

Engineering for Survival in Rural Africa in the Era of Covid-19

Kehdinga George Fomunyam

Abstract: *Engineering has been reputed as a discipline that makes things work better. By the ingenuity of engineering, there is the potential to deploy creativity to solve some of the problems of the world and help in shaping the future. Shortly after the novel coronavirus, SARS-COV-2 (2019-NCov) was initially identified in the Chinese city of Wuhan in a group of patients diagnosed with pneumonia on December 31, 2019, it resulted to fast paced human to human transmission which has generated lots of media stirs and hype concerning issues of public health globally. Corona virus disease 2019 (COVID-19) is a ribonucleic acid virus (RNA) which has the physical appearance of a crown when viewed under the microscope which is as a result of glycoprotein spikes on its envelope. Findings from the study revealed that engineering has great impact on health conditions in rural Africa and the era of COVID-19 brought with it various consequences on the health systems of people. Understanding that there is no known cure for COVID-19 is key and various countries of the world depended on their knowledge and expertise to deal with the disease. This study therefore recommends that there is a need for intensified effort on engineering in rural Africa.*

Keywords: *engineering, survival, COVID-19, corona virus, rural Africa*

I. INTRODUCTION

Engineering has been reputed as a discipline that makes things work better. By the ingenuity of engineering, there is the potential to deploy creativity to solve some of the problems of the world and help in shaping the future. This is well captured in the definition of engineering by the Royal Academy of Engineering which defined engineering as the creative use of scientific principles and knowledge to invent, design, build, maintain and improve structures, machines, devices, systems, materials and processes. This definition embodies the multi-dimensionality and multi-versatility of engineering as a tool for making structures, systems and processes better. It also typifies the dynamic nature of the discipline as it is constantly evolving to create solution to many challenges of the world. The multidimensionality and multi-versatility of engineering has many applications in various fields including those that are pivotal to human existence and survival. The search for survival is important for a better way of life and processes which is a dimension of engineering education. Taking a look at the etymology of survival according to Merriam-Webster dictionary (2020), the first known use of the word survival was in 1598 and it was defined as the act or fact of living or continuing longer than another person or thing or the continuation of life or existence. Survival is a construct which depends on context. There are various elements embedded in survival when defined and it is often used to suit various situations. Some of the various elements in it include economic survival, social survival, political survival, organizational survival etc.

Revised Manuscript Received on August 12, 2020.

Dr. Kehdinga George Fomunyam, Mangosuthu University of Technology E-mail.kehdinga.george@mut.ac.za

Diseases are deviation from the normal physiological functions of the body and with it are various consequences on the human life. Much more are the effects when it occurs across wide geographical space, hence the nomenclature pandemic. This in the long run necessitates the need to ensure survival. Shortly after the novel coronavirus, SARS-COV-2 (2019-NCov) was initially identified in the Chinese city of Wuhan in a group of patients diagnosed with pneumonia (Li *et al*, 2020) on December 31, 2019, it resulted to fast paced human to human transmission which has generated lots of media stirs and hype concerning issues of public health globally (Ippolito *et al*, 2020). As a result of the rate and pace at which human to human transmission increased, the World Health Organization in January 31st 2020 through the Director General Dr. Tedros Ghebreyesus declared the disease a public health emergency of international concern. This was necessary to ensure that the potential for the virus to spread to regions with weaker health systems in which Africa is a part of be reduced. Evidences from various outbreaks of preventable emerging and reemerging infectious diseases had affected health systems of many African countries which necessitates the demand for survival. Consequently, this study will explore how engineering has been a vital tool for survival in rural Africa in the era of COVID-19

II. METHODOLOGY

To tackle the major crux of this research, a literature review was carried out to locate and comprehensively synthesize research on the impetus of engineering for survival in rural Africa during the era of COVID-19. Engineering has many positive impacts in ensuring survival in rural Africa in the era of COVID-19, though, it has not been appropriately leveraged on. Therefore, this review seeks to gain insights into how prepared Africa is for the disease, the etiology and epidemiology of the disease and how engineering has facilitated survival in the era of COVID-19.

