Review

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Laboratory diagnosis of COVID-19 in Africa: availability, challenges and implications

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SUMMARY The COVID-19 infection has been a matter of urgency to tackle around the world today, there exist 200 countries around the world and 54 countries in Africa that the COVID-19 infection cases have been confirmed. This situation prompted us to look into the challenges African laboratories are facing in the diagnosis of novel COVID-19 infection. A limited supply of essential laboratory equipment and test kits are some of the challenges faced in combatting the novel virus in Africa. Also, there is inadequate skilled personnel, which might pose a significant danger in case there is a surge in COVID-19 infection cases. The choice of diagnostic method in Africa is limited as there are only two available diagnostic methods being used out of the six methods used globally, thereby reducing the opportunity of supplementary diagnosis, which will further lead to inappropriate diagnosis and affect the accuracy of diagnostic reports. Furthermore, challenges like inadequate power supply, the method used in sample collection, storage and transportation of specimens are also significant as they also pose their respective implication. From the observations, there is an urgent need for more investment into the laboratories for proper, timely, and accurate diagnosis of COVID-19.

Keywords Africa, challenges, COVID-19, implications, laboratory diagnosis

1. Introduction

The outbreak of the new coronavirus disease of 2019 (COVID-19) infection began on November 17, 2019, in the Hubei province of Wuhan, China (*1*). This infection was identified by real-time polymerase chain reaction (RT-PCR) assay on December 30, 2019, by the WHO office in China (*2*). The virus has spread across regions and territory of many countries since then (*3*). The causative agent of the disease is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is currently being diagnosed with the RT-PCR because of its reliability (*4*). SARS-CoV-2 is similar to the severe acute respiratory syndrome virus (SARS-CoV) by ~80%, also has ~50% similarity to the Middle East respiratory syndrome virus (MERS-CoV) and ~96% closeness to bat coronavirus (RaTG13) (*5*).

The COVID-19 has been classified as a pandemic by the World Health Organization (WHO) on March 11, 2020 (*6*). A total of 5,596,550 confirmed cases and 353,373 deaths have been reported globally. African Region has reported 124,733 cases, which are approximately 2.23% of the global confirmed cases as well as 3,700 deaths (1.05%) of the worldwide death toll. All record is given as of May 28, 2020 (*7*). The decreased number of confirmed cases and death rates in

Africa compared with the other continents may be due to the lower rate of testing, which undermines the incident rate and therefore not giving the real picture of the outbreak (*8*).

At the beginning of this pandemic, only two African countries were conducting COVID-19 diagnoses using the RT-PCR (*9*). Later on, many African countries introduced laboratory diagnostic tests. For example, Nigeria has four laboratories that can detect COVID-19 infection. These laboratories are facilitated by the African Center for Disease Control (ACDC) and Nigeria Center for disease control (*9,10*).

Generally, COVID-19 can be diagnosed using the following laboratory techniques: molecular methods (nucleic acid testing), serology (protein testing), rapid antigen test (point of care testing), cell culture, computed tomography. The molecular method using RT-PCR is the most specific and sensitive diagnostic method with as fast as three hours of reliable diagnosis (*10*). Africa as a case study, many laboratories diagnosing COVID-19 have proven to be a massive challenge due to various factors such as resource limitations, unavailability of sensitive diagnostic tests, and implementation of prevention strategies during diagnoses process. In contrast, in the developed nations of the world, multiple laboratory diagnostic methods are being employed. In the advent of a disease outbreak, developing an effective diagnostic protocol is always a clamour of the general masses and scientists. However, the scientific community is equally faced with the task of developing rapid diagnostic techniques and equipment, especially in severe cases of epidemic and pandemic where a need for mass diagnosis must be met (*11*).

The absence of extensive testing data has contributed to the inappropriate estimation of the outbreak and the response to it in Africa. Some deaths have been recorded. Therefore, swift responses are required in Africa to overcome the challenges of laboratory diagnosis to minimize the implications of COVID-19 infection. Also, there must be an appropriate protocol for sample collection, transportation, and precise diagnosis to help reduce the impact on the continent (*11*). Those, as mentioned above, will help us to unravel the real implication of the pandemic on African populace and take appropriate steps.

2. Laboratory techniques for COVID-19 diagnosis

2.1. Serology

In serology, antigen and antibody of viral proteins that elicit a response to SARS-CoV-2 infection are being used for COVID-19 diagnosis. Serology tests can be used to monitor the progress of the disease, past infection, and developed an immunity. Early-stage of infection is indicated by the presence of immunoglobulin M (IgM), while prior-infection and post-infection protection are indicated by immunoglobulin G (IgG) (*12*). The use of the test is also essential in epidemiological investigations and the development of vaccines (*12*). A recent study showed that both IgM and IgG antibodies were detected in all the 39 infected patients who were studied after 5 days of being infected (*11*).

