions, innovative ways to adapt and sustain livelihoods within the constraints of the pandemic were devised, this included the reliance on some communities tapping into the informal economy. Cross-sector collaborations between governments, NGOs, private sectors, and academia were crucial in finding holistic solutions to multifaceted challenges.

Faced with ailing health infrastructure, ill-equipped diagnostic facilities, and limited healthcare resources, Africa had to innovate to address the healthcare and socioeconomic challenges resulting from the COVID-19 pandemic. The proceeding sections of this review provide a synopsis of the innovative approaches and solutions that the SANBio network of countries and institutions devised to survive the menace of the disease, and we extrapolate on what this means for pandemic preparedness.

RESEARCH METHODOLOGY

The aim of this study was to empirically document the response of AUDA NEPAD SANBio network countries to COVID-19 and their get insights on their preparedness for future pandemics. The study adopted a rapid literature review methodology to provide evidence prior studies for systematic reviews. Initially, the study covered countries in the SANBio network and partner countries that have SANBio has worked with during the study period. Several papers were screened by title and abstract, followed by a full-text review. Among 25 research papers identified, only 10 were screened and relevant information was extracted.

Both primary and secondary data sources were used. The questionnaire was designed and filled online with Kobo toolbox to collect the primary data in census format. The census provided a chance for every institution in the SANBio network to take part. Secondary data was collected through document review of various documents. The data collection took place from 24th April 2021 to 18th October 2021. To get the data, SANBio, sent an introductory email informing all the representatives about the data collection, and then an email transmitting the data collection tool was sent to all the identified contributing institutions. The survey included ethics prior informed consent as required by the ethics committee.

Stakeholder mapping was based on current NEPAD-SANBio member states which are the purposive sampling technique known as the non-probability sampling method used to reach participants. After mapping various actors that responded to the online survey, an online interview was set up on teams. Stakeholders made up of representatives of university institutions, Government institutions, and the Private sector innovating during the COVID-19 period were contacted by e-mail, and telephone through a designed questionnaire to gather information on their contribution to face this unforeseen period.

The information gathered from the respondents was examined for completeness and collated using MS Excel version 2019. The data was cleaned and analyzed using R software version 4.2.0. Data analysis will be performed using statistical methods and using the SADC COVID-19 innovation Map. Case studies were compiled from all data sources including the literature studies.

FINDINGS

SANBio network background

The African Union Development Agency-NEPAD Southern Africa Network for Biosciences (SANBio) was established in 2005 within the framework of NEPAD's Centres of Excellence for Science and Technology. It covers the SADC region as one of the five sub-regional networks established in the AU under the African Biosciences Initiative (ABI) of the Consolidated Plan of Action (CPI). Currently membership includes Angola, Botswana, Malawi, Mauritius, Mozambique, Namibia, Lesotho, South Africa, Seychelles, Swaziland, Zambia, and Zimbabwe. This initiative was started as an innovation platform for collaboration among actors in Biosciences (*Adelle et al., 2018*). Primarily, the network facilitates the establishment and sharing of state-of-the-art research and development facilities that can enable institutions to pool resources to address common biosciences challenges. The focus areas include human health, agriculture productivity, sustainable water resource use management, biodiversity management and sound environmental management. SANBio's objectives are to: support an effective and dynamic regional research network; enhance human and infrastructure capacity; and develop and commercialise innovation products in health and nutrition. In

2014, SANBio was reconfigured to respond to the Science Technology and Innovation Strategy for Africa (*STISA 2024*), the first 10 years of Agenda 2063 of the African Union.

Sampling population

The current SANBio Member States are Angola, Botswana, Malawi, Mauritius, Mozambique, Namibia, Lesotho, South Africa, Seychelles, Swaziland, Zambia and Zimbabwe. At the end of data collection period, 8 countries responded, which gave us a 67% response. The respondents have been received from the network institutions in the SADC region. These included 33% from private sector, 52% from High Education and 14% from government departments. Generally, the response rate was very low even when done through purposive sampling, however, the data was complemented by the desktop reviews.

Over this total from the different sectors, 62% have responded to the local or international calls to address the COVID-19 pandemic as innovation. These innovations cover a domain such vaccine development, efficacy testing, protective and sanitation (sanitization tools, washing devices, social distancing tools, training tools, early warning system, and PPE), Ventilations and medical devices, Diagnostics test kits (screening tools, molecular kits, PCR kits, and thermal scanners), treatment (drugs, remedies, preventive medicine, nutrition for recovery, COVID-19 Apps, patient monitoring and Remote COVID-19 screening), Automation (wearables devices, Big data, Temperature scanning, Fever detecting, and contact tracing), Big data profiling (AI analysis, Data visualisation, mobile Apps and COVID-19 preserving tools), Crisis communication (flyers on managing Covid in local African languages developed and disseminated). The period of the COVID-19 innovation to get the final product varies from 4 minimal months to a maximal of 9 months and most of the COVID-19 innovation was just prototyped. It is also revealed that most institutions have received a marketing or training support from relevant stakeholder as well as Grants, relief funds and other. Among other, the institutions finance the research project by own (38%), Government (24%), Private institutions (5%), Foreign (5%) and others (14%). Most of these products is not registered or licenced.

Harnessing manufacturing capabilities

The COVID-19 pandemic brought unprecedented challenges globally however Africa was hard hit with challenges such as vaccine hoarding by high-income countries (HICs) which made procurement agreements with pharmaceutical companies, posed challenges for low-income countries with no vaccine and diagnostic reagents manufacturing capacity (*Kunyenje, et al., 2023*). Vaccine inequality and lack of manufacturing capability by low and middle-income countries (LMIC) were implicated in risks of the emergence of new variants like the Omicron variant (B.1.1.529 BA.1) in South Africa which was one of the under-vaccinated countries (*Oehler & Vega, 2022*). Initiatives to reduce vaccine distribution inequality like COVAX, were established (Tatar, et al., 2022), however, they did not ensure equitable distribution of vaccines with low coverage (*Kanyanda, 2021*), (*Kim, 2021*). Besides not having the technology and manufacturing infrastructure needed to produce vaccines, countries like South Africa that tried to invest in manufacturing vaccines were faced with challenges in obtaining intellectual property rights (IP) from vaccine developers (*Pilkington, Keestra, & Hill, 2022*), (*Sariola, 2021*), however, these restrictions were late eased after the introduction of the World Trade Organization TRIPS waiver (*Acharya, Ghimire, & Subramanya, 2021*), (*Hunter, et al., 2022*). A variety of COVID-19 supplies, short supply in the SADC region (*SADC, 2020*)

including PPE (facemasks, gloves, medical ware), diagnostics, vaccination and medical supplies, hygiene and disinfectants and other social distance aids. As of October 2020, an analysis by WHO found that about 12.8% of innovations developed worldwide were in Africa, and about 13% of the innovations by that time were done in South Africa (COVID-19 spurs health innovation in Africa. 2020 [cited 2023 24/11/2023]; Available from: <https://www.afro.who.int/news/covid-19-spurs-health-innovation-africa.>, 2020).

