



Coping with COVID-19 in Sub-Saharan Africa: What Might the Future Hold?

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The African COVID-19 Scenario

On December 31st, 2019 an unexplained case of pneumonia was reported in Wuhan, Hubei Province, China (Zhou *et al.* 2020). On January 9th, 2020, Chinese authorities and the World Health Organization (WHO) officially announced the discovery of a new type of coronavirus called SARS-CoV-2 that causes the coronavirus disease 2019 (COVID-19) (Shereen *et al.* 2020; WHO 2020j; Zhou *et al.* 2020). A few months later, the virus is sweeping the world with almost 18 million recorded global cases and 709,000 deaths as of August 7th 2020 (WHO 2020a). After China, Europe and United States, South America is currently the new epicenter of the pandemic, but the situation is worsening in India, and the pandemic is moving fast. Nevertheless, confronted by the disastrous socio-economic consequences of the epidemic, a number of countries have already started a progressive end to the lockdown. Africa confirmed its first case of COVID-19 in Egypt on February 14th. On February 27th, Nigeria reported the first official case of SARS-CoV-2 in the sub-Saharan area, and on March 18th Burkina Faso the first death. On August 7th 2020 this number has risen to more than 1,000,000 cases and caused about 22,000 deaths in Africa according to the Africa Centers for Disease Control and Prevention (Africa CDC) (Africa CDC 2020a). Southern and Northern Africa have currently the highest number of official cases and deaths, but Western Africa is the most impacted by the death toll in sub-Saharan zone, followed by Eastern and Central Africa. However, these

numbers are probably undervalued and could represent only the “tip of the iceberg”. According to the WHO, the highest mortality rates for COVID-19 were observed in the Republic of Chad (8.5%), Niger (6.2%), Algeria (5.7%), Angola (5.4%), Burkina Faso (5.3%), Mali (5.1%) and Liberia (4.5%). On July 8th 2020, South Africa, Nigeria, Algeria and Cameroon accounted for 75% of the total official deaths reported in Africa.

Picturing the Sub-Saharan Health Situation

Sub-Saharan Africa is home to nearly 60% of the world’s population living in extreme poverty (The World Bank 2018; The World Bank 2020c). Despite a significant improvement over the last 10 years, too little is yet known about the health situation in Africa. It is, however, the continent with the poorest resourced health, the highest mortality rates and also the highest number of deaths due to infectious diseases. With variations between countries, lower respiratory infections, diarrheal diseases, malaria, HIV/AIDS, meningitis and tuberculosis are among the principal causes of death (El Bcheraoui *et al.* 2020; United Nations 2020a). Moreover, sub-Saharan African zones have become the epicenter of major infectious disease outbreaks during the last decade (Cholera, Ebola, Measles, Yellow Fever) (Fenollar and Mediannikov 2018; Mboussou *et al.* 2019), which are considerable burden on the economy and public health (Jones *et al.* 2008).

The Example of the Republic of Chad

As an example, the republic of Chad is a landlocked nation located in the heart of sub-Saharan central Africa, with a population of 16 million (Worldometer 2020). In common with most of the sub-Saharan countries, the Republic of Chad is linked to poor indicators, such as high poverty and mortality rate, heavy disease burden, insufficient epidemiologic surveillance and poorly developed infrastructure (WHO 2020k). The health system is understaffed,

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fragmented, underfunded and poorly coordinated (Azétop and Ochieng 2015; Deaton and Tortora 2015). Infant mortality rate is higher than 7% and under-five mortality rate is close to 12% (United Nations 2020a). According to the Yearbook of Health Statistics of Chad, the country has an average of 4.5 doctors, 27 nurses and midwives per 100,000 inhabitants with poor geographical distribution of health workers, mainly focused in the region of N'Djamena (OCHA 2020c). HIV/AIDS prevalence rate among the Chadian population is estimated at 1.6%. The life expectancy at birth, both sexes combined, is around 54 years (The World Bank 2020a). Living conditions are often unsanitary and the state of sanitation is deteriorating. Garbage and wastewater disposal are almost nonexistent and access to clean water remains limited (Roche *et al.* 2017; Armah *et al.* 2018).