The infection causes changes in viral load, which make viral proteins challenging to detect. Kelvin *et al.* (*13*) found high salivary viral loads in the first weeks, after the onsets of symptoms, which gradually declined with time, but on the other hand, antibodies produced in response to viral proteins provide a full-time frame for the indirect detection of SARS-CoV-2. This test targeting antibodies as markers of SARS-CoV-2 infection can be of use in COVID-19 diagnosis. The shortcoming of this method is the possibility of having cross-reactivity of SARS-CoV-2 antibodies with antibodies produced against other coronaviruses (*14*).

2.2. Rapid antigen test

Rapid antigen test is a lateral flow technology that uses a protein biomarker whereby the colourimetric signal is produced on the paper by the gold-coated antibodies, which confirm the presence of SARS-COV-2 (*15*). They are meant to provide a reasonable turnaround time, and they are of lower-cost in the diagnosis of COVID-19 (*11*). They are used for the determination of infection without sending samples to microbiological laboratories. Thus, rural communities without laboratories can conduct a diagnosis of suspected patients using rapid antigen tests (*14*). Though, rapid antigen test is limited by their reduced sensitivity. Lateral flow antigen detection for SARS-CoV-2 is an approach of quick antigen test, and this approach is undergoing development for diagnosis of COVID-19 (*14*).

2.3. Computed tomography (CT)

Usually, a chest radiograph is commonly employed as an imaging study for patients with respiratory illnesses. Chest CT scan was used for diagnosis of COVID-19 infection in the Hubei Province China due to the shortage of RT-PCR kits. In a chest CT scan, many X-ray measurements are taken at different angles across the chest of the patient; this is to produce cross-sectional images. The images are then subjected to analysis by radiologists to examine abnormal features that can raise a cause for further diagnosis (*14*).

There are controversies on the suitability of CT scan for diagnosis of COVID-19. Earlier studies have reported a high degree of sensitivity of CT scan for diagnosis of COVID-19 (*16,17*). But the reports have been faulted based on poor research design, incomplete methodology, and lack of gold standard. There are also many confounding variables, a short discussion, and pair review process query. Therefore, caution should be taken in the use of this method (*18*). Also, typical CT scan results in COVID-19 patients at the early stage of disease infection (0-2 days) are not frequently precise (*19*). These shortcomings of CT scans make the diagnosis of COVID-19 challenging to be differentiated from other viral infections like pneumonia, and there is also the hysteresis of abnormal CT imaging in the process of diagnosis (*20*).

2.4. Cell culture

According to WHO interim guidance for COVID-19, virus isolation is not recommended as a routine diagnostic procedure. Isolation of human coronaviruses in cell culture is not a conventional diagnostic technique due to lack of permissive cell lines, labour, expertise requirements and lack of commercial antisera for culture confirmation (*11*). Also, there is a strict guideline for cell culture procedure for COVID-19. The biosafety practices in the laboratory concerning COVID-19 infection are classified under the biological safety level-3 (BCL-3), requiring personal protective device and respirators, scrub suits, and solid-front wraparound gown. Also, the biological safety cabinet (BSC) must be available, hand-free sink, eyewash, and sustained directional airflow towards a self-closing door (*21*). However, cell culture is essential for antiviral and pathogenesis research (*22*).

2.5. Nucleic-acid testing

2.5.1. Real-time polymerase-chain reaction

In Africa, only the molecular method of nucleic acid testing is being carried out in specialized laboratories. It will be essential to acknowledge that RT-PCR testing is the standard gold method for diagnosis of COVID-19 (*23*). This method is basically to genetically test for SARS-CoV-2 by using reverse transcription-polymerase chain reaction (RT-PCR) kit. Using RT-PCR kits, the SARS-CoV-2 RNA is reversely transcribed into complementary DNA strands, then subjected to amplification of specific regions of the cDNA (*14*). Real-time PCR is the technique of retrieving data throughout the process of PCR by joining amplification and detection into one single operation. The principle is using a variety of different fluorescent chemistries in correlation with the concentration of PCR product to florescent activity (*24*).

2.5.2. Real-time quantitative reverse transcription PCR

Real-time quantitative reverse transcription PCR is a reliable technique for product detection and measurement during each cycle of the PCR process. It is essential for effective counting of microbial load. Hence it is imperative for the diagnosis of viral infection. Depending on the kind of probe (SYBR Green or Taqman), the fluorescent dye binds to the amplified gene product, and the qPCR reads the CT value (*25*). QRT-PCR is done in a specific thermal cycler that can illuminate each sample with a light beam of a specific wavelength and afterward detect the fluorescence that the excited fluorophore is emitting (*26*). This technique is being used in diagnosing COVID-19 (SARS-COV-2) as earlier described by Chu *et al*. (*27*) and Tang *et al*. (*28*). The peculiarity