Understanding Africa's preparedness for the disease

Epidemics has been in existence as the development of humans and various diseases have ravaged humans ever since. With the impetus for learning and the benefits of civilization, some have been tackled decisively. One of the recent analysis of the spatial and temporal distribution of infectious disease epidemics revealed that in World Health Organization Africa region, disasters and other potential public health emergencies were highlighted in 41 African countries which makes up 87% of the continent and these countries have at least one epidemic, while 21 countries which makes up about 45% had at least one epidemic annually (Talisuna *et al*, 2020).



This brings to the fore the series of health issues being faced in some countries in Africa and the capacity built to curtail it. There are various diseases which as a result of their intensity and spread have become epidemics in Africa and the top five are cholera, measles, viral hemorrhagic diseases, malaria and meningitis. There are efforts by countries in Africa to overcome these diseases and this is seen in the various workloads in hospitals and clinics. It was revealed that the drive to respond to an international health regulation hazard such as the importation of the novel corona virus (COVID-19) must be improved across sub-Saharan Africa (WHO, 2020c)

This necessitates the impetus to be prepared for such situations before it happens and encourage proactive and better surveillance systems for monitoring and rapid detection of any case of COVID-19 from spreading rapidly as seen in China. Taking a look at history, from the outbreak of Ebola (WHO, 2020d) in year 2014-2016, some lessons have been learned from previous outbreaks and there has been significant investment and improvement in surveillance and preparedness (WHO, 2020d, Largent, 2016, Hoffman and Silverberg, 2018). This is necessary because Africa as a developing region is still characterized by widespread poverty and this has attendant consequence on the general health condition of people in Africa. With more deaths from sicknesses like malaria, having to deal with other epidemics and pandemic might come with huge costs and consequences for Africa. The case of preparedness cannot be over emphasized as diseases are dangerous and a certain degree of mismanagement of any health condition might have general consequence on the entire population in the country. Africa has shown the commitment for preparedness over the years going forward from the outbreak of Ebola in the region.

With Africa being a developing region, much help is needed from other countries of the world in terms of infrastructure, manpower and development. This has necessitated more than ever before the need to heighten alerts to detect and isolate imported cases of COVID-19. What gave credence to this decisive action was the re-organization of the WHO and the creation of the Africa centers for disease control and prevention (Africa CDC, 2020) and other consortia such as the ONE HUMAN-ANIMAL-HEALTH Africa-Europe research, training and capacity development network (PANDORA-ID-NET) (PANDORA-ID-NET, 2020) for curtailing emerging and re-emerging cases of infectious diseases. The essence of the one health network is to work effectively and equitably across all regions of Africa and form synergy with national disease control authorities and public health institutes. Of note is the Nigeria CDC and Africa CDC and other African and global public health agencies which has strengthened communication and establishment of trust and unity of purpose among the government of African countries, Africa CDC, Nigeria CDC (Nigeria CDC, 2020), local governments and some consortium such as the PANDORA-ID-NET and European public health workers and scientists.

With the need for reliance on foreign aid in terms of infrastructure, manpower and development, Africa has depended on other nations of the world. This is in line with the report by African Union (2020) that many African economies are closely interlinked with China, which also affect supply chains (African Union. It was revealed that an estimated 2million Chinese nationals live and work in

Africa. This gives much impetus for travel in both direction as people go to China for education, business and leisure while some Chinese come to Africa for work and business. This exchange has the potency to increase chances of disease outbreak and this necessitated the need to place travel restriction which was imposed after the outbreak of COVID-19. Prior to the outbreak, it was estimated that there were about eight flights a day operating between China and African cities (Hader *et al*, 2020a, b). This typifies the need to ensure rapid action like imposing restriction on travels especially international travels, rapid detection and monitoring for cases of COVID-19, prompt isolation and treatment of imported cases of COVID-19