What Could COVID-19 Have in Store for Africa?

Answering this question is of course not straightforward, as Africa is still facing unique challenges. Despite some variations between cultures, economies and infrastructures of the different countries, some comparisons provide a tentative picture. Looking at the daily increase in the number of people testing positive for COVID-19 worldwide, it appears that Africa is overlooking the spread better than Europe, the United States or South America so far. Disaster scenarios speculating about the devastating effect of COVID-19 in Africa have fortunately not materialized, at least not for the time being. The reasons for such a situation are multiple and not always clearly established (Payne 2020). The epidemic reached Africa a few weeks after Europe, allowing its leaders to adopt preventive measures well in advance. It also has been suggested that unlike most Western countries, many parts of Africa remain isolated, with low tourism and international air traffic, thus limiting population migration and the circulation of the virus. Africa does, however, have massive trading interactions with Asia and between bordering countries. Also, sub-Saharan countries have probably learnt important lesson from previous major epidemics, especially the Ebola outbreak of 2014 in western Africa. Experience gained has probably facilitated the installation of ad hoc measures against this new outbreak. Awareness was faster in Africa in comparison to Europe and America, probably because from an African perspective the COVID-19 is just another sanitary crisis.

Experiences in Asia and Europe have shown that people over 60 years of age and those with significant health problems are most exposed to severe and fatal cases of COVID-19. A recent study from the UK, exploiting very large datasets, showed that patients older than 80 years old

had a more than 12-fold increased risk of fatality compared with those aged 50–59 years (Williamson *et al.* 2020). By contrast, pediatric population is relatively spared by the disease and Africa's population is very young. More than 40% of the African population is under 15 years old and the median age of the continent is around 20 years. In comparison, the median age is 38.2, 38.4 and 43.1 years old in United States, China and Europe respectively. People over 65 years of age represent only 3.5% of the African population in comparison to 20% in Europe (WHO 2020i). The median age in the republic of Chad is only 16.6 years (United Nations 2020b; Worldometer 2020). Reasons why young people and children are rarely developing severe forms of the disease are still unknown. The immune systems of children and adults are different in terms of composition and functional reactivity and evolve throughout life (Simon *et al.* 2015). One possibility is that other airway pathogens which are frequent in children, could limit the growth of SARS-CoV-2 by direct virus-to-virus interactions and competition (Brodin 2020). Another lead is thought to be related to the difference in angiotensin converting enzyme (ACE) 2 receptor expressions in respiratory tissues, necessary for SARS-CoV-2 infection of cells (Dalan *et al.* 2020). However, to a lesser extent, children and youth may still develop complications, or severe forms of the disease, requiring intensive care and do transmit COVID-19 to adults (Tezer and Bedir Demirdağ 2020). Therefore, if only age is taken into consideration, African demographics suggest less exposure to the development of severe forms of COVID-19, but unfortunately the equation is not that simple. Infectious burden, malnutrition, social behaviors, genetic background, and health system have also to be taken in consideration. It is mostly the quality of health systems that defines generally both the socio-economic and the death tolls on a country faced with an epidemic of this magnitude. The use of the State Party Self-Assessment Annual Reporting score (SPAR), a metric of infrastructure and preparedness to handle health emergencies, as well as modeling studies showed that sub-Saharan countries are particularly vulnerable to the epidemic (Gilbert *et al.* 2020; WHO 2020f). Today, for an ever-increasing number of African countries, the virus is taking roots, rising and the epidemic is stretching already very fragile health systems (Africa CDC 2020c; Martinez-Alvarez *et al.* 2020; WHO 2020d).

