Desk Review on COVID-19 Pandemic in Sub-Sahara Africa: The Challenges and Proffered Solutions

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ABSTRACT

Like every other case of a pandemic that ever occurred, the COVID-19 pandemic has come with its lessons and implications to every aspect of life. In Asia, Europe and America, a considerable number of lives were claimed in the first two waves of the corona virus disease, while Africa, though predicted to suffer more loss, was relatively speared from enormous death rate. Nonetheless, the COVID-19 pandemic has revealed how much the African continent needs to prepare for future pandemics. Across the globe, several efforts were made towards identifying the epidemiology, controlling the spread, treating the infected, discovering and developing drugs or vaccines, as well as producing medical devices. In Africa, researchers were on their toes to maximize available resources and facilities to support government policies and ensure optimum safety of lives from the infectious disease. Therefore, this paper focuses on the more notable impacts of the COVID-19 pandemic on sub-Saharan Africa, while simultaneously highlighting the efforts that were made by researches, the government, individuals and other policy makers in mitigating the negative effect on human lives.

Keywords: COVID-19 pandemic, Engineering and Technology, Health care, sub-Saharan Africa, SARS-CoV-2, Socio-economic

I. INTRODUCTION

About a century after the Spanish flu, the world is again hit with a related devastating airborne disease. While the Spanish flu caught the world completely unprepared being the first, the COVID-19 pandemic ensued at a time when the world is believed to have advanced in sciences, yet claiming about 100 million lives in two years (Ashton, 2020) and hitting the world in three different waves; a case similar to the 1918-1920 influenza pandemic. Between 11 March, 2020 when the World Health Organization (WHO) declared it a pandemic and 14 July, 2022, there have been over 556 million confirmed cases worldwide (WHO, 2022) making it one of the deadliest in human history with over 6 million deaths despite administering more than 12 billion doses of vaccines (David et al., 2020; WHO, 2022).

Like other countries in the world, every African country experienced the negative effects of the pandemic. According to WHO, the number of confirmed cases of COVID-19 in Africa currently stand at over 9 million while mortality is around 175,000 (WHO, 2022). Given the weak health sector in the continent, this figure is astounding. Factors such as large youth population, a warmer climate, and experience are among factors suggested by Kulohoma, (2021) to have contributed in dealing with infectious disease outbreaks resulting in low incidence in Africa compared to the projected figure.

African governments incorporated major risk measures set in place by the Western world. These include boarder closure and strict scrutiny at important entries into various countries. Also, ban on public gatherings, and washing of hands, covering of noses, and safety distance were enforced in instances where it is unavoidable for people to gather. Asides implementing measures employed globally, several research, inventions and policies developed by scientists and innovators of African descent were adopted in different places across the continent. Although, the

approaches to the outbreak differ from country to country in Africa, coordinated efforts by the Africa Centre for Disease Control (CDC) was instrumental in bringing about positive impacts in combating the outbreak using engineering and technology, medical sciences, mathematical models, as well as reports and discussions from educationists, psychologist, legal practitioners, peace and conflicts experts among others.

Despite the courageous moves made by African researchers and innovators to mitigate the impact of the pandemic, most of the significant achievements were not published in the early period of the spread of the COVID-19 virus. Only a few literatures are available with specific information on efforts of African-based researchers during the COVID-19 pandemic, which creates an opening for the myth that Africans properly did little to solve domestic issues that aroused from the global pandemic. Therefore, this paper attempts to bring together notable research contributions, innovations and policies made by Africans, especially home-based researchers, agencies, organizations, institution, the government, and innovative individuals from across the continent towards tackling the covid-19 pandemic. To achieve this, we reviewed existing literatures on the negative effect of the COVID-19 pandemic on regular day-to-day life of African citizens, in particularly, and took into account attempts made towards lessening and eliminating the negative impact on socio-economic, health, education and employment.

II. METHODOLOGY

This study was a desk review of extant literature. We adopted a mixed methods approach by considering published journals available on the Internet on COVID-19 pandemic in Africa between 2019 and 2022. The initial search was limited to articles available on Google Scholar and Research Gate. The second approach was to access pre-publication and not yet peer-reviewed publications from reliable sources such as University press, BBC documentary and random Internet search, which was then filtered by the authors for quality and interest to the current article. Furthermore, the different materials were reviewed by the co-authors based on their areas of teaching and research expertise and was finally addressed holistically by all authors before developing the entire manuscripts.

IV. FINDINGS

4.1 Impact of the Covid-19 Pandemic on Sub-Sahara African and Significant Contribution towards Mitigating the Associated Effects

4.1.1 Socio-economic Impacts

The most enforced safety measure was the compulsory lockdown during the first wave of the COVID-19 pandemic. Although this was effective in limiting the spread of the disease, it negatively impacted the socio-economy of sub-Sahara Africa (SSA) (Deloitte, 2020). These measures acutely impede social sectors including tourism, entertainment, travel and hospitality since social interactions and trade became almost impossible. This resulted in a sharp decline in the revenues generated from different sectors and by extension the Gross domestic Product (GDP) of SSA.