Much more is the need to deal with subsequent local outbreaks of COVID-19 championed by Africa CDC, Nigeria CD, African Union, PANDORA-ID-NET and other research and training consortia. It is important to note that the only saving grace in times of outbreak of diseases such as COVID-19 is early detection and prompt treatment as there has not been any known vaccine to tackle the virus. The spread of the disease is geometric and once the infection starts, it might be difficult to stop it especially at community level. Going forward from this knowing, many countries in Africa introduced screening of arrivals for COVID-19 at the airports, seaports and border of their state and some isolated for a period of 14days to detect if someone has been infected with the virus. As a result of the decisiveness of African countries to deal with the covid-19 pandemic, the first public health emergency responders met in Senegal in early February 2020 to advance their knowledge of the disease and to also arm themselves with the recent advances on COVID-19 prevention, diagnosis and treatment (Corman *et al*, 2020). Various countries in Africa can now test for the disease and some countries have built isolation and quarantine centers to deal with the disease. Some of the countries are Nigeria, Kenya, Ethiopia, ivory coast, Ghana, Uganda, Botswana etc. This shows the preparedness of some countries in Africa and they have demonstrated such by carrying out laboratory tests and placing people in quarantine while laboratory tests were conducted.

A note on the Etiology and epidemiology of COVID-19

Diseases occur when there is deviation from the normal physiological functions with signs and symptoms. The concluding part of year 2019 came with series of pneumonia which emerged in Wuhan China (Lu, H.; Stratton, C.W.; Tang, Y.W., 2020). This was taken as a normal medical condition but few weeks into the new year, deeper sequencing analysis from the lower respiratory tract revealed a novel severe acute respiratory syndrome called Coronavirus 2 (SARS-CoV-2) which was the causative agent for the pneumonia previously discovered (Huang, C.; *et al*, 2020). The true nature of diseases might not be known until they are subjected to deeper test and this revealed the novel corona virus. As humans evolve and develop in knowledge, there are new challenges that arises with it and this might not be limited to various known and unknown diseases that are emerging and would still emerge with time.



Not only that but the realization that human life and survival must be made sacrosanct necessitates the drive for better health conditions for all especially in rural Africa which is characterized by poverty and poor health condition among the citizenry in the region. The director General of the World Health Organization Dr. Tedros Adhanom Ghebreyesus on February 11th 2020 named this new disease caused by SARS-CoV-2 as COVID-19. With the spread of the disease, it picked up pace and by March 11th 2020, the numbers of countries affected was 114 with more than 118000 cases and over 4000 deaths the World Health Organization (WHO) declared the disease a pandemic (WHO, 2020). Being a pandemic means the disease has become a matter of global concern and it is not limited to a geographical location. With the impetus for commerce, international exchange and trade, education etc., This necessitates the need for movement of people, goods and properties across various geographical divides which aided the spread of the disease globally. With the increasing knowledge of how the disease spreads, various countries of the world made effort at reducing the spread by restricting local and international movements, banning congregating in groups, ensuring maintenance of safety conditions such as social distancing. It is important to note that with the enforcement of such regulation in some countries, the pace at which the disease spread was on an upward spiral.