Vaccine manufacturing

Less than 1 % of the vaccines used in Africa are manufactured in the continent and prior to the COVID-19 pandemic, only about 10 vaccine manufacturers were producing the vaccine's active ingredients and final fill and finish (which involves mainly packaging of the imported vaccines (Africa is bringing vaccine manufacturing home. Nature, 2022. 602(7896): p. 184-184., 2022). Africa had to come up with proactive measures to reduce COVID-19 infections and deaths. In previous epidemics like Ebola, Africa has been using mainly simple traditional low-cost solutions. In this section, we articulate some of the steps that are implemented in the SANBio countries toward manufacturing vaccines and health products. African vaccine manufacturing companies did not have the capacity for upstream development of vaccines hence these companies made partnerships with pharmaceutical companies from HICs (Africa is bringing vaccine manufacturing home. Nature, 2022. 602(7896): p. 184-184., 2022). Notable fill and finish manufacturing agreements in the SANBio partner countries were in South Africa which include the Johnson & Johnson/Aspen Pharmacare (Aspen concludes agreement to manufacture and make available an Aspen-branded COVID-19 vaccine (*Aspenovax*) *throughout Africa.*, 2022) and Pfizer-BioNTech/Biovac Institute (Pfizer and BioNTech Announce collaboration with Bivac to manufacture and distribute COVID-19 vaccine doses within Africa. , 2021) partnerships.

With nominal COVID-19 vaccine manufacturing capacity in Africa, the World Health Organization (WHO) created vaccine hubs around the world which include the mRNA vaccine hub based at Afrigen Biologics and Vaccines in South Africa (*Kana, 2023*). The focus of this hub is to manufacture mRNA vaccine formulations, ensuring the training and transfer of the technology to other African countries. This hub created a partnership between two South African companies Afrigen Biologics and Vaccines and Biovac to develop Africa's first mRNA COVID-19 vaccine (*Jack, 2022*). This vaccine is however still undergoing vaccine phase one trials, and the final product will probably be available on the market around 2025. With the pandemic long gone, this project now seeks to create a platform for future pandemics and the development of other vaccines endemic in Africa. The South African-born biotech billionaire Patrick Soon-Shiong launched two vaccine manufacturing companies in South Africa (NANTSA) and Botswana (NANTBotswana) (*Botswana, 2022*). His company aimed to produce a protein subunit vaccine Pula Corbevax. A plant-based protein reagent manufacturing plant was set to be established in Mauritius in 2020, by Cape Biologix Technologies (Mauritius, 2020). No COVID-19 vaccine manufacturing initiatives were recorded in Angola, Malawi, Mozambique, Namibia, Lesotho, Swaziland, Seychelles, Madagascar, Zambia and Zimbabwe. Although notable steps in vaccine manufacturing were noted in SANBio these countries still rely on buying and receiving donations from HICs.

Diagnostic and other therapeutics manufacturing

One of the challenges that Africa faced during the COVID-19 pandemic was the availability of test kits

and the turnaround times at the testing laboratories. The Medical Diagnostech (Pty) Ltd company launched South Africa's first COVID-19 Antigen self-test with a companion mobile phone application (HealthPulse TestNow) (RSA, 2023). In 2020, CapeBio Technologies developed the first 65-minute COVID-19 testing kit (Capebio™ SARS-CoV-2 Multiplex RT-qPCR Kit), which can amplify and detect the SARS-CoV-2 virus (SAHPRA, 2021). In 2021 Cape Biologix Technologies, a Cape Town-based company, started producing SARS-CoV-2 proteins for use in lateral flow test kits using the plant-expression system (Biologix, 2020). No manufacturing start-ups or innovations for diagnostic reagents for COVID-19 were noted in other SANBio countries.

Repurposing of technologies to produce PPE equipment.

Amid the COVID-19 pandemic, one notable phenomenon has been the creative repurposing of technologies to manufacture essential Personal Protective Equipment (PPE). This adaptability and innovation have been instrumental in addressing the critical shortage of PPE worldwide. In Africa various institutions and laboratories transformed their facilities to the repurposing of technologies to produce PPE equipment during the COVID-19 pandemic, utilising equipment such as 3D printing labs and maker spaces, to craft face shields, masks, and other protective gear for frontline workers. In Uganda, a biotechnology company PHARMBIOTRAC repurposed its technology capabilities to mass produce and manufacture liquid and gel hand sanitizers designed to adhere to the World Health Organization (WHO) recommended standards for COVID-19 prevention. This capability of accelerating local manufacturing and production was to reduce product costs associated with PPE procurement and make them more accessible to the local population. Moreover, across the continent, collective efforts were made by various higher education institutions. The MakerSpace center at the University of Pretoria is manufacturing 3D-printed visor frames for healthcare professionals to use as facial shields (UP, 2020). Similarly, the 3D printing lab within the orthopaedic surgery division at Stellenbosch University has been adapted to produce and put together essential visors for frontline workers. 3D printing technology was also used to design and produce masks by the Robots Can Think platform and Women in the artificial intelligence (AI) community (Paul, 2020). In addition, Addis Ababa University has also started manufacturing personal protective equipment (PPE), including face shields and bubble helmets, for both healthcare providers and patients. What was demonstrated by this government-led consortium is that it is possible to rapidly develop, design, and manufacture local solutions within South Africa, while playing a crucial role in saving lives across the country. The pandemic highlighted the importance of adaptable and robust manufacturing capabilities in times of crisis, emphasizing the need for continued investment and innovation in this sector to better prepare for future challenges. The following section highlights some of the manufacturing capabilities exhibited by the Council for Scientific and Industrial Research (CSIR), Manufacturing cluster, in close collaboration with SANBio network partners. Moreover, this swift adaptation underscores the resilience and resourcefulness of communities, showcasing how collaboration and technology can play a crucial role in responding to public health crises.

Case Study: Manufacturing of ventilators in South Africa

Harnessing manufacturing capabilities played a pivotal role during the COVID-19 pandemic, enabling swift and effective responses to the unprecedented healthcare crisis. Countries and industries around the world shifted gears to produce essential medical supplies such as personal protective equipment (PPE),

ventilators, and diagnostic tests at an accelerated pace. Pharmaceutical companies worked tirelessly to develop, manufacture, and distribute vaccines in record time. The South African government established a response programme termed “The South African National Ventilator Program” (NVP) which consisted of various stakeholders such as the Scientific Research Councils, the Department of Health, universities, and other Private-Public stakeholders in addressing the need for locally manufactured and cost-effective ventilators in South Africa, particularly during the COVID-19 crisis (Kim, 2021). This collective effort not only ensured the availability of critical resources but also contributed to addressing shortages and saving lives. The Southern Africa local manufacturing capability through the NVP programme helped reduce dependency on global supply chains that were disrupted during the pandemic, thus promoting self-sufficiency and resilience in healthcare systems.

Moreover, the Council for Scientific and Industrial Research (CSIR) in close collaboration with the manufacturing sector and universities demonstrated intermediate to advanced innovation capabilities by designing and developing a first in the continent ventilator (CPAP) to assist with the COVID-19 pandemic (Kim, 2021), which are fundamentally new products suitable not only for the local market but also for export (Kim, 2021). Despite the complex challenges of a resource constraint environment and an emerging sector, these firms have successfully designed and commercialized product innovations.