In regards to the socio-economic impacts of COVID-19 on Africa, different researches have been published between 2020 and 2022. For instance, (David *et al.*, 2020) applied *probit* regression model to examine the effects of COVID-19 pandemic on the sub-Saharan Africa economy, with focus on economic measures such as employment rate and oil prices. They found out that both measures were 5% and 10% statistically significant respectively, implying negative affect of the pandemic on the SSA economy. In 2020, (UN Habitat, 2020) projected that the pandemic will make attaining many of the Sustainable Development Goals (SDGs) difficult. In fact, SSA's economy only improved by 1.87% in the first quarter of 2020 as against growth rate of 2.5% in the previous period, thus welcoming the region's first recession in 25 years (World Bank, 2020). The World Bank estimated that COVID-19 pandemic cost SSA between $37 and $79 billion (World Bank, 2020) with declined supply chains, increased unemployment rates, significantly decreased agricultural productivity, endangered local and international trades and aggravated political and regulatory ambiguities (United Nations, 2020). In addition, SSA's GDP growth declined by -1.66%. Nigeria, South Africa and Zambia were the worst hit, with a growth reduction of 3.4%, 5.8% and 3.5% respectively. Likewise, the export growth of SSA also declined to -1.87 (African Union, 2020). Nigeria as a case study experienced a nose dive in her oil sales during the COVID-19 era. Even though the oil benchmark in the 2020 Federal budget was US$57 per barrel, crude oil was sold at US$29.62 per barrel as of March, 2020. This was due to lack of demand by Nigeria's crude oil customers.

While the developed countries are beginning to crawl out of the global economic slowdown resulting from the lockdown measures imposed during the pandemic and their businesses are beginning to reopen for economic

activities; this may not be the trend in SSA economies. This is because, it is looking as though the SSA economies are tending towards a deeper recession with further possibilities of production and trade related constraints (Fakhruddin *et al*., 2020; Fairlie, 2020). When (Ozili, 2020) studied the COVID-19 situation in Africa and its effects on the socio-economy of SSA countries, he found out that even though SSA governments took bold steps in containing Coronavirus; however, there were consequences. These costs were the collapse of SSA health systems and a painful economic crisis and recession. In SSA's aviation sector, International Air Transport Association (IATA) estimated loss of revenue due to COVID-19 shock (Ozili, 2020), the imposed compulsory lockdown measures and the resulting decline in air travels in and out of Africa at US$113bn (IATA, 2020). Even African Airlines lost US$400m at a time in 2020 and several airways including South African Airways had to suspend flights to and fro China (Ozili, 2020). The effect of the pandemic on financial markets in SSA cannot be overlooked. Nigeria, for instance, had to devalue her currency by adjusting it to 380 naira per Dollar as at March, 2020 (David *et al*., 2020). Naira today is trading at ₦490 to a Dollar at the parallel market in Nigeria as at July, 2022 (abokiFX, 2022). Besides, a 3.7% slum in the Johannesburg Stock Exchange Top 40 Index was recorded in SA as at 24th February, 2020 (Whitehouse, 2020). There was loss of value in investment equity in the stock exchange immediately SARS-CoV-2 was confirmed in Morocco. Major stocks in Kenya including Safaricom and ICCB Bank slummed by 54% and 7% respectively (Wafula, 2020). Tourism to South Africa fell by 80% while Kenya witnessed 55% fall in the number of tourists who visit the country. All these were direct results of the impacts of COVID-19 pandemic.

Table 1

Negative Effects of COVID-19 Pandemic on sub-Sahara Africa (SSA) Sectors

S/N	Sector slum (worst hit)	Percent (%) slum/decline
1	**Gross Domestic Product** (African Union, 2020) SSA Nigeria South Africa Zambia	 -1.66 3.4 5.8 3.5
2	**Tourism** (Wafula, 2020) South Africa Kenya	 80 55
3	**Financial** (Wafula, 2020) Johannesburg Stock Exchange (South Africa) Safaricom (Kenya) ICCB Bank (Kenya)	 3.7 54 7
4	**SSA Aviation** (IATA, 2020)	US$113 billion