Getting Ready For the Epidemic with the Means at Hand

Responding to emergency calls from international health organizations and due to a certain habit of epidemic emergencies, the response of sub-Saharan countries has

been relatively fast in the face of the COVID-19 threat. From the appearance of the first case, strict control measures were taken at airports. Massive public awareness campaigns on barrier gestures were launched, borders closed, containment and curfew enforced to the population. Also, in preparation for the inevitable importation of COVID-19 to Africa, the Africa CDC established the Africa Task Force for COVID-19 (Africa CDC 2020b). The Africa Task Force for COVID-19 was created to reinforce: laboratory diagnosis, surveillance, prevention and control of infections in health care facilities, clinical management of people with severe COVID-19, risk communication, community engagement and supply-chain management and stockpiles. Despite true efforts made by governments from sub-Saharan countries, there are still major gaps in the implementation of the resources and surveillance effort (Paintsil 2020).

How Is the COVID-19 Epidemic Situation at the Republic of Chad on August 7th 2020?

While some countries are starting to exit containment, SARS-CoV-2 is still gaining ground in sub-Saharan countries, fortunately slower than expected. On March 1st 2020, although not yet affected by the virus, the Chadian government developed a National contingency plan for preparedness and response to the COVID-19 epidemic (OCHA 2020a). The plan is developed over a period of 12 months (from 1 March 2020 to 28 February 2021), and could be readapted according to the real evolution of the epidemiological situation, for a total budget of more than 15 billion FCFA (23 million EUR). According to the Chadian authorities themselves, due to weaknesses of the structural and organizational system of basic health facilities, there is a real risk of the epidemic spreading. Consequently, several measures of protection were rapidly taken by the authorities. On March 19th 2020, the first case of COVID-19 was reported and, for the next month, the country appeared to be relatively unaffected by the virus, with only a few, non-fatal cases of COVID-19 reported for weeks. Suddenly, on April 28th, the Republic of Chad showed a spring in the number of cases, registering 52 cases, also mourning his first two deaths. A week later, 170 cases were reported with 17 deaths. By June 4th, with less than 2800 tests performed, 803 cases of COVID-19 and 66 deaths were officially reported (Africa CDC 2020a). Similarly, across the country, there has been a dramatic increase in the number of hospital and community deaths, often with only a suspicion of COVID-19. With a single mobile diagnostic laboratory in function, provided by the Ministry of Health and WHO, only the “*provincial hospital of Farcha*” of N’Djamena was at the beginning of the epidemic authorized to test for COVID-19. All suspicious

cases had to be referred to this single health center designated by the state. The capacity of this hospital is 118 beds, extensible up to 140 beds, but with only 10 rooms to take in infected patients. The situation was alarming, because numbers of staff at this hospital have already been contaminated. Since the beginning of May, the “*Renaissance*” Hospital of N’Djamena is also authorized to take in infected patients and is in charge of the most severe cases. The “*Renaissance*” hospital is under the supervision of the Ministry of Public Health of Chad, but is managed by a private company. Nowadays only those with severe forms of the disease are admitted to the hospital and many COVID-19 infections are diagnosed late or post mortem. At the beginning of May 2020, national statistics on COVID-19 worried and accentuate the public’s fears. Health authorities were overwhelmed and the country was not ready for what is likely to be a potentially long and difficult fight. But without widespread testing, it is difficult to measure the magnitude of the pandemic. Consequently, those numbers are probably not reflecting the reality of the situation, but do reveal that the virus is installing itself in the Republic of Chad. In view of the worsening situation, the government reacted firmly to the health emergency by strengthening measures already in place, urging the population to observe the barrier measures in order to interrupt the chain of contamination. N’Djamena and 22 other towns were isolated. On May 8th, the strict curfew was extended in the capital and the main cities of the country. Wearing masks became mandatory in public places and the confinement of populations was imposed. But recently, the burden of COVID-19 on the Chadian economy, particularly on the informal sector, has led the government to ease restrictive measures. In particular, the reopening of bars and restaurants has been authorized for take-away purchases, as well as the circulation of minibuses, which can take up to 10 passengers. Physical contact is unavoidable in this type of transport. Fortunately, health measures taken appear to have been effective. The COVID-19 situation at the beginning of July seems to be improving in the Republic of Chad, at least as far as N’Djamena is concerned, with a sharp decline in the number of new cases officially detected in recent weeks. On August 7th, 2020, 942 cases of COVID-19 and 76 deaths were reported, but only 7743 tests were performed since the beginning of the pandemic. However, the rate of spread of the coronavirus is accelerating worldwide and many countries are stepping up health measures after a slackening in recent weeks.