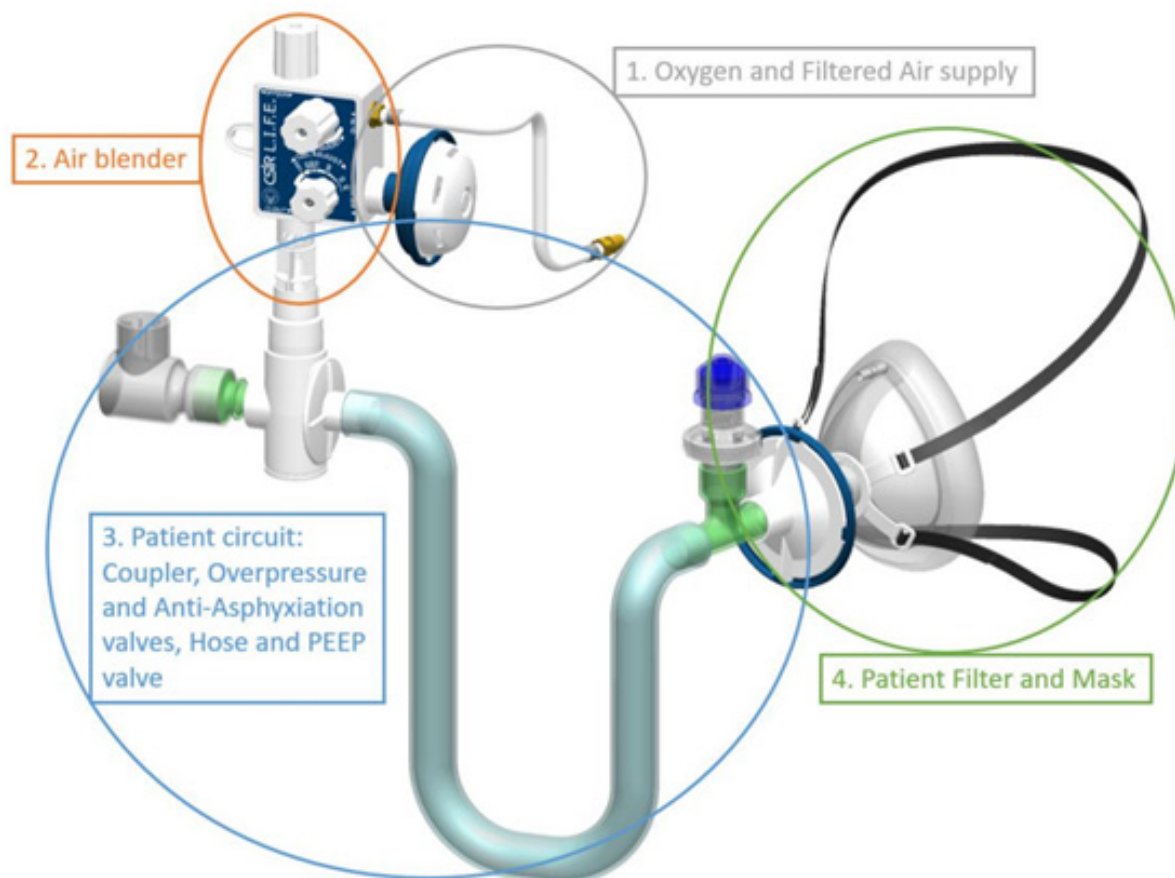


Fig. 1: A complete ventilator system, locally designed, manufactured, and redistributed for its use in various hospital settings in South Africa during the COVID-19 pandemic

Source: Kim, 2021.

In addition to the substantial work put into solving technical challenges, another factor contributing to the swift achievement of success was the elimination of conventional hurdles. These included procurement regulations, which were effectively managed through an emergency procurement directive South African Health Products Regulatory Authority (SAHPRA) also streamlined its procedures, implementing an accelerated process under emergency pandemic guidelines, which significantly facilitated and expedited the medical approval process (*Kana, 2023*).

Health Regulatory Authority during the Pandemic

During the COVID-19 pandemic, the South African Health Products Regulatory Authority (SAHPRA) played a vital role in ensuring the safety and efficacy of medical products and interventions. Some of the key roles and responsibilities carried out by SAHPRA during this time included regulatory oversight, here SAHPRA was responsible for overseeing the regulation of medical products, including vaccines, treatments, and diagnostic tests related to COVID-19. This involved reviewing applications for emergency use authorization, conducting assessments of product safety and efficacy, and granting approvals when appropriate. SAHPRA played a significant role in performing emergency Approvals, and here they played a critical role in implementing and expediting approval processes to facilitate the rapid authorization of COVID-19-related medical products. This was crucial for ensuring that effective treatments and vaccines could be made available to the public in a timely manner. During the pandemic as unprecedented the situation was, it was also vital that the quality and manufacturing standards of COVID-19 medical products were continuously monitored to ensure they met the required safety and efficacy standards. Moreover, SAHPRA aligned its regulatory processes and decisions with international standards and guidelines set by organizations like the World Health Organization (WHO) and other relevant global health agencies. This helped prevent the distribution of substandard or counterfeit products. Overall, SAHPRA played a critical role in ensuring that COVID-19-related medical products were safe, effective, and readily available to the South African population while also contributing to the global effort to combat the pandemic. This involvement of health regulatory agencies in Southern Africa through SAHPRA and its collaborations with other regulatory agencies, both domestically and internationally, to share information, best practices, and regulatory strategies for managing the pandemic further proves that the African region might be capable of managing future pandemics, provided proper structures are in place. In conclusion bottlenecks that Africa experienced as a continent include a lack of investments by governments, weak regulatory capacity for vaccine research, development, and production, and that most African countries do not buy locally-made vaccines but rather opt for importing from giant pharmaceutical companies based in HIC (WHO, What is Africa's vaccine production capacity?, 2021). There is therefore a need for African governments to adopt policies to buy locally.

Leveraging digital technologies for pandemic response.

Across the African continent, a lot of countries have harnessed the adoption of digital technologies to pave the path for economic growth and new service delivery methods as digitalization has been brought to the forefront of national development, not least in the years following the outbreak of the COVID-19 pandemic (*World-Bank, 2020*). Digital technology has been regarded to be critical in encouraging real-time surveillance and response to COVID-19 outbreaks. These technologies have made data gathering, processing, and distribution faster and more precise, enabling more effective and focused public health

actions. According to AUDA-NEPAD (*AUDA-NEPAD, 2021*), innovative and digital technologies have been acknowledged as playing a vital part in Africa's immunization roll-out procedures. Hence, the World Health Organization's Digital Health Flagship initiative has advised using digital technology to combat the COVID-19 pandemic, particularly inside the systems that oversee vaccination roll-out. Digital technologies can enhance pandemic management, improve communication, encourage vaccine return, and enhance public healthcare functions, thereby building trust and promoting vaccination programs in high-risk African communities (*AUDA-NEPAD, 2021*). On the other hand, African countries can use digital technology to effectively organize, distribute, and administer the extensive immunization campaign by using them to handle the COVID-19 vaccine roll-out. However, the COVID-19 pandemic limitations have increased the use of digital technology, but it has also had an impact on cybersecurity awareness-raising efforts and attitudes in the SADC area (*Laban Bagui, et al., 2023*).

Table 1: Digital technologies developed and utilized during the pandemic

Country	Technology Developed
South Africa	- Electronic Vaccination Data System (EVDS) - developed effective monitoring and evaluation systems incorporated within digital technology platforms. - The digital system tracks vaccine information, patient demographics, dose administration, safety, and adverse events, and provides details of vaccine administration sites in South African communities and towns.
South Africa	COVID Alert SA - SA developed a digital contact tracing app that has helped to identify close contacts of infected individuals.
Botswana	- SmartBots initiative leverages various digital technologies to provide solutions and support in several key areas such as contact tracing and monitoring; telemedicine and remote consultations; and emergency response. - Botswana Telemedicine Network - platform allows people to access healthcare services remotely from healthcare providers located anywhere in the country.
Botswana, Eswatini, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Zambia and Zimbabwe	Drone Technology & Contact Tracing - To monitor the virus's transmission and find the close contacts of affected people, digital contact tracing apps are utilized. The data can then be used to alert close contacts and recommend quarantine or testing.
Namibia	Namibia COVID-19 Information System - Namibia has developed a digital platform used to register citizens for COVID-19 vaccines and manage the vaccination rollout.