4.1.2 Healthcare

The pressure that COVID-19 outbreak posed on the health care system of SSA countries is unprecedented. This is due to the fact that most Federal governments of SSA countries pay lip service when it comes to investment in the health sector. The health care infrastructure in most SSA countries is in shambles. While the national and regional authorities in Europe make policies relating to the health of her citizens and pay their health bills; 65% of SSA citizens are individually responsible for their health expenses (Ozili, 2020). During the heat of the pandemic, there were not enough ventilators, isolation and treatment centers, Personal Protective Equipment (PPEs) for frontline health workers. In addition, testing centers were inadequate. The absence or the inadequacy of these health facilities weakens the capacity to respond decisively to the pandemic and make difficult the efforts to flatten the curve of infection. It took a while before COVID-19 data from SSA countries started trickling into the database of WHO. This was because testing facilities were very inadequate. Because there was no data to show the extent of infections, the number of infected people started increasing significantly. This then brought about an unprecedented pressure on the health system in many SSA countries. At a time during the heat of the pandemic, governments of Nigeria and Cameron had to convert national football stadia into isolation centers (Ozili, 2020). Some private hospitals rejected patients while public hospitals could no longer admit because their health facilities have been completely overwhelmed.

Even though sometimes in 2020, reports from WHO showed that Africa was the least affected continent in terms of COVID-19 infection (Ozili, 2020), frankly, the number of COVID-19 cases overwhelmed Africa's fragile, weak and

vulnerable health infrastructure. Many patients who died lost their lives not because of the virus or its resulting complications, rather because they were left untreated/unattended to. The doctors to patients ratio in Africa is alarming (about 2 to 10,000 patients) according to Bloomberg (Bloomberg, 2020). This is a revelation of the weaknesses in Africa's health care system. Just as Egypt had shortage of medical doctors and front line workers, lack of testing and insufficient PPEs (Ozili, 2020), so was the case in Nigeria. At a point when Morocco's health care system was overwhelmed, the government had to convert Casablanca's exhibition center into an isolation center (Ozili, 2020). WHO believes that the poor health care system of African countries might not give them the capability to be able to cope with the health shock resulting from COVID-19 pandemic.

4.1.3 Unemployment and the fall of Financial Sectors

The lockdown measures brought about increase in unemployment rate in SSA (United Nations, 2020; David *et al*., 2020). Job seekers' hopes were dashed because private companies, governmental organizations/agencies could not recruit. Only the frontline health workers were in high demand during this period. Besides, a lot of people also lost their jobs because of the pandemic since companies and corporations had to retrench staff to reduce cost. Others who retained their jobs had to work from home. Furthermore, as the pandemic was gaining grounds, SSA trade, services and financial sectors suffered immense disruptions. There was a sudden drop in oil prices and constrained international trade, significant global disruptions in education, tourism, aviation, accommodation, support services, extraction, mining and manufacturing sectors. Sadly, SSA in 2020 experienced what seemed to be the slowest economic growth since the third quarter of 2018.

Authors of Mashige *et al*. (2021) employed the results of the analysis of responses of 1970 respondents from a web based cross-sectional survey to evaluate the health, economic and physical impacts of COVID-19 lockdown measures among SSA populations and associated demographic variations. Mashige *et al*. (2021) strongly believes that the preventive measures undertaken by SSA governments to flatten the curve of COVID-19 infection had significant negative health, economic and physical implications on mostly the developing countries in SSA. To the extent that one in four SSA respondents who are mostly from southern and eastern Africa were the most adversely affected by the lockdown which was as a result of COVID-19. They were followed by central Africa while West Africa was the least negatively impacted. The profound shock from the pandemic is expected in SSA since the economies of SSA was almost in a state of comatose following the temporary closure of local and international airports, small and medium scale businesses, educational institutions, social and hospitality services. There is no gainsaying in the fact that the pandemic really exposed the inadequacies and rot in health, educational and economic sectors of many SSA countries. For instance, study carried out by Trillo *et al*. (2007) in South Africa showed that 99.7% of the hotels were adversely affected by COVID-19. This is in regards to loss of jobs by staff, shortfall in income, risk of bankruptcy and eventual permanent business closure for some of the hotels.

4.1.4 Educational Sector

As COVID-19 infections were progressing, SSA government swung into action and took the initiative of shutting down educational institutions temporarily to curb the virus spread (Crawford et al., 2020). For instance, Morocco substituted classes for distance learning (Ozili, 2020). In Nigeria, classes and examinations were held online. Even some Television (TV) stations like Ogun TV (OGTV), Lagos TV (LTV), and Ondo State Radio Corporation TV (OSRC TV); featured primary and secondary school teachers who taught pupils and students respectively via the TV, while according to Sahu, (2019), social media networks were used by private schools to distribute learning materials to parents directly. Over 85% of Africa's students' populations was affected by the nationwide school closures in SSA countries (Ozili, 2020). Just as some educational institutions were prepared for the kind of shock posed by the pandemic, yet, many schools in SSA countries were unable to keep up with the tide. They were left out because of absence of online platforms or distance learning educational programs. This in turn made the continuity of education for the youth population very difficult during the heat of the pandemic. There is the likelihood that the remaining youths who were idle could involve themselves in vandalism of offices, small businesses, and engage in online fraud. For instance, in Nigeria, the food palliatives (aids) donated by churches, corporations and hoarded by government officials, state governors and politicians alike were eventually looted by the people who took laws into their own hands after the hijack of the EndSARS protest in Nigeria that took place on October 2020 (Orjinmo, 2020).