What Are the Factors That Could Tip the Balance One-Way or the Other?

The Infectious Burden of the Population

Regardless of how quickly the disease spreads, the impact of COVID-19 on patients in Africa will be mitigated by some unique factors and amplified by others. If the age pyramid of African societies is a positive element, we must put this into perspective by pointing out that populations in sub-Saharan countries are often affected by undernourishment, dietary deficiency and high-burden infectious diseases such as AIDS, malaria or tuberculosis. As the COVID-19 outbreak advances, governments are warning individuals at high risk. In sub-Saharan Africa, HIV is one of the leading causes of morbidity at young and adult ages, often in dual infection with tuberculosis (Collaborators 2018). Since no country with a high prevalence of HIV is currently experiencing advanced stages of the COVID-19 outbreak, it is yet difficult to affirm that HIV infection is a comorbid factor for COVID-19. At present there is no evidence to suggest an increased risk of infection or severity of illness for people living with HIV under antiretroviral therapy (ART) compared to the general population (WHO 2020h). However, people with HIV may also be at increased risk of developing severe COVID-19 depending on their general health status. Most HIV deaths in sub-Saharan countries are due to co-infections with other diseases, and individuals living with HIV also have a greater risk of dying from influenza infection or developing a range of non-communicable diseases such as hypertension and cardiovascular disease (Nepomuceno 2020). For example, the Chadian “*Bon Samaritain*” hospital, located in Walia, one of N’Djamena’s poorest neighbourhoods, had a cohort of 2400 HIV-infected patients in January 2020. Among these patients, only 1800 are currently clinically followed in the hospital and treated with ART, meaning that 25% of them are untreated or lost to follow-up. Thus, particular attention must be given to young individuals living with HIV in low income countries, high infectious burden and fragile health systems, as they may be a group at risk that is more vulnerable to SARS-CoV-2 (Adepoju 2020; Shiau *et al.* 2020).

Tuberculosis is the world’s leading infectious cause of death. Latest estimations suggested that about a third of the world’s population is infected with *Mycobacterium tuberculosis* (Gong *et al.* 2018; WHO 2020g). According to the WHO, over 25% of tuberculosis deaths occur in the African region and are often driven by HIV coinfection, with a clear impact on mortality. COVID-19 and tuberculosis are very different diseases, but both attack the lungs and are associated with respiratory disorders (Wingfield *et al.*

2020). Moreover, for both diseases, advanced age and comorbidities, such as hypertension, diabetes and coronary heart disease, are major risk factors to poor outcomes (WHO 2019). Also, immune status that makes people with HIV vulnerable to tuberculosis could also make them susceptible to SARS-CoV-2 infection (Yadav *et al.* 2020). Despite multiple uncertainties that will hopefully dissipate over the next few months, especially concerning how SARS-CoV-2 will infect people with tuberculosis or vice versa, the HIV-Tuberculosis-COVID-19 infectious triangle does not currently inspire an optimistic prognosis for sub-Saharan populations.

Another alarming and misidentified infectious event is the current measles outbreak. In spite of an important decline in the last 30 years, measles is now gaining ground worldwide, especially in sub-Saharan countries. According to the WHO and the CDC, large measles outbreaks are being reported in the Republic of Chad, Guinea, Nigeria, Madagascar and particularly the Democratic Republic of Congo (DRC) where the virus has killed more than 6500 people in 2019. As of 30 April 2020, the Ministry of Public Health from the republic of Chad reported 7635 suspected cases (OCHA 2020b). The measles virus is highly contagious and associated with a high mortality rate, especially in poor countries, mainly due to malnutrition. Possible complications include encephalitis, pneumonia, severe diarrhea and dehydration. Survivors can be left with permanent disabilities (Roberts 2020). The virus also causes a transient immune suppression, leading to increased susceptibility to opportunistic infections. SARS-CoV-2 infection also appears to induce major immunomodulation in the host, including dysregulation of type-1 IFN production, lymphopenia, neutropenia, modulation of the cytokine production or adaptive T cells activation/orientation (Qin *et al.* 2020; Saghadzadeh and Rezaei 2020). From the immunologist’s point of view, uncertainties about the relationship between measles, COVID-19 and the host immune response make the situation worrisome, especially among pediatric populations in low incomes countries.