Source: The Electronic Immunization Data System (EVDS) was developed and largely used in South Africa in the COVID-19 immunization program to register people for immunizations, set appointments, monitor immunization coverage, and track immunization distribution (*Annual Report, National Department of Health, South Africa, 2023*) The digital technology was applied to accelerate the vaccination process and to ensure data accuracy as the system automatically records each vaccination event; and feeds data to its data analytics platform so that it can track and report on the vaccinations administered. Moreover, the COVID-19 vaccination roll-out was managed and monitored with help from the EVDS in South Africa. Data on vaccination sites and vaccinators was required for tracking vaccine uptake and coverage, prioritization, planning, safety monitoring, and vaccine-related studies (*Annual Report, National Department of Health, South Africa, 2023*).

HARNESSING THE APPLICATION AND UTILIZATION OF TRADITIONAL AND HERBAL MEDICINES AMID THE COVID-19 PANDEMIC

Many regions in Africa harnessed the utilization of traditional and herbal medicines as part of their response to the COVID-19 pandemic. This is because during the COVID-19 pandemic, there was growing interest in and discussion about the potential role of traditional and herbal medicines in the prevention, treatment, and management of the disease (*Kanyanda, 2021*). Many communities and regions around Africa have a long history of using herbal/traditional remedies for various health issues, and some turned to them in the face of the pandemic. Given the significant role that patients' immune systems play in responding to COVID-19, traditional medicines with immunomodulatory effects are considered potential candidates for both the prevention and treatment of COVID-19 patients. Different findings suggested that herbal medicine can reduce severity and prevent COVID-19. Beverages like teas and drinks from *Artemisia annua* and *Artemisia afra* have gained popularity as preventative measures against SARS-CoV-2 infection and in the battle against COVID-19 (*Hunter, et al., 2022*). During the initial phase of the COVID-19 pandemic, communities in Africa were using herbal remedies that contained specific active components known for their antimicrobial, antiviral, anti-inflammatory, and immune-boosting properties (*Hunter, et al., 2022*). These herbal compounds, such as Echinacea, Quinine, and Curcumin, are believed to have the potential to regulate the immune systems of patients, and they may offer positive effects in preventing or addressing COVID-19. However, it wasn't until the bold assertion made on April 20th by Madagascar's president, Andry Rajoelina, suggesting that a tonic derived from sweet wormwood could treat and prevent COVID-19, which garnered significant attention (*Hunter, et al., 2022*). Nevertheless, it also drew attention to South Africa's own variety of wormwood. *Artemisia afra*, known as African wormwood, umhlonyane, lengana, zengana, and wilde-als, ranks among the most used indigenous medicinal plants in the region (*Hunter, et al., 2022*). Its leaves have traditionally been employed for various health issues, including coughs, colds, flu, and fevers (*Hunter, et al., 2022*). The Madagascan product, marketed as COVID-Organics and developed by the Malagasy Institute for Applied Research, is crafted from *Artemisia annua*, which originates from Asia and Eastern Europe but has adapted to numerous other regions globally (*Hunter, et al., 2022*) (*Acharya, Ghimire, & Subramanya, 2021*) (*Pilkington, Keestra, & Hill, 2022*).

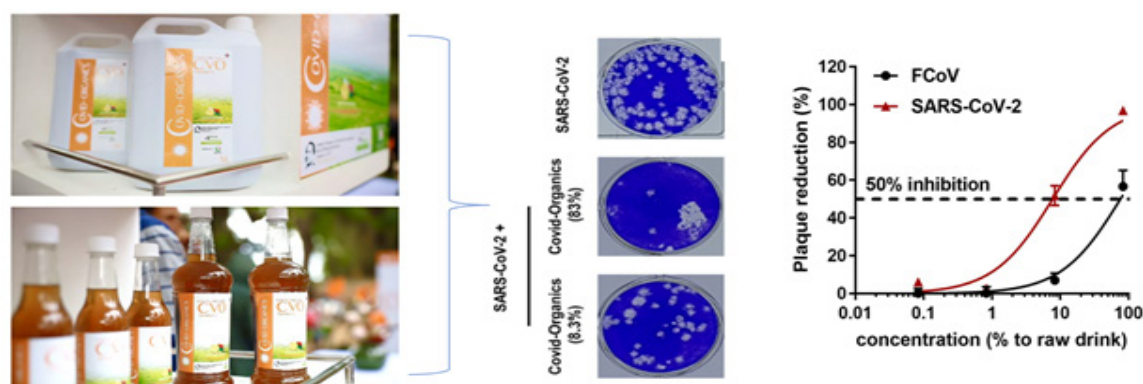


Fig. 2: The activity of Covid-Organics beverage manufactured in Madagascar was found by Nie and colleagues to be effective against the infection of different coronaviruses, the human isolated SARS-CoV-2 and feline coronavirus (FCoV) in a laboratory setting. Moreover, they observed that varying the concentration of Covid-Organics beverage, a drink made from *Artemisia* extracts had no adverse/ cytotoxic impact on cell viability and healthy cells. Recommendations were made by the researchers that more clinical studies are required to assess the potential value of *Artemisia* extracts and other herbal drinks in preventing or treating COVID-19 in patients (*Acharya, Ghimire, & Subramanya, 2021*).

More recently, (Nie, *et al.*, 2021) conducted a study in which they tested plant extracts and the Covid-Organics drink produced in Madagascar for their efficacy against SARS-CoV-2 and feline coronavirus (FCoV) in vitro (Acharya, Ghimire, & Subramanya, 2021). In this study, they found that several extracts and Covid-Organics showed inhibitory activity against SARS-CoV-2 and FCoV at non-toxic concentrations (Acharya, Ghimire, & Subramanya, 2021). Even though different extracts of *Artemisia annua* and *Artemisia afra*, as well as the Covid-Organics drink produced in Madagascar, have shown inhibitory activity against SARS-CoV-2 and feline coronavirus (FCoV) in vitro (Acharya, Ghimire, & Subramanya, 2021), it is unclear if the concentrations achieved in humans after consuming these teas or drinks are sufficient to inhibit viral infection. Therefore, several clinical studies are currently ongoing in South Africa and globally to evaluate the efficacy of plant extracts and the Covid-Organics drink produced in Madagascar for COVID-19 prevention or treatment (Acharya, Ghimire, & Subramanya, 2021).

Overall, what is evident here is that Harnessing the potential benefits of traditional remedies requires multidisciplinary approaches. Moreover, requires scientific knowledge on how traditional medicine can be explored and integrated or harmonized with modern medical approaches to effectively address the challenges posed by the pandemic and potential future pandemics. Additionally, it may involve assessing regulatory frameworks and safety concerns related to the use of these medicines during a global health crisis, all while considering the broader implications for public health, safety, and cultural practices.

Government policy interventions to mitigate the impact of COVID-19

The COVID-19 issue has had a very diverse regional and local impact, which has important effects on crisis management and policy solutions. In response to the COVID-19 issue, numerous governments at all levels have moved fast, enacting national and subnational measures and using a place-based approach to policy solutions (OECD, *Policy Responses to Coronavirus (COVID-19)*, 2020). The SADC government originally used emergency pandemic response money for urgent medical requirements, such as the establishment of testing labs, the creation of special wards to increase hospitalization and care capacity, and the acquisition of vital medical supplies. In South Africa, through the Unemployment Insurance Fund (UIF) and special initiatives from the Industrial Development Corporation, the government helped businesses and employees that were in need (IMF, *Policy responses to Covid-19*, 2021). The health response to COVID-19 received additional funding, employees with incomes below a particular threshold received a tiny tax break for four months, and the most disadvantaged families temporarily received greater social benefit amounts by the end of October 2020. Through April 2021, a new temporary COVID-19 grant was established to pay for unemployed individuals who do not get grants or UIF payments. Moreover, the central bank (SARB) announced measures to ease liquidity conditions on March 20, 2020. These included (i) increasing the number of repo auctions to two in order to provide intraday liquidity support to clearing banks at the policy rate; (ii) lowering the upper and lower limits of the standing facility to lend at the repo rate and borrow at 200 basis points below the repo rate; and (iii) increasing the size of the main weekly refinancing operations as necessary (IMF, *Policy responses to Covid-19*, 2021).