4.1.5 Mental Health and Social Implications

Globally, the impact of the COVID-19 pandemic has caused several mental health issues because of the disease, physical isolation, stigma and discrimination, and job losses in many of the areas hardest afflicted by the

pandemic. Several African scholars wrote extensively on the outbreak of the covid-19 and its social and health implication for Africans. In the view of Anazonwu and Okike, (2020), post-traumatic stress disorder was rampant among healthcare personnel who were assigned to look after COVID-19 patients as they experience anxiety, sleeplessness, and sadness during the peak of the Covid-19 spread in Nigeria. The impact of COVID-19 on the social and health situation of Africans was stressed by Dixit et al. (2020) who also reported that the hardest hurt by lockdowns were the informal workers, including traders, retail employees, and physical laborers; putting their survival in jeopardized. In another study by Gyasi (2020), the author noted that COVID-19 has created several difficulties for services for older individuals seeking mental health care. The fact that so much work is being put into reacting to COVID-19 means that little attention is being provided to this vulnerable population. Author of David *et al*. (2020) believes that COVID-19 pandemic is a threat to peace and social cohesion. They hinged this submission on the fact that in Nigeria for instance, some police reports indicated that domestic violence tripled during the pandemic. There were also several reported cases of violence against frontline health workers, probably due to the physical, psychological and emotional stress that COVID-19 viral infection places on the patients. As of August 2020, the number of rape cases in Nigeria increased by 20%. Cybercrimes were also reported to have significantly increased. On the social level, COVID-19 has also taken its negative toll on people who do not have access to portable water or who are refugees, migrants, displaced persons in many SSA countries. The lockdown measures affected adversely social events, communal gatherings which promote social development most especially in SSA that places high value on individual level interactions.

In lieu of the discussions in the foregoing section, and to monitor the socio-economic impact of COVID-19 and the government's containment measures, and to provide policymakers and the World Bank with up-to-date evidence of their effect, a new, high-frequency survey – the Djibouti COVID-19 National Panel Phone Survey 2020 (ECV 2020) – was initiated in Djibouti in July 2020 and is expected to cover 4 rounds until February 2021.

4.2 Attempts and Effectiveness of Laws and Policies, Engineering and Technology, and Medical Statistic during the COVID-19 Crisis

4.2.1 Laws and Policies: A Case Study of Nigeria

Society is regulated by laws; laws are created to address societal issues. The existed laws create prior to the occurrence of Covid-19 may not have contemplated the emergency situation at the behest of Covid-19. This necessitated the creation of laws or policies to address this novel situation. Due to the contagious disposition of Covid-19, there was need for social distancing measures to avoid physical contact and continuous spread of the disease. Due to the urgency of the situation and the difficulty for the legislative houses of Assemblies at the federal and state level to convene, the government had to resort to regulations, directives and executive orders as urgent legislative tools to address the issue. This section discusses the various laws and regulations with particular reference to those addressing issues of public health, environmental protection, virtual court session and law enforcement measures.

4.2.2 Effect of the Pandemic on Law Enforcement

Other than the negative economic impact of lockdown, the judicial system initially faced indefinite shut down. This created a standstill in the justice system, with its attendant collapse of law and order. People tend to resort to self-help, whereas the justice system is inaccessible for litigants to seek judicial redress. It is found that, between the effective lockdown period of 30th March, 2020 - mid-April of the same year, the National Human Rights Commission indicted several security agencies in Nigerian for abuse of power and involvement in extrajudicial killings as posited by the Assessment Capacities Project (ACAPS, 2020). Up to 18 people were reportedly killed by law enforcement agents for allegedly breaching the preventive measures of covid-19 (ACAPS, 2020). Within this same period, it was reported that there were 33 instances of human right abuse and 27 cases of unlawful arrest and illegal detention occurring in localities subjected to lockdown or movement constrains (ACAPS, 2020). More importantly, it became imperative that persons who are in breach of the lockdown regulations that were as arrested and held in police custody needed to be prosecuted as they could not be held beyond the constitutional required period. The key concern was the competing need to balance access to justice, on one hand, while still upholding social distance prescription set out to prevent continuous transmission of the virus.