According to Perlman, S *et al* (2009), corona virus disease 2019 (COVID-19) is a ribonucleic acid virus (RNA) which has the physical appearance of a crown when viewed under the microscope which is as a result of glycoprotein spikes on its envelope. The spikes on the envelope prompted the nomenclature corona. The coronavirus disease is not new and the family has been studied over time. The coronavirus has also been a significant global threat. Some of the cases of its occurrence was on November 2019 where the disease broke out with severe acute respiratory syndrome (SARS-CoV) in the Chinese province of Guangdong, also in September 2012 where the middle east respiratory syndrome (MERS)-CoV appeared (Lu, R *et al*, 2020). This typifies that there has been evidences of coronavirus in human existence over the years but COVID-19 was not previously discovered. Some scientists have thus opined that the disease is smart and with each day there is new revelation about the disease as it keeps evolving. With various symptoms which keeps changing on a daily basis, scientists are still discovering more about the disease. In terms of classification, there are four genera of COV and they are (i)alpha-coronavirus(α -CoV) (ii)beta-coronavirus(β -CoV) which was seen in bats and rodents (iii)coronavirus (delta-CoV) and (iv) Gamma-coronavirus(GammaCoV) which was probably present in aves(Perlman, S *et al*, 2009;Lu, R, 2020, Yin, Y, 2018). Understanding the origin of the disease has come with lots of controversies and some scientist opined that the disease has natural and zoonotic origin and the basis for this argument was that the disease has been by natural selection in an animal host before it became zoonotic and also natural selection in humans as a result of zoonotic transfer (Lu, R *et al*, 2020; Yin, Y *et al*, 2018). Zoonotic means the disease can be transferred from animals to humans. Symptoms of the disease varies and the disease in some instances has the capacity to mask itself and such patients are asymptomatic. Also, there are cases of extreme severity to fatality (Phan, T, 2020) in some patients. This has given more impetus to various researches on the disease

to understand more its clinical features, diagnosis, management and prevention. There are heavy investments across the countries of the world to have good understanding of the disease and huge financial commitment has been made into it across board.

With the epicenter of coronavirus being Wuhan China, the disease spread from China to some other countries. The first confirmed occurrence of coronavirus outside China was in Bangkok Thailand and this took place on 13th January 2020. (WHO, 2020b). As time began to pass, 67 territories outside mainland China had confirmed 8565 cases of COVID-19 with 132 deaths and this culminated in community transmission which took place in several countries worldwide. The number of confirmed cases of coronavirus has been on increase since then globally and it might be difficult to quantify the impact and damage it has caused and it is still causing at the moment. One thing to bear in mind is that there has been no general convention or global standard to follow in dealing with the disease and each country has relied on the strength of their health workers to deal with the disease. With this in mind, there are different methods of testing, quarantining, isolation and treatment which makes it difficult to calculate the total number of people affected by the disease. Some of the symptoms of the disease include fever, cough, Dyspnea, headache, sore throat, rhinorrhea etc.

Impetus of engineering for survival in rural Africa in the era of COVID-19

The era of COVID-19 came with its peculiarities and countries of the world took different steps to deal with it. Some enforced total lockdown, restricted international and local movement, banned congregation in large numbers. The onus was on people to survive and the avenues by which engineering education aided survival in Rural Africa will be considered. Engineering has great impact on health conditions in rural Africa and the era of COVID-19 brought with it various consequence on the health systems of people. Healthcare in rural Africa is at a turning point as a result of the various advances in engineering which has helped to ensure survival in the era of COVID-19. As a result of technology made possible by engineering, it has improved the effectiveness of health care services and access. To corroborate this point, a report by World Economic Forum (2020) revealed that Africans are designing mobile tech solution to help tackle the coronavirus pandemic. this is pivotal for survival and it can only be possible through engineering. Some of the tech tools are the online COVID-19 Triage tools created by Wellvis which helps users to self-assess their coronavirus risk category, South Africa WhatsApp service to run an interactive chat service about coronavirus. Understanding that there is no known cure currently for COVID-19 is key and various countries of the world depended on their knowledge and expertise to deal with the disease. Engineering through the provision of ventilators has helped in encouraging recovery of people that were exposed to the virus in rural Africa and this is a dimension in which engineering has proved vital for survival in rural Africa in the era of COVID-19.