Briefly, other policy interventions that governments had to put in place included:

- a. Community Engagement and Education: Community involvement has been key. Most countries in Africa and in the SADC region particularly have employed innovative campaigns using radio,

- television, social media, and community leaders to educate the public about COVID-19 preventive measures, symptoms, and vaccination.
- b. **Vaccine Distribution Strategies:** Innovative approaches to vaccine distribution have been crucial. Some countries in the region have implemented mobile vaccination units, drive-through vaccination centers, and community-based vaccination campaigns to reach remote or underserved populations.
 - c. **Partnerships and Collaborations:** Collaboration between governments, private sectors, NGOs, and international organizations has been pivotal. Public-private partnerships have facilitated the procurement of medical supplies, including vaccines, and have supported healthcare infrastructure improvements.
 - d. **Local Production of Medical Supplies:** Some countries in the SADC region have explored local manufacturing of personal protective equipment (PPE), ventilators, and other medical supplies. This reduces dependency on imports and ensures a more sustainable supply chain.
 - e. **Research and Innovation Hubs:** Establishing research and innovation hubs dedicated to COVID-19 has allowed for the development of rapid testing kits, treatment protocols, and potential therapeutics tailored to the region's needs.
 - f. **Addressing Socioeconomic Impact:** Innovative approaches have been taken to mitigate the socioeconomic impact of the pandemic. This includes social protection programs, cash transfers, and support for small businesses and vulnerable populations affected by lockdowns and economic disruptions.
 - g. **Cross-Border Coordination:** Cooperation and coordination among SADC member states have been crucial for managing border restrictions, facilitating the movement of essential goods and personnel, and sharing best practices for pandemic response.
 - h. **Adaptive Health Systems:** Flexibility and adaptability in healthcare systems have been important. Hospitals and healthcare facilities have adopted innovative measures such as telemedicine, remote patient monitoring, and flexible staffing to accommodate COVID-19 cases while maintaining essential healthcare services.
 - i. **Adaptive business models:** In summary, most African countries have tried to maintain and enhance existing business models. Issues of urgency and uncertainty have been addressed in very specific ways by private and public companies, training centres and development communities alike.

Lessons learnt on pandemic preparedness and response strategies

Indeed, the COVID-19 pandemic has greatly impacted all aspects of our lives, while exposing the weaknesses in both our national health systems and global preparedness policies. Even though preparedness and readiness were lacking, valuable lessons were, however, learnt. The COVID-19 pandemic underscored the importance of self-reliance and strategic planning in Africa's healthcare systems. This highlighted the importance of Investing in local vaccine production, and biotechnology research infrastructure to foster resilience, reduces dependence on global supply chains, and creates economic opportunities. As African countries continue to develop their healthcare infrastructures, they are better positioned to address region-specific health challenges and future pandemics thus ensuring equitable access to resources and mitigating

the broader impacts of health crises (*WHO-Report 2021, Oladipo, Olufemi et al. 2023*). This reinforces the need for ongoing investment in healthcare and biotechnology, as long-term preparedness and self-sufficiency reduce vulnerabilities and strengthen the overall response to global health threats (*WHO-Report 2021, Oladipo, Olufemi et al. 2023, Moonasar, Leonard et al. 2022*). Strengthening these areas can help African countries reduce vulnerabilities, ensure timely access to essential resources, and improve their ability to respond effectively to future health crises. Together, these factors underscored the need for more investment in African health systems to enhance resilience against future public health threats.

i. Robust and effective healthcare systems

The importance of effective preparedness and response strategies to manage global health crises are some of the few invaluable lessons learned during the COVID-19 pandemic (*Cunningham, Hopkins 2023*). These lessons have highlighted the need for robust and effective healthcare systems that can enhance surveillance, early detection, and a robust infrastructure to ensure timely access to healthcare medical supplies and vaccines. Furthermore, they underscore the critical role of public health communication, international cooperation, and the swift development of research and technologies. By addressing these areas, countries and organizations can better equip themselves to mitigate the impact of future pandemics and safeguard public health on a global scale. The following sections will detail some of the strategies that were implemented and lessons that could be learned for future pandemic readiness within the SADC region and Africa to enhance pandemic responses by strengthening surveillance, enabling early detection, and building infrastructure for rapid deployment of medical supplies and vaccines.

ii. Borrowing from the past

Another lesson drawn from the SARS-CoV-2 pandemic was the importance of repurposing existing technology to address the health risks posed by COVID-19. Africa has long faced challenges from both communicable and non-communicable diseases, and while the COVID-19 pandemic may have diverted already limited resources away from addressing other prevalent diseases, such as malaria, tuberculosis, and HIV (*Chanda-Kapata, Ntoumi et al. 2022*). South Africa has maintained a strong infrastructure for monitoring infectious diseases like HIV/AIDS and TB (*Brault, Vermund et al. 2021*). South Africa's experience with HIV/AIDS and tuberculosis in the SADC region has led to the development of extensive disease monitoring systems and community health networks that have proven valuable in managing health crises (*Brault, Vermund et al. 2021*). When COVID-19 reached South Africa, the National Institute for Communicable Diseases (NICD) played a critical role in tracking the spread of the virus (*Moonasar, Leonard et al. 2022*). The NICD operates the National Surveillance System (NIDS), which integrates various data sources to track the incidence of infectious diseases across South Africa. During the pandemic, this system was quickly adapted to monitor and track COVID-19 cases (*Moonasar, Leonard et al. 2022*). These pre-existing networks within the NICD facilitated real-time data collection, case reporting, and trend analysis to monitor COVID-19 infections. These established disease surveillance platforms allowed South Africa to rapidly identify hotspots, enabling authorities to implement targeted interventions, such as localized lockdowns and mass testing in specific areas, like the measures used in previous TB outbreaks.

iii. A shift toward domestic production capabilities in liaison with government stakeholders for vaccines and medical supplies

Amid the COVID-19 pandemic, South Africa demonstrated remarkable innovation by utilizing locally developed technologies, including the rapid production of ventilators through the National Ventilator Project (*Brault, Vermund et al. 2021, Bosscha, Ronde 2022*). This initiative, supported by local government agencies, allowed the country to quickly supply essential life-saving equipment when global supply chains were strained. South Africa also developed COVID-19 testing kits and established advanced laboratory networks, significantly enhancing its national testing capacity to better manage and contain the virus (*L. Kwezi 2021*). A key lesson from these efforts is the importance of investing in domestic production capabilities for essential medical equipment, which ensures greater self-sufficiency and resilience when international supply chains are disrupted. Moreover, the collaborative initiatives by the Department of Science and Innovation (DSI) with the Council for Scientific and Industrial Research (CSIR) played a pivotal role in expanding South Africa's testing capacity by establishing high-throughput laboratory networks (*DSI-Reports 2020b*) (*CSIR-Reports 2020*). These facilities enabled rapid, large-scale testing, which was crucial in tracking and containing COVID-19. By leveraging its expertise in biotechnology and data analytics, the CSIR minimized test turnaround times and collaborated with the National Health Laboratory Service to streamline testing processes (*DSI-Reports 2020a*). This collaboration allowed for higher testing volumes, which proved essential during peak infection periods, thus ensuring timely diagnoses and effective containment of the virus. This stakeholder engagement by the CSIR with DSI and NHLS further demonstrates the need to continuously develop laboratory networks with high-capacity testing and data management, thus allowing for preparedness and swift responses to future infectious disease outbreaks. Moreover, this shift toward local production not only addresses immediate vaccine needs but also fosters long-term resilience by creating a sustainable healthcare infrastructure capable of responding rapidly to emerging health threats. Developing the capacity to produce vaccines and other essential medicines locally strengthens Africa's autonomy, reduces dependency on external sources, and creates economic opportunities through job creation and skills development in the pharmaceutical sector.