4.2.3 Health Safety Regulations

Pursuant to the presidential powers under Section 2 of the Quarantine Act 1926, the federal government Corona Virus was declared to be a 'dangerous and contagious disease'. In line with Sections 2-4 Quarantine Act 1929, the President also established a Covid-19 Regulations 2020. The regulation basically restricted movement of citizens,

with the exception given to certain persons providing essentially services such as: financial, telecommunication, broadcasting, seaport, conveyance of consumables and relief materials. This was immediately followed by a lockdown order placed on the States of Lagos, Ogun, and Abuja. Some States Governors followed suit and put their States on lockdown while some only adopted the curfew modality within a particular length of hours on daily basis. A ban was placed on inter-state travels except for movement of essential services/commodities. The Coronavirus Disease (Covid-19) Health Protection 2021 contains code of conduct and operations of persons in public places. This regulation mandates the compulsory wearing health protective gears and maintenance of social distance in public places to avoid spread of the virus.

Legal issues may be raised regarding the constitutionality of restricting human movement. This is in view of the provisions of Section 41 Constitution of the Federal Republic of Nigeria (CFRN) 1999, which secures the right to freedom of movement of persons. However, it is argued that the right to freedom of movement does not have absolute application. The same constitution, in Section 45 (1) CFRN allows derogation from the fundamental right to freedom of movement on the grounds of public health and safety pursuant to a law. Provided that the regulations were validly made by the President for the purpose of preventing the spread of the virus considering its highly contagious nature actuated by physical contact, it would not be regarded as a breach of the fundamental right to freedom of movement of citizens.

In terms of governments' responses to the virus, the Presidential Task Force was created as the central coordinating executive body, while the National Centre for Disease Control (NCDC) was the chief administering institution saddled with the task to prevent and control Covid-19 (Oniemola, 2021). The NCDC is also tasked with the duty to create guidelines towards the performance of its functions. This was the basis for its establishment of the National Interim Guidelines for Clinical Management of COVID-19. The provision of the guideline is not restricted to the clinical management of the virus but extended to environmental impact of the virus (Herbert & Akinleye, 2022).

4.2.4 Virtual Court Session

Covid-19 has changed the landscape of justice dispensation in Nigeria to shelf its hitherto phobia for digital culture (Sunday-Ayeerun et al., 2022). The lockdown order also affected courts. Considering the essential role of courts in justice dispensation and ensuring peaceful and orderly society, the courts could not afford to stay shut for long. This prompted the National Judicial Council, at its 91st meeting held on 22nd April, 2020, to constitute the committee task with the function of formulating guidelines and action plans to guarantee safe court sittings within the prevalent period of the pandemic (National Judicial Council, 2020). The Chief Justice of Nigeria adopted the Committee's report to form the 'Guidelines for Court Sittings and Related Matters in the Covid-19 Period.'

Borno State High Court achieved the first Nigeria court session held virtually (Umah, 2020). This was practicalized in the State v. Ali Mohammed case (Unreported. Suit No. BOHC/MG/CR/115/19. Judgement delivered on 27th April, 2020). In the aforesaid case, Umar J. delivered a final pronouncement of discharge and acquitted in a murder charge against the defendant. This was immediately followed by another virtual judgement delivered in the People of Lagos v. Olalekan Hameed case (Unreported. Suit No: ID/9006C/2019. Judgement delivered on 4th May, 2020) by the Lagos State High Court) (All Africa, 2020). In the said case, the defendant was held liable for the offence of murder, convicted accordingly and sentenced to death, in a judgement delivered via Zoom app (Erezi, 2020).

4.2.5 Mathematical Approaches Employed to Control and Curtail the Spread of the Virus

As COVID-19 continued to spread for more the two years, policymakers in particular felt the need to safeguard the economy and save the failing healthcare systems. There were worries about how to effectively stop the spread and safeguard the economy at the beginning of the outbreak, and there are concerns about the availability of incidence data that are crucial to containment (Adebowale et al., 2021). Therefore, non-pharmaceutical intervention appears to be the most suitable options in restricting the devastating spread to manage it at the initial stage and in the absence of immunization. To ensure the effectiveness of control measures, implementation must be led and reviewed, and one way to gather vital information for such policy decision is the use of mathematical models, discussed extensively by Ayoub et al. (2021), Kinyili et al. (2022), Nkwayep et al. (2022), Keeling et al. (2021a), Keeling et al. (2021b), Mangal et al. (2021), Silva et al. (2021), Keeling et al. (2021a). Even though there is a wealth of research from Europe, Asia, North America, and other continents, African mathematicians and statisticians also played a significant role in assisting local decision-makers with policy decisions. Different methods were employed to capture assumptions and provide direction to decision-makers, ranging from the straightforward deterministic SIR model to the more complex modified SEIR model, stochastic, and other statistical models. For instance, in their research, Taboe et al. (2020) evaluated the control mechanisms in place, evaluated the pattern of COVID dissemination, and forecasted