To ensure survival in the era of COVID-19, there is the need to ensure that the consequences and impacts of COVID-19 in rural Africa are addressed and the Royal Academy of Engineering (2020) mobilized African entrepreneurs from its Africa prize and leaders in innovation fellowships programme to address this. With this at play, the project CARE (COVID-19 African Rapid Entrepreneurs) provided support to engineering entrepreneurs to produce and supply personal protective equipment that can be used in healthcare facilities in rural Africa. This encouraged buildup of skills, production, quality, supply and user support for users of the equipment's produced which are all necessary for survival in rural Africa. In rural Africa, there is a high social complex and people are closely knitted compared to other climes. With socialization starting from the family and progressing to the larger society, there is a close form of relationship in rural Africa. Also, with this is the realization that the essence of humanity is social relationship which must at all-time be strengthened. With the emergence of COVID-19 and the consequences that came with it, the actions taken by some countries in Africa had an effect on the social life of people. Sport activities stopped, some work stopped, some social hotspots were totally lockdown etc. with the numerous advantages embedded in engineering, people have continued to survive in the era of COVID-19. With unrestrained access to sport programs on television, and all form of telecast made possible by engineering, it has aided survival in the era of COVID-19. With economies taking a heavy toll from the effect of COVID-19, rural Africa is not left out. There has been series of economic consequences brought as a result of COVID-19. There has been clampdown on markets, closure of some nonessential workplaces, loss of jobs, reduced economic activity etc. To survive, there has been more impetus given to electronic marketing done through mobile devices and the internet. A report by WEF (2020) revealed that stay-at-home marketplace is gaining traction currently and for instance in Uganda, many people are using apps and websites to educate themselves about coronavirus and to help market sellers sell and deliver fruits and vegetables to customers. The use of several mobile money platforms such as the M-Pesa in East Africa has facilitated survival. People that are literate and capable to use such methods have leveraged on it for survival. Also, business owners and some workers through the apparatuses of technologies have been able to continue some of their businesses online. The various technologies brought about by engineering has helped to ensure survival in the era of COVID-19. To keep the economy running, there has been a change called the new normal in which people have to understand that there has been a shift in paradigm and people must respond swiftly to it by changing their methods. Engineering technologies in various ways have encouraged economic survival in the era of COVID-19. With education vital for national development, it has taken a backseat as a result of COVID-19. The closure of schools generally to ensure that movement be restricted has consequences for the educational sector in rural Africa. With kids denied access to education in the four walls of their academic environment, they have to rely on other means to be imparted with the knowledge they need to lead meaningful lives. A brief by the World Bank (2020) revealed that the organization is working with ministries of education in some countries to support their effort to utilize educational

technologies of all kinds for remote learning. Some parents and schools in rural Africa that are well to do have leveraged on the technologies embedded in engineering to encourage education and survival in the era of COVID-19. With access to various application necessary for virtual meetings and video conferencing like Zoom and Google meet, it has encouraged sharing of knowledge across various divides in Africa which is important for survival in the era of COVID-19. With this also is the availability of various massive open online courses (MOOCs) which has helped in imparting people with knowledge in the era of COVID-19. Religion is major in Africa and people their practice various forms of religion. With their religion is the appetite to gather in groups which was rendered impossible by the guidelines of some of the countries to prevent the spread of the virus. Churches, mosques and other religious houses were closed down as a result of COVID-19. This thereafter gave more impetus to virtual and online church where you can comfortably connect with any service from the comfort of your homes. This is corroborated by a report on Nduka Orjinmo (2020) for BBC News revealed that most churches have adapted to the changes brought about by the virus. And they have leveraged on engineering technologies. Engineering has been helpful in surviving this time as it encouraged access to all forms of religious worship. With the help of various platforms like YouTube, Facebook, Instagram, mxlr, twitter, the live features there has defined the conduct of religion and people have learned to embrace the new normal in religion which is not predicated on physical gathering. This has been possible by engineering and it has helped in survival during the era of COVID-19. With the hold on movement physically, there is a need to depend on other means and communication made possible by engineering has helped people to survive. Take for instance in the olden days, when there were no means of communication, how would people survive the lockdown and restricted movement, it would be herculean. Humans are wired to communicate and it is a strategy for survival. This has affected physical communication but the technologies in engineering has helped in shaping that narrative. Phone calls, mobile telephoning, video calls etc. are now available to people to communicate across various geographical divide.