iv. Developing a self-reliant healthcare system capable of responding more rapidly to future pandemics

The pandemic exposed vulnerabilities in Africa's reliance on imported medical supplies and vaccines, highlighting how quickly a global health crisis can overwhelm existing systems. Developing a self-reliant healthcare system means creating a robust, locally supported infrastructure that enables rapid, independent responses to future pandemics thus, reducing reliance on external resources and enhancing resilience against health crises (*Cunningham, Hopkins 2023*). A key lesson which can be learned from SARS COV-19 pandemic is the value of forging partnerships with global organizations (*Nsanzimana, Rawat et al. 2022*) while simultaneously building stronger healthcare systems locally, which can reduce dependency and ensure continuity of care in times of crisis. A significant example was the efforts which were seized by South African Government, whereby to safeguard healthcare workers and vulnerable populations in South Africa, initiatives with Aspen Pharmacare partnered (local South African pharmaceutical company) and Johnson & Johnson was forged to locally produce millions of COVID-19 vaccine doses. Despite these advancements, further investments in healthcare infrastructure, including vaccine production and rural healthcare facilities, are necessary to bolster South Africa's resilience in future health crises.

Similarly, Madagascar undertook significant efforts to enhance its testing capacity during the pandemic. By establishing advanced laboratory networks and partnering with local and international organizations, Madagascar expanded its testing infrastructure to cover both urban and rural areas (*UNICEF-Reports 2020*). This expansion was vital in increasing testing accessibility in regions with limited healthcare resources, enabling quicker diagnoses and helping to control the virus's spread (*UNICEF-Reports 2020*). This underscores the importance of inclusive healthcare infrastructure, as rural and underserved areas must be integrated into national health systems to manage public health risks effectively.

In response to the continent-wide challenges posed by limited vaccine access, South Africa advanced vaccine production efforts, underscoring the need for local manufacturing. Partnering with Johnson & Johnson, South African pharmaceutical company Aspen Pharmacare produced COVID-19 vaccines for distribution across Africa, reducing dependency on global suppliers (*Oladipo, Olufemi et al. 2023*). South Africa's collaboration with the World Health Organization to establish an mRNA vaccine technology transfer hub further reinforced Africa's capacity for local vaccine production, supporting both regional healthcare and economic growth (*WHO-Report 2021*). A critical takeaway is the necessity of developing local vaccine production capabilities, which can provide timely access to essential vaccines in future pandemics, thereby reducing reliance on external suppliers. Overall, the response strategies implemented by the members of the SADC union such as South Africa and Madagascar during the COVID-19 pandemic have revealed essential strategies for enhancing future pandemic preparedness across Africa. The key lessons included the importance of fostering local capacity for producing critical medical equipment, establishing high-throughput laboratory networks, and ensuring inclusive healthcare infrastructure that reaches underserved areas. Moreover, the development of local vaccine production capabilities, as demonstrated through South Africa's partnerships, highlights the need for self-reliance in securing timely and equitable vaccine access across Africa. Furthermore, the strategic value of balancing international partnerships with local infrastructure investment underscores the importance of resilience and autonomy in healthcare systems. Despite the challenges, by prioritizing these areas, African nations can build robust, self-sustaining health systems capable of managing future public health crises more effectively, ultimately safeguarding both public health and economic stability across the continent. The strategies implemented by SADC member states to tackle the pandemic could empower Africa to respond effectively not only to the current crisis but also to future diseases and challenges.

CONCLUSIONS

COVID-19 is still spreading across the globe; hence innovations in containment, treating the ill, and helping communities cope with the epidemic are essential. The different innovations developed in different countries play a tremendous role in response to the government's call on COVID-19 innovations and future preparedness for the future pandemics. The call was mobilized in search of the production of COVID-19 treatment, vaccination, personal protective equipment (PPE), and much more to curb the spread of the virus. The governments have implemented policy interventions to address the global crisis to mitigate the impact of COVID-19. At the end, the COVID-19 pandemic has highlighted the potential of digital technologies in addressing challenges in Africa, such as healthcare, education, and governance, to strengthen resilience and future crises. It is critical for the SADC region and African continent to learn from global experiences, modify best practices for its own situation, and work toward a future where it is digitally empowered while

the globe continues to navigate the pandemic. By doing so, SADC and the whole African continent will be able to use digital technologies to address COVID-19's current difficulties as well as create a more resilient and prosperous future. Overall, it is evident that the SADC region and African countries have adopted and developed the use of digital technologies to harness the challenges posed by COVID-19 and prepare for a possible new pandemic.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

1. Adelle C, Elema N, Chakauya E, & Benson D. (2018) Evaluating 'homegrown' research networks in Africa. *S Afr J Sci.* 2018;114(3/4), Art. #2017-0070, 7 pages. <http://dx.doi.org/10.17159/sajs.2018/20170070>
2. Acharya, K., Ghimire, T., & Subramanya, S. (2021). Access to and equitable distribution of COVID-19 vaccine in low-income countries. *NPJ Vaccines*, 54.
3. AUDA-NEPAD. (2021). African Union Development Agency - NEPAD. Annual Report. <https://www.nepad.org/publication/2021-auda-nepad-annual-report>
4. Biologix, C. (2020). Cape Biologix Technologies rapidly launched a suite of SARS-CoV-2 proteins into the market for use in lateral flow test kits., <https://capebiologix.com/about/>
5. Bokolo, J. A. (2020). Use of Telemedicine and Virtual Care for Remote Treatment in Response to COVID-19 Pandemic. *National Library of Medicine*.
6. Botswana. (2022). Botswana launches COVID-19 vaccine manufacturing plant.
7. Caballero, V., & Vera-Valdés, J. (2020). Long-Lasting Economic Effects of Pandemics: Evidence on Growth and Unemployment. *Econometrics*, 16.
8. COVID-19 spurs health innovation in Africa. (2020) [cited 2023 24/11/2023]; Available from: <https://www.afro.who.int/news/covid-19-spurs-health-innovation-africa>.
9. Global Economic Effects of Covid-19. (2021).
10. Green, E. D., Gunter, C., Biesecker, L., Francesco, V., Easter, C., Feingold, E., & Felsenfeld, A. (2020). Strategic vision for improving human health at The Forefront of Genomics.
11. Haleem, A., Mohd, J., Singh, R., & Rajiv, S. (2021). Telemedicine for healthcare: Capabilities, features, barriers, and applications.
12. Hunter, D., Karim, S., Baden, L., Farrar, J., Hamel, M., Longo, D., Rubin, E. (2022). Addressing Vaccine Inequity - COVID-19 Vaccines as a Global Public Good. *The New England Journal of Medicine*.
13. IMF. (2020). IMF financial data.
14. IMF. (2020). World Economic Outlook: The great Lockdown. Washington DC: International Monetary Fund.