A Potential Influence of Host Genetic Variation?

The genetic diversity of the world’s human population is considerable, largely due to geographical differences in allele frequencies. Immune systems of individuals can respond differently to a natural infection or therapeutic treatment, such vaccines. Growing data have shown that African and European populations have genetically different immune systems. The magnitude of the immune response in Africans and Europeans differs, particularly for genes involved in inflammatory and antiviral responses. These variations can be attributed to the lifestyle, environment and infectious burden, but also to genetic variants,

which modulate the expression of immunity genes (Quach *et al.* 2016). The immune response to an aggression or a stress is highly complex. An inadequate immune response can increase susceptibility to infectious, inflammatory or autoimmune diseases or influence the way we respond to vaccines (Brinkworth and Barreiro 2014; Çalışkan *et al.* 2015; Zimmermann and Curtis 2019). Consequently, clinical manifestations may vary considerably between individuals, ethnic groups and populations. Previous research has shown that HLA polymorphism is associated to genetic susceptibility to SARS infection (Xi and Yongzhi 2013). Thus, many interrogations remain on how the virus will spread in sub-Saharan sub populations according to their genetics specificities. A recent study has shown that individuals from Asian and Black groups have a significantly higher risk of dying in hospital due to COVID-19, and contrary to some earlier speculation, this was only partially attributable to pre-existing clinical risk factors or deprivation (Williamson *et al.* 2020).

The Complicated Situation of the Tail-Eating Snake

Losing Ground on Old Infectious Battles

From an African perspective, SARS-CoV-2 could be seen just as an additional threat on top of the many other challenges that have plagued the continent for generations. COVID-19 will also inflict on Africa unique health difficulties by hampering the efforts to combat recurrent infectious diseases that have been launched for many years by international health organizations and governments. Previous outbreaks have been found to have severely disrupted health services and had a significant impact on local populations. For example, the 2014 outbreak of Ebola virus hampered malaria control efforts and led to a sharp increase in malaria morbidity and mortality in east Africa (Walker *et al.* 2015). Thus, national and international funding for HIV, tuberculosis, measles and malaria control are likely to decrease sharply due to unplanned spending on the fight against COVID-19, as well as the new budgetary priorities expected by rich countries and international health organizations, which generally support vulnerable populations. Fear of this unknown virus will most likely also lead some local staff to withdraw from health programs. Prevention services and field trials are likely to be disrupted or even interrupted. The WHO estimated that the number of malaria deaths in sub-Saharan Africa could double this year if access to insecticide-treated nets and anti-malarial drugs is severely disrupted by the COVID-19 pandemic (WHO 2020). Access to ART could also be key to improving the immune response against COVID-19 for

HIV infected people (Shiau *et al.* 2020). Currently, more than 20 countries have already suspended measles vaccination campaigns, including the Republic of Chad, where measles cases are on the rise amid COVID-19 fears, or because health workers struggle to fight the SARS-CoV-2. Pathogens are killing at least one million people each year in sub-Saharan Africa, and the COVID-19 epidemic could indirectly increase this number significantly by disrupting essential day-to-day health efforts (Africa WHO 2020).

A Social Impact That Can Lead to Harmful Behavior

International health organizations and experts emphasize that these infectious diseases also have a considerable social impact, including stigma, discrimination and isolation (Des Jarlais *et al.* 2006). The COVID-19 pandemic has also resulted in social stigmatization and discriminatory behavior against people of certain ethnic backgrounds as well as anyone perceived to have been in contact with the virus. The harms of infectious disease stigmatization are significant, and there are no public health benefits. Stigma can change the environment in which pathogens evolve, making them even more problematic (Smith and Hughes 2014). Thus, stigma could contribute to a situation where the virus is more likely to spread by pushing people to hide the disease, impacting access to early health care and safety behaviors (Stangl and Grossman 2013; WHO & UNICEF 2020). This situation can be particularly disastrous in low-income countries where part of the population has a low level of education, is ill-informed and is more likely to turn to local beliefs and customs that may be dangerous for the evolution of the epidemic.