III. FINDINGS AND DISCUSSION

Findings from the study revealed that engineering is a discipline with many potentialities and from the definition of the Royal Academy of Engineering, the various functionalities embedded in engineering were captured. Some of the many potentialities of engineering is to invent, design, build, maintain and improve structures, machines, devices, systems, materials and processes. This implies that engineering has the capability to ensure survival in critical times like this. It was also found out in the study that COVID-19 is not new and it has always been in existence but the new strain was not discovered until recently. Hence, the revelation that a novel severe acute respiratory syndrome called Coronavirus 2 (SARS-CoV-2) which was the causative agent for the pneumonia previously discovered



(Huang, C.; et al, 2020) was in the offing. With the strain of the disease not known previously, understanding the severity of COVID-19 was a bit difficult.

As the disease gained traction and it spread to some regions of the world, the director General of the World Health Organization Dr. Tedros Adhanom Ghebreyesus on February 11th 2020 named this new disease caused by SARS-CoV-2 as COVID-19. Apart from the nomenclature, the disease picked up pace and by March 11th 2020, the numbers of countries affected was 114 with more than 118000 cases and over 4000 deaths the World Health Organization (WHO) declared the disease a pandemic (WHO, 2020).

Findings from the study also revealed that the number of confirmed corona cases has been on the increase globally with various consequences on economies. There have been various consequences on the governance, economy, social, educational life of people globally. There are also fatalities and death of people globally. The study made the case for engineering being a panacea for survival in rural Africa in the era of COVID-19. Various avenues where engineering has proved pivotal for survival in the era of COVID-19 were considered in this study.

IV. CONCLUSION AND RECOMMENDATIONS

Engineering has been a discipline with many potentialities and this was captured in this study. The discipline is also dynamic as it is constantly evolving to create solution to many challenges of the world. The multidimensionality and multi-versatility of engineering has many applications in various fields including that are pivotal for human existence and survival. The search for survival is important for a better way of life and processes which is a dimension of engineering. Engineering has proved pivotal as a tool for survival in rural Africa in the era of COVID-19 and some dimensions in which engineering has been helpful for survival in rural Africa in the era of COVID-19 were considered. This study therefore recommends that there is a need for intensified effort on engineering in rural Africa to encourage survival.

REFERENCES

1. African Union: Impact of the Coronavirus COVID-19 on the African Economy. African Union. 2020; Accessed on April 22, 2020.
2. Corman VM, Landt O, Kaiser M, et al. Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. *Euro Surveill* 2020;25(January (3)), doi:http://dx. doi.org/10.2807/1560-7917.ES.2020.25.3.2000045.
3. Haider N, Yavlinsky A, Simons D, Osman AY, Ntoui F, Zumla A, et al. Passengers' destinations from China: low risk of novel coronavirus (2019-nCoV) transmission into Africa and South America. *Epidemiol Infect* 2020a;148:e41, doi:http://dx.doi.org/10.1017/S0950268820000424 Published 2020 February 26.
4. Hoffman SJ, Silverberg SL. Delays in global disease outbreak responses: lessons from H1N1, Ebola, and Zika. *Am J Public Health* 2018;108(3):329–33, doi:http://dx. doi.org/10.2105/AJPH.2017.304245.
5. <http://www.africacdc.org/Africa-centers-for-disease-control-and-prevention/>. [Accessed 17 February 2020].
6. <http://www.merriam-webster.com/dictionary/survival#h1>
7. <http://www.raeng.org.uk/publications/reports/assessing-the-economic-returns-of-engineering-rese>
8. Huang, C.; Wang, Y.; Li, Z.; Ren, L.; Zhao, J.; Hu, Y.; Zhang, L.; Fan, G.; Xu, J.; Gu, X.; et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020, 395, 497–506.