15. IMF. (2021). Policy responses to Covid-19.
16. Jack, D. (2022). First African-made mRNA vaccine, a test platform for the future.
17. JARVIS, M. C. (2020). Aerosol Transmission of SARS-CoV-2: Physical Principles and Implications. *Front Public Health*, 8, 590041.
18. Kana, B. (2023). Opportunities and challenges of leveraging COVID-19 vaccine innovation and technologies for developing sustainable vaccine manufacturing capabilities in Africa. *Lancet Infect Dis*.
19. Kanyanda, S. e. (2021). Acceptance of COVID-19 vaccines in sub-Saharan Africa: evidence from six national phone surveys. *BMJ Open*.
20. Khera, A., Baum , S., Gluckman , T., Gulati, M., Martin , S., Michos , E., Toth, P. (2020). Continuity of care and outpatient management for patients with and at high risk for cardiovascular disease during the COVID-19 pandemic: A scientific statement from the American Society for Preventive Cardiology.
21. Kim, H. (2021). We need people's WHO to solve vaccine inequity, and we need it now. *BMJ Glob Health*.
22. Kunyenje, C., Chirwa, G., Mboma, S., Ng'ambi , W., Mnjowe, E., & Nkhoma , D. (2023). COVID-19 vaccine inequity in African low-income countries. *Front Public Health*.
23. Laban Bagui, Lusinga, , S., Pule, N., Tuyeni, T., Mtegha, , C., Calandro, E., von Solms, B. (2023). The impact of COVID-19 on cybersecurity awareness-raising and mindset in the southern African development community (SADC).
24. LIU, Y. C. (2020). COVID-19: The first documented coronavirus pandemic in history. *Biomed J*, 43, . 328-333.
25. LIU, Y. C., KUO, R. L., & SHIH, S. R. (2020). COVID-19: The first documented coronavirus pandemic in history. *Biomed J*, 43, 328-333.
26. Martins, B. O., Lavallée, C., & Silkoset, A. (2021). Drone Use for COVID-19 Related Problems: Techno-solutionism and its Societal Implications.
27. Mauritius. (2020). Mauritius: EIB and FIND back innovative plant-based reagent manufacturing in Africa to fight COVID-19 and other endemic diseases. 2020 24/11/2023]; <https://www.eib.org/en/press/all/2020-388-eib-and-find-back-innovative-plant-based-reagent>.
28. Mbunge, E., Muchemwa , B., & Batani , J. (2022). Are we there yet? Unbundling the potential adoption and integration of telemedicine to improve virtual healthcare services in African health systems.
29. Nie, C., Trimpert, J., Moon , S., Haag, R., Gilmore, K., & Kaufer, B. (2021). In vitro efficacy of Artemisia extracts against SARS-CoV-2.
30. OECD. (2020). Policy Responses to Coronavirus (COVID-19).

31. OECD. (2021). Covid-19: A pivot point for science, technology and innovation.
32. OECD. (2021). Science, technology and innovation in the time of Covid19.
33. OECD. (2021). Science, technology and innovation in the time of Covid19.
34. Oehler, R., & Vega, V. (2022). Worldwide vaccine inequality threatens to unleash the next COVID-19 variant. *Int J Infect Dis.*, 133-135.
35. Paul, E. (2020). amazing African innovations against COVID-19: A cure from physics? Techpoint Africa.
36. Pfizer and BioNTech Announce collaboration with Bivac to manufacture and distribute COVID-19 vaccine doses within Africa. . (2021).
37. Pilkington, V., Keestra, S. M., & Hill, A. (2022). Global COVID-19 Vaccine Inequity: Failures in the First Year of Distribution and Potential Solutions for the Future. *Front Public Health*.
38. RSA. (2023). South Africa's first COVID-19 Antigen Self-test launched. 2023 24/11/2023]; [https://www.samrc.ac.za/press-releases/south-africas-first-covid-19-antigen-self-testlaunched#:~:text=Today%2C%20the%20Medical%20Diagnostech%20\(Pty,Seattle%2Dbas](https://www.samrc.ac.za/press-releases/south-africas-first-covid-19-antigen-self-testlaunched#:~:text=Today%2C%20the%20Medical%20Diagnostech%20(Pty,Seattle%2Dbas).
39. SADC. (2020). SADC Regional response to Covid-19 pandemic with focus on health, law enforcement and security; and food, Nutrition security and Livelihoods sectors. Gaborone, Botswana: SADC Secretaries.
40. SADC-Secretariat. (2020). SADC Regional response to Covid-19 pandemic with focus on health, law enforcement and security; and food, Nutrition security and Livelihoods sectors. Gaborone, Botswana: SADC Secretaries.
41. SAHPRA. (2021). SAHPRA authorises CapeBio to manufacture COVID-19 Rapid Test Kits locally.
42. Sariola, S. (2021). Intellectual property rights need to be subverted to ensure global vaccine access.. *BMJ Global Health*.
43. Statista. (2021). Cumulative number of coronavirus (COVID-19) cases in Southern Africa as of March 08, 2021, by country., <https://www.statista.com/statistics/1191500/coronavirus-cases-by-country-in-southern-africa/#statis>.
44. Tatar, M., Shoorekchali, J. M., Faraji, M. R., Seyyedkolaei, M. A., Wilson, F. A., & Pagán, J. A. (2022). COVID-19 vaccine inequality: A global perspective. *J Glob Health*.
45. UP. (2020). UP MakerSpace Centre producing 3D visor frames for facial shields for healthcare workers. 2020 [cited 2023 24/11/2023]; https://www.up.ac.za/news/post_2884720-up-makerspace-centre-producing-3d-visor-frames-for-facial-shields-for-healthcar.
46. WHO. (2020). Covid-19 Could be springboard for African innovations.
47. WHO. (2021). WHO. What is Africa's vaccine production capacity?, <https://www.afro.who.int/news/what-africas-vaccine-production-capacity>.
48. World-Bank. (2020). The Global Economic Outlook During the Covid-19 Pandemic: A changed World. <https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-wo>.

49. ZHU, N. Z. (2020). A Novel Coronavirus from Patients with Pneumonia in China.
50. WHO-WHE-SPP (2022). Covid 19 in Africa. Pandemic Preparedness and Response: Lessons from the Past, Insights for the Future.
51. WHO Comments Breed Confusion Over Asymptomatic Spread of COVID-19. <https://www.the-scientist.com/news-opinion/who-comments-breed-confusion-over-asymptomatic-spread-of-covid-19-67626>.
52. AGARWAL, K.M., MOHAPATRA, S., SHARMA, P., SHARMA, S., BHATIA, D. and MISHRA, A. (2020) Study and overview of the novel Corona Virus Disease (COVID-19). *Sensors international*, 1, pp. 100037.
53. BOSSCHA, P.A. and RONDE, W.D. (2022) The Journey of the CSIR L.I.F.E. CPAP Ventilator. *MATEC web of conferences*, 370, pp. 5002.
54. BRAULT, M.A., VERMUND, S.H., ALIYU, M.H., OMER, S.B., CLARK, D. and SPIEGELMAN, D., 2021. Leveraging HIV Care Infrastructures for Integrated Chronic Disease and Pandemic Management in Sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, 18(20).
55. CHANDA-KAPATA, P., NTOUMI, F., KAPATA, N., LUNGU, P., MUCHELENG; ANGA, L.A., CHAKAYA, J., TEMBO, J., HIMWAZE, C., ANSUMANA, R., ASOGUN, D., MFINANGA, S., NYASULU, P., MWABA, P., YEBOAH-MANU, D., ZUMLA, A. & NACHEGA, J.B. (2022.) Tuberculosis, HIV/AIDS and Malaria Health Services in sub-Saharan Africa – A Situation Analysis of the Disruptions and Impact of the COVID-19 Pandemic. *International Journal of Infectious Diseases*, 124, pp. S41.
56. CSIR-REPORTS (2020) CSIR SUPPORTS NATIONAL COVID-19 RESPONSE WITH LOCALLY DEVELOPED VENTILATOR.
57. CUNNINGHAM, N. and HOPKINS, S. (2023) Lessons identified for a future pandemic. *Journal of Antimicrobial Chemotherapy*, 78(Supplement_2), pp. ii43.
58. DSI-REPORTS, 2020a. NSTF-COVID-presentation.
59. DSI-REPORTS, 2020b. Research needed into COVID-19 in South Africa.
60. MOONASAR, D., LEONARD, E., NAIDOO, R., PILLAY, Y., GOVENDER, N., MOREWANE, R., RAMKRISHNA, W., FURUMELE, T., RAMADAN, O.P., PILLAY, A. & MAYET, N., (2022). Governing a pandemic: A case study of South Africa's coordination and management structures used to respond to the COVID-19 pandemic. *South African Medical Journal*, 112(5b), pp. 356.
61. NSANZIMANA, S., RAWAT, A., WILSON, L.A., FORREST, J.I., REIS, G., RAMAGOPALAN, S., MUYEMBE-TAMFUM, J., NTOUMI, F., ZUMLA, A., SOW, P.S., NACHEGA, J.B., BINAGWAHO, A., DYBUL, M. & MILLS, E.J. (2022) Toward a New Paradigm of North–South and South–South Partnerships for Pandemic Preparedness: Lessons Learned from COVID-19 and Other Outbreaks. *American Society of Tropical Medicine and Hygiene*.