Damaging Local Beliefs and Incomprehension on Legitimate Questions on COVID-19

The perception of the COVID-19 epidemic can vary considerably depending on countries, populations and a very large number of factors, such as religion, ethnicity, beliefs, education, socio-cultural level and social environment. Misunderstanding and mistrust can prevail when populations are faced with a new epidemic about which little is known. However, conspiracy theories and fake news that are developing around the epidemic worldwide are of concern and may encourage anxiety, stress, risk behaviors and consequently the spread of the virus. People's legitimate questions sometimes find dubious answers on social networks. This phenomenon has become so widespread throughout the world that the WHO has decided to launch a plan to combat misinformation and has published an article entitled "*Putting an end to preconceived ideas*". This report examines a whole series of unfounded or even

totally false and dangerous rumors about COVID-19 (WHO 2020b). Without being isolated cases, unfounded rumors are a reality worldwide, and sub-Saharan Africa is not spared, because beliefs are strong and persistent and access to information and knowledge is sometimes difficult to reach for the majority of the population. Local beliefs on such a serious subject can be harmful, and misinformation through social media might have also a devastating impact (Střížová *et al.* 2020). In Africa, until recently, it was common to hear that COVID-19 is a “white man’s disease” or a tool of a “political war” between the major powers. In that matter, an African proverb says “When elephants are fighting, it is the ants that suffer”. The epidemic was also often perceived as a “myth”, but seeing the first victims and the recent dramatic increase in the number of deaths due to the virus, the perception of the disease began to change. At the “Bon Samaritain” hospital, there has been finally a shift from denial to acceptance of the reality of this disease. It has unfortunately been considered a fable for a long time by a large part of the population. This view has prevented adherence to control and prevention measures, including barrier measures. As an example, at the “Bon Samaritain” hospital, there is only 3 oxygen extractors, 3 pulse oximeters, no safety suit, a defective electrocardiogram, an extremely limited stock of antibiotics, no anticoagulants, and for the moment no possibility of SARS-CoV-2 screening. Fortunately, solidarity actions have also been implemented by local organizations trying to get involved in the fight against this new epidemic, but most of the time with insufficient means. Traditional healers are preparing “remedies” against COVID-19 from local plants that are commonly used by the population. “In a time of crisis everyone is trying to come up with something as a solution” says one of our testimony on-the-spot. Chadian populations also take very seriously the artemisia-based “cure” called “Covid-organics”, promoted by Madagascar’s authorities that could protect against the SARS-CoV-2. Though, the WHO affirms that there is currently no scientific evidence at this time that this “remedy” can prevent or cure COVID-19. In addition, the WHO recently announced that it would help Madagascar test *Covid-Organics* herbal tea, but has not approved it. Despite the enormous and global controversy over the use of hydroxychloroquine that has lasted for months, and against the WHO recommendations, many African countries are still refusing to abandon hydroxychloroquine or chloroquine for the treatment of COVID-19. Since the beginning of the epidemic, people infected with COVID-19 in the Republic of Chad are treated with chloroquine and azithromycin. In addition to the elements that call into question the therapeutic use of this drug for the treatment of COVID-19, there is also the very real threat of self-medication and the risk of the use of counterfeit drugs that

are already flooding markets in Africa. Nevertheless, part of the African population feels powerless and sometimes extremely desperate, forcing them to make decisions more often based on beliefs or superstitions than on scientific observations. Boasting non approved preventive product against COVID-19 that might be ineffective could make people believe that they don’t need to comply with the other measures. Nevertheless, sub-Saharan populations are generally disciplined and try to respect as much as possible the health safety instructions imposed by the authorities. But in Africa, rules that should be applied are often confronted with the realities of life. Among these realities, the African populations cannot face the epidemic with the same resources, measures or methods as the major world powers, which today show their difficulties and weaknesses despite their significant financial and material resources. Sub-Saharan countries must find their own strategies to control and limit the epidemic that seems to persist.