the disease's future trend in West Africa. Their research suggested that to stop the spread, asymptomatic people must be quickly located and segregated. Also, Siraj et al. (2020) predicted if local transmission of the virus was maintained in SSA using the deterministic model. They concluded that implementing prevention strategies including social isolation, contact tracing, and nose covering early on could help keep the virus's transmission to a bare minimum. A challenge in disease control can be failing to recognize asymptomatic infections or failing to report symptomatic cases in a timely manner. To this end, scientist from North African countries (Djilali et al., 2020) studied the impact of unreported cases in COVID-19 transmission in Algeria, Egypt and Morocco, while Adeniyi et al. (2020) and Ryan et al. (2020) from Nigeria and Kenya, respectively, provided guidance on the most effective control measures to be deployed for effective control during the period.

Furthermore, African mathematicians and scientists used mathematical modelling studies to address even more intriguing African-centered concerns on COVID-19 pandemic (see Figure 1 and 2). For instance, one of the key elements that contributed to the spread of the coronavirus around the world was international travel. A study from Kenya (Mbogo & Orwa, 2021) used a modified SEIR model to demonstrate the effects of disregarding safety guidelines on the dynamics of disease spread and control, with a focus on determining the impact of daily international travel and the split between infected and uninfected travelers. Another study (Kolebaje et al., 2022) supports the Kenya study by drawing the conclusion that the reproduction number—the number of secondary infections that can be produced from a single infectious individual in a completely susceptible population—can be kept below one (1) if at least 55.29 percent of the susceptible population adhere to non-pharmaceutical interventions. Sometimes in 2021, there was also concern that the current attention given and various COVID-19 interventions could have a negative impact on the prevention of other illnesses in Africa. To this end, Silhol et al. (2021) used mathematical modelling techniques to predict the potential effects of COVID-19-related disruptions to HIV prevention/treatment services while Aliee et al. (2021) investigated the impact of COVID-19 control measures on neglected tropical disease (Gambiense human African trypanosomiasis (gHAT)). However, Kassa et al. (2021), Gweryina et al. (2021) concentrated on the use of the modified SEIR model to examine how behavioral changes in adopting preventative behaviour fluctuate as the population's number of new cases rises. Other studies conducted (Gweryina et al., 2021, Kulohoma, 2021, Djomegni et al., 2021) examined the effects of control measures and the best control that can aid policymakers in striking a balance between preventing the spread of disease, stabilizing the economy, and preventing the collapse of the health systems.

In cases of disease outbreaks such as the COVID-19 pandemic, studying the African setting is crucial because of the continent's unique cultural landscape. In lieu of this, studies from South Africa (Oshinubi et al., 2022, Oloniiju et al., 2022) created a mathematical model of the COVID-19 dynamic in their work, focusing on control strategies that are workable in an African environment. With regards to establishing control strategies, Adeniran et al. (2021) studied the interaction of sneeze and cough droplets with indoor air of a regular African hospital clinic to investigate the feasibility of adopted protocols and guidelines to control the spread of COVID-19 transmission using numerous three-dimensional coupled Discrete Phase Models, shown below.