9. Ippolito G, Hui DS, Ntoui F, MAeurer M, Zumla A. 2020. Toning down the 2019-nCoV hype-and restoring hope. *Lancet Resp Med.* 8(3):230-1, doi: [http://dx.doi.org/10.1016/S2213-2600\(20\)30070-9](http://dx.doi.org/10.1016/S2213-2600(20)30070-9)
10. Largent EA. EBOLA and FDA: reviewing the response to the 2014 outbreak, to find lessons for the future. *J Law Biosci* 2016;3(3)489–537, doi:http://dx.doi.org/ 10.1093/jlb/lsw046 [published 2016 September 16].
11. Li Q, Guan X, Wu P, et al. 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med.* Doi:http://dx.doi.org/10.1056/NEJMoa2001316
12. Lu, H.; Stratton, C.W.; Tang, Y.W. Outbreak of pneumonia of unknown etiology in Wuhan, China: The mystery and the miracle. *J. Med. Virol.* 2020, 92, 401–402.
13. Lu, R.; Zhao, X.; Li, J.; Niu, P.; Yang, B.; Wu, H.; Wang, W.; Song, H.; Huang, B.; Zhu, N.; et al. Genomic characterization and epidemiology of 2019 novel coronavirus: Implications for virus origins and receptor binding. *Lancet* 2020, 395, 565–574.
14. Matthews, P., Ryan-Collins, L., Wells, J., Sillem, H. and Wright, H. (2012). *Engineers for Africa: Identifying engineering capacity needs in sub-Saharan Africa*. Royal Academy of Engineering, Africa-United Kingdom Engineering for Development Partnership.
15. [ncov.pdf](https://www.raeng.org.uk/policy/engineering-response-COVID-19-coronavirus/project-care) (accessed on 25 March 2020).
16. Nduka Orjinmo. 2020. Coronavirus: Nigeria's mega churches adjust to empty auditoriums <https://www.bbc.com/news/world-africa-52189785>
17. Nigeria CDC 2020. <https://ncdc.gov.ng/ncdc>. [Accessed 18 February 2020].
18. Perlman, S.; Netland, J. Coronaviruses post-SARS: Update on replication and pathogenesis. *Nat. Rev. Microbiol.* 2009, 7, 439–450.
19. Phan, T. Novel coronavirus: From discovery to clinical diagnostics. *Infect. Genet. Evol.* 2020, 79.
20. *Respirology* 2018,23, 130–137
21. Royal Academy of Engineering. 2020. Project CARE (COVID-19 AFRICAN Rapid Entrepreneurs) <https://www.raeng.org.uk/policy/engineering-response-COVID-19-coronavirus/project-care>
22. Talisuna AO, Okiro EA, Yahaya AA, et al. Spatial and temporal distribution of infectious disease epidemics, disasters and other potential public health emergencies in the World Health Organisation Africa region, 2016-2018. *Global Health* 2020;16(1)9, doi:http://dx.doi.org/10.1186/s12992-019-0540-4 [published 2020 January 15]
23. WHO. Ebola virus disease. 2020. <https://www.afro.who.int/health-topics/ebola-virus-disease>.
24. WHO. WHO African Region: JEE mission reports. 2020. <https://www.who.int/ihr/procedures/mission-reports-africa/en/>.
25. World Bank. 2020. How countries are using edtech (including online learning, radio, television, texting) to support access to remote learning during the COVID-19 pandemic. <https://www.worldbank.org/en/topic/edutech/brief/how-countries-are-using-edtech-to-support-remote-learning-during-the-COVID-19-pandemic>
26. World Economic Forum. 2020. Here's how Africans are using tech to combat the coronavirus pandemic. <https://www.weforum.org/agenda/2020/04/africa-technology-coronavirus-covid19-innovation-mobile-tech-pandemic>
27. World Health Organization Director-General's Opening Remarks at the Media Briefing on COVID-19—11 March 2020. Available online: <https://www.who.int/dg/speeches/detail/who-director-general-s-openingremarks-at-the-media-briefing-on-COVID-19---11-march-2020>
28. World Health Organization Novel Coronavirus (2019-nCoV), Situation Report 1. 21 January 2020. Available online: <https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200121-sitrep-1-2019->
30. Yin, Y.; Wunderink, R.G. MERS, SARS and other coronaviruses as causes of pneumonia.