What Could Possibly Be the Solutions?

Answering that question seems presumptuous. Still, sub-Saharan African populations are once again suffering, and probably much more than others, who might be more impacted by the epidemic but are also better protected. Sub-Saharan countries must integrate the dimensions linked to the socio-economic and, above all, cultural realities of their populations. While Africa has so far avoided the worst-case scenarios, socio-economic studies project that poor and vulnerable populations could bear a greater burden of COVID-19 in the long-term scale. For certain, sub-Saharan countries must take appropriate sanitary measures that they will be able to manage during the next few months or years.

Adapting and Strengthening Diagnostic Strategies

The control of COVID-19 relies primarily on a country’s public health capacity, i.e. its ability to detect, prevent, control and treat cases. Diagnostic tests for COVID-19 have become a key weapon to contain, track and eventually stop the current SARS-CoV-2 pandemic (OECD 2020). Because “we cannot fight a fire with our eyes blindfolded” the WHO has called for countries to “test any suspected case”. However, if high-quality diagnostic technologies are available for SARS-CoV-2 in most developed countries, they are neither accessible nor affordable in sub-Saharan countries. Today, most sub-Saharan countries are apparently able to test for COVID-19, but kits are scarce, infrastructure is inadequate and surveillance and communications are limited, making it extremely difficult to truly

assess the magnitude of the epidemic using a diagnosis-based strategy (Chersich *et al.* 2020). Accordingly, diagnosis should be reinforced in sub-Saharan countries. Therefore, the WHO and CDC are encouraging increasing access to diagnostics through technology transfer and local production (CDC 2020c; WHO 2020e). But the real question is whether medical facilities, local authorities, international health organizations and funding agencies will be equal to the task and able to implement effective COVID-19 diagnostic strategies for months to come. Being pragmatic, if international health organizations are strongly recommending COVID-19 diagnosis with a combination of strategies (molecular and serological), sub-Saharan countries will be in critical need of a rapid, affordable and as reliable as possible, COVID-19 diagnosis strategy that is in ad equation with the socioeconomic reality of the country.

More Pragmatic and Better Adapted Solutions

What solutions would be best adapted to the realities of the socioeconomic situation in sub-Saharan countries? The COVID-19 pandemic is testing the limits of societies and economies across the world. Many African countries have implemented containment measures to stop the spread of SARS-CoV-2. These measures appear to have been relatively effective for the time being. Among these, a strict lockdown and curfew have been imposed. However, infectious diseases develop differently in different communities, depending on social conditions and customs. If the famous statement “*the cure will be worse than the disease*” is definitely debatable in high-income countries where populations are relatively protected and where life is literally not threatened by “*the cure*”, this sentence takes on a more realistic meaning in sub-Saharan countries. In addition to harsh living conditions, large families are confined to a limited living space under extreme temperatures. In Africa, people are frequently living from “*day to day*”, with no projection of “*tomorrow*”. Thus containment poses real problems of survival for these populations. Yet, Governments across the world have agreed that protecting lives is more important than protecting profit. Moreover, health measures are only effective if the overwhelming majority of the population agrees with them and is fully involved in their planning and implementation. People must be first informed, and then act to protect themselves with guidance and full support of the authorities and health agencies. Of course, we must control the spread of the virus by limiting population migration and contact between people, but locking down sub-Saharan populations for too long will probably kill more than the virus.