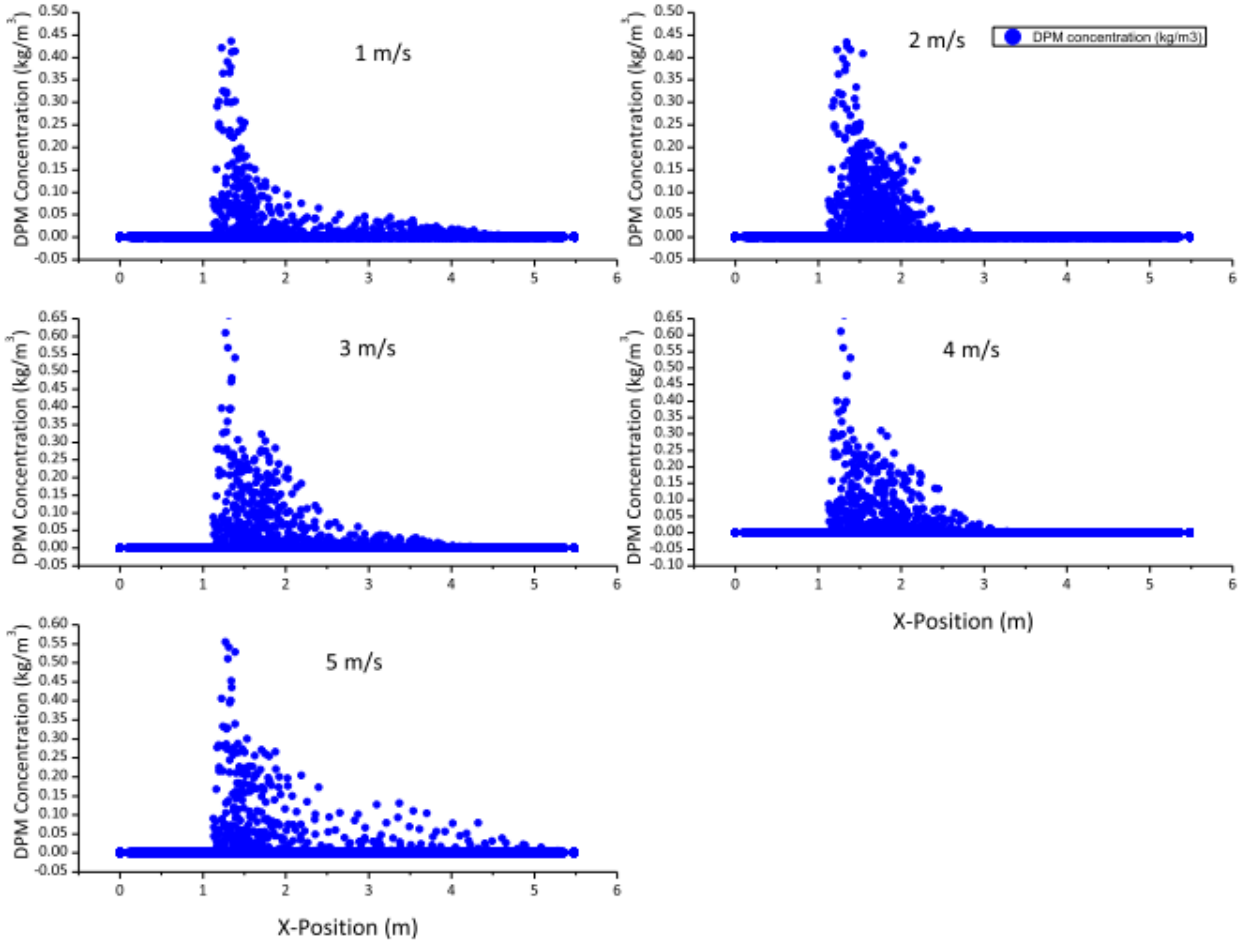

Figure 1

Concentration maps at 1–5 m/s air velocity illustrating the impact of air dynamics on the transport of sneeze droplets (X-position). (Distribution of sneeze droplet sizes: 0.5–12 µm)

Source: Adeniran et al. (2021)

Likewise, Musa et al. (2021) suggested a mathematical model which was used to analyze the dynamics of COVID-19 transmission in Nigeria to determine the impact of public awareness campaigns on the dynamics of COVID-19 infection. Djomegni et al. (2021) created a COVID-19 epidemic model to describe interaction between the infected and susceptible individuals, while for the purpose of predicting the COVID-19 transmission dynamics in Ethiopia, Gebremeskel et al. (2021) proposed and examined an epidemic model tacking into account certain peculiarities of Ethiopians. To emphasize the value of taking precautions, Masandawa et al. (2021) and Masandawa et al. (2022) offered a mathematical model which analysis the potential of safety of healthcare workers in Tanzania if public control measures are adhered to. Gweryina et al. (2021) developed a mathematical model to evaluate the negative role of denial in the global spread of the pandemic on African, which reveals that many Africans, due to culture and religion, were nonchalant about the spread. Also, in a model developed by Barnes et al. (2021) using information extracted from a Susceptible-Exposed-Infected-Quarantined-Recovered (SEIQR) model and the epidemiology data of COVID-19 infection, it was discovered that at least three people contract the Covid-19 infection from an infected person every day. This model also yielded the threshold condition for the long-term stability of the Covid-19 infection in Ghana as shown in Figure 2.