62. OLADIPO, E.K., OLUFEMI, S.E., OJO, T.O., ADEDIRAN, D.A., IDOWU, A.F., IDOWU, U.A. & ONYEAKA, H., (2023). Africa (COVID-19) Vaccine Technology Transfer: Where Are We? *Life*, 13(9).
63. OWIE, U.N. (2022) Multilateralism and Management of Public Health Emergencies: A Case Study of the Africa Joint Continental Strategy for COVID-19 Outbreak. *Southern African public law*, 37(1), pp. 1–15.
64. Travaly, Y, (2018). Tracing Our roots: Understanding African Innovations. OECD Development Matters. <https://oecd-development-matters.org/2018/09/20/tracing-our-roots-understanding-african-innovation/>
65. PAUL ADEPOJU, (2022). Africa CDC warns COVID-19 vaccine production could cease A lack of demand could jeopardise manufacturing of the Johnson & Johnson vaccine in South Africa.
66. UNICEF-REPORTS (2020). The United Nations supports covid-19 testing campaign in Madagascar.
67. WHO-REPORT (2021). WHO supporting South African consortium to establish rst COVID mRNA vaccine technology transfer hub.
68. Elvis Korku Avenyo, Maty Konte, Pierre Mohnen (2019). The employment impact of product innovations in sub-Saharan Africa: Firm-level evidence, *Research Policy*, Volume 48, Issue 9, 103806
69. SADC (2020). SADC Regional Response to COVID-19 Pandemic. Bulletin No.2 ed.: Southern African Development Community.

الملخص العربي

الابتكارات للحد من كوفيد-١٩: وجهات نظر من دول شبكة AUDA-NEPAD SANBio

تابيسا نومافا فينيز^١، زانديله نكسومالو^٢، مونيارادزي تيناروو^٣، باغال أغبانغلانون^٤، سيكي لوكوفي^٥،
وإريك تشاكوايا^٦

^١وكالة الاتحاد الإفريقي للتنمية (AUDA-NEPAD)، شبكة إفريقيا الجنوبية للعلوم

البيولوجية (SANBio)، طريق مايرينغ ناودي، بروميريا، بريتوريا، ٠٠٠١

^٢مجموعة التكنولوجيا الحيوية النانوية الاصطناعية والآلات الحيوية، مركز البيولوجيا التركيبية

والطب الدقيق، مجلس البحوث العلمية والصناعية (CSIR)، بريتوريا ٠٠٠١، جنوب أفريقيا.

^٣جامعة كيب تاون، قسم البيولوجيا الجزيئية والخلاوية، شارع الكيمياء، رونديبوش، كيب تاون، ٧٧٠٠

^٤منظمة CeRADIS غير الحكومية، أبومي-كالافي، جمهورية بنين

^٥وكالة الاتحاد الإفريقي للتنمية-نيباد، طريق ١٥ رقم ٢٣٠، رانديزبارك، ميدراندي، ١٦٨٥

^٦مجال تركيز الأمن الغذائي والسلامة، كلية العلوم الطبيعية والزراعة،

جامعة الشمال الغربي، ماباثو ٢٧٣٥، جنوب أفريقيا

البريد الإلكتروني: ^١Echakauya@csir.co.za; ^٢TFiniza@csir.co.za; ^٣ZNxumalo@csir.co.za; ^٤munyaradzi.tinarwo@
gmail.com; ^٥godpagal@yahoo.fr; ^٦pagala@auda-nepad.org; lukovis@auda-nepad.org; ^٦Echakauya@csir.co.za

شكلت جائحة كوفيد-١٩ أزمة صحية عالمية، ولا سيما في البلدان منخفضة الدخل، وذلك بسبب انخفاض قدرات التصنيع والابتكار، وضعف النظم الصحية، واضطراب سلاسل الامداد. وقد كان متوقعا ان تكون افريقيا الاكثر تأثرا؛ الا ان النتائج جاءت على غير المتوقع. تسهم هذه الورقة في توضيح الاسباب التي جعلت الوضع في القارة اقل قتامة مما كان متوقعا. تستكشف الدراسة وتعرض الاستجابة الديناميكية والمبتكرة للبلدان منخفضة الى متوسطة الدخل تجاه كوفيد-١٩ ضمن شبكات وكالة الاتحاد الافريقي للتنمية AUDA-NEPAD شبكة افريقيا الجنوبية للعلوم البيولوجية SANBio. وتمثلت الاهداف المحددة في: (١) توثيق كيفية استجابة الجهات ضمن شبكة SANBio لجائحة كوفيد-١٩ باستخدام القدرات المتاحة، و(٢) اجراء مسح ميداني للتحقق من نتائج البحث المكتبي واعداد دراسات حالة. تظهر تحليلاتنا انه، رغم محدودية الموارد والبنى التحتية، فقد ابدت البلدان منخفضة الى متوسطة الدخل قدرا ملحوظا من الابداع في تصميم استراتيجيات محلية للتعامل مع الآثار المتعددة الابعاد للجائحة. وفي القطاع الصحي، برزت ابتكارات شملت حولا سريعة ومنخفضة التكلفة للكشف عن الفيروس، ومنصات جديدة للطب عن بعد، ومبادرات صحية مجتمعية. وقد مكنت هذه المقاربات من الكشف الفعال عن حالات الاصابة ومتابعتها ومعالجتها، مع تخفيف

العبء الواقع على النظم الصحية المثقلة. وتعد هذه الابتكارات شاهدا على مرونة المجتمعات وقدرتها على التكيف واصرارها في مواجهة تحديات غير مسبوقة. ان فهم اثر الابتكار المحلي على حياة الانسان يعد خطوة مهمة نحو الدعوة الى التصنيع المحلي والابتكار القاعدي في معالجة المشكلات الافريقية. كما ان الاستفادة من هذه الابتكارات تساهم في تعزيز المعرفة وتقدم رؤى مهمة للاثمات المستقبلية.

الكلمات المفتاحية: الابتكار، كوفيد-١٩، افريقيا، شبكة SANBio، المرونة.