Lower the R_0 by All Available Means

In humans, virus transmission occurs by close contact with an infected person, exposition to coughing, sneezing, respiratory droplets or aerosols that penetrate the human body via inhalation. Because no antiviral treatment or vaccine against SARS-CoV-2 has yet been found with proven efficacy, the use of protecting face masks has become ubiquitous worldwide and has become the center of great protection debates. As a result, the WHO and CDC decided to make a guideline to when and how to use masks (CDC 2020a; WHO 2020c). The WHO currently recommends that people should wear face masks if they have respiratory symptoms or if they are caring for somebody with symptoms, but consideration should also be given to variations in societal and cultural paradigms of mask usage (Feng *et al.* 2020). Many studies indicated that properly fitted surgical face masks could prevent transmission of human coronaviruses or influenza viruses from symptomatic individuals and curb the pandemic (Saunders-Hastings *et al.* 2017; Leung *et al.* 2020). Used properly, chirurgical and N95/FFP2/3 professional protection mask are undoubtedly the best choice to protect against contaminating aerosols projections, but they are also currently expensive and were dramatically hard to procure until recently. And yet, the R_0 (virus transmission rate) must be further reduced in sub-Saharan countries. Homemade masks could be part of the solution by helping to curb COVID-19 epidemic in low-income populations where the containment will be virtually impossible to apply. In this context, the CDC recommends wearing cloth face coverings in public settings where social distancing measures are difficult to maintain, especially in areas of significant community-based transmission (CDC 2020b). The fact is that any type of mask is effective only when used in conjunction with other preventative measures such as frequent hand-cleaning, but also knowledge of how to use it and how to dispose of it properly (van der Sande *et al.* 2008). A protective mask may reduce likelihood of infection, but will not eliminate the risk. Local authorities and agencies must supervise locally proper production of protecting homemade masks and insure their distribution to identified at-risks sub populations. Protective masks must be made by the local community according to CDC recommendations and useful information from the scientific literature (Davies *et al.* 2013). African communities are afraid of the pandemic, but they also need to survive from day to day and should not have to choose between hunger and contamination.

What Might the Future Hold After the COVID-19 Storm?

Once again, many uncertainties still remain and it is difficult to predict with certainty the trajectory of the epidemic in Africa. In addition to the health crisis, there is also a global economic crisis, the consequences of which might be even more severe in sub-Saharan countries (Ataguba 2020). To this gloomy picture, are added real threats of drought and insecurity, because any country exposed to poverty or conflict will always be more vulnerable to natural disasters (The World Bank 2020b). Like the rest of the world, sub-Saharan populations are waiting for a final efficient solution, such as a cure or a vaccine (Thanh Le *et al.* 2020). With the expectation that future vaccines will be available to all, there is likely to be a strong mistrust of vaccines in Africa and a need to rebuild collective confidence. Concerning the cure for COVID-19, we are clearly in an almost delirious situation never encountered before. Shortcuts and methods used to communicate unofficially proven facts can be dangerous, dividing populations, contributing to create a climate of suspicion and fear, thus promoting the spread of the virus. Nevertheless, we hope that the “cure” will remain affordable for Africa. In a war of prices and out-bidding strategies on the battlefield of global epidemic, African sub-Saharan countries have very little chance to pull through.

Hoping For the Best and Preparing for the Worst

The COVID-19 issue in sub-Saharan countries is a very complicated equation that takes into account many unknown parameters but also factors that are specific to the sub-Saharan regions. These factors were often ignored or underestimated and must now be taken into consideration by leaders on the front line and the decision-maker countries. We believe that one of the major threats that sub-Saharan populations are facing during this COVID-19 pandemic is once again Western indifference. We hope for a surge of international solidarity, and a change in attitude towards Africa, which represents 16.72% of the world's population and faces greater difficulties than most other countries. In Dr. Paintsil's excellent “*Viewpoint*” on COVID-19 in sub-Saharan countries published at the end of March in JCI (Paintsil 2020), the situation was metaphorically referred as “*the crocodile's eye*”. The crocodile's eyes and body represented public health preparedness and health systems, respectively. We personally prefer to return the metaphor to the “*eye of the*

hippopotamus” often seen on the Chari River from the compound of the “*Bon Samaritain*” hospital in N'Djamena, hoping that the “*body of the hippopotamus*” will be better able to absorb the influx of COVID-19 patients that still could come in sub-Saharan African zone.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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