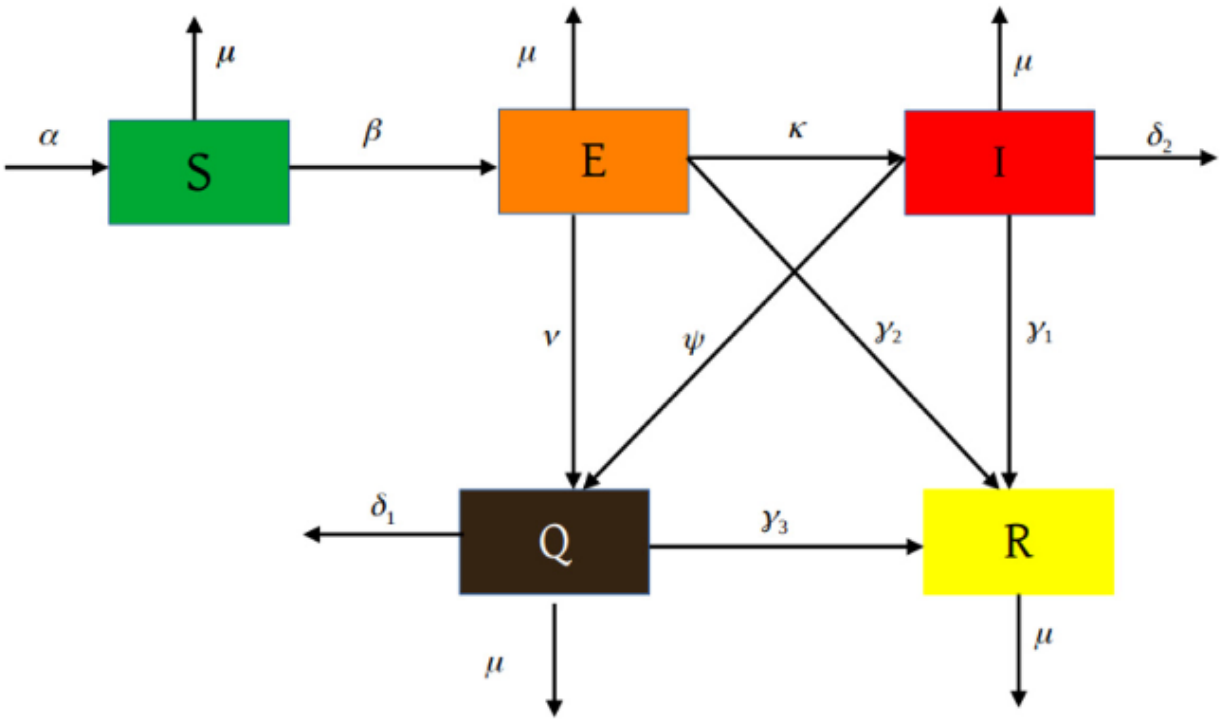

Figure 2
The SEIQR model describing the COVID-19 infection epidemiology in Ghana
Source: Barnes *et al.* (2021).

Furthermore, utilizing data on cumulative mortality collected in South Africa, Garba et al. (2020) fitted and parametrized a compartmental model to examine the effects of different control and mitigation measures for the pandemic. Ndolovu et al. (2022) attempted forecasting the size and event of the fourth wave, and to provide proof of seasonality in three distinct countries (Botswana, South Africa, and Zimbabwe) using the most recent COVID-19 datasets. To account for the seasonality effect, they modified the SVIR model by adding moving averages and signal processing methods to the rate of virus transmission. Assob-Nguedia et al. (2020) examined the dynamics of the West African outbreak's transmission nearly 5 months after its actual onset. Four West African nations with the highest proportion of infected cases: Cameroon, Ghana, Guinea, and Nigeria were focused-on. They were able to forecast the COVID-19 epidemic's short-term transmission times, peak times, peak rates, final sizes, and initial doubling times for these nations.

4.2.6 Engineering and Technology

In most African countries, one of the biggest challenges to limiting the spread of the COVID-19 virus was establishing a workable strategy to limit physical contacts. However, researchers and innovative individuals within Africa made notable contribution, particularly in the area of Artificial Intelligence, robotics, manufacturing, software, electrical & electronics applications, mechanical tools and protective equipment, educational tools (Agbehadji et al., 2020; Daramola *et al.*, 2021; Rouabah *et al.*, 2021; British Broadcasting Corporation Africa, 2020).

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The World Health Organization proclaimed the acute phase of the coronavirus pandemic to be over based on several studies conducted in Europe and South Africa. Although, almost every African country recorded published significant attempts toward tackling the COVID-19 pandemic, there is need for further proactiveness by policy makers across the African continent to establish plans that enable quick responses and immediate solution-oriented action

against possible future pandemic. Generally, the greatest challenge with health-related issues in Africa and developing countries has been lack of health infrastructure, in terms of facilities for diagnosis, extensive research, treatment, training and case tracking. Against the backdrop of the socio-economic impacts of COVID-19 on SSA which have been expounded in details in this write-up, (Ozili, 2020) believes strongly that a coordinated and bold response is essential from the SSA authorities. This includes improvement in the capacity of SSA counties' health system, access to effective communication system by people in small communities of different SSA countries which will enhance their social interactions. Without mincing words, the attempts of Africans in tackling COVID-19 have revealed their capability to react to global, particularly in the continent's region, if the enabling environment is put in place by her political leadership.

5.3 Recommendations

Although the initial intention was to carry out a survey across the entire African countries about the documented and on-going research and innovations that were employed during the COVID-19 pandemic, we could not achieve this because of the large scope. Hence, this review analysis is not a representative of the whole African continent. Consequently, an elaborate systematic review is recommended for future studies of this kind in order to inclusively applaud the intellectual efforts of home-based African researchers, policy makers and innovative individuals across the continent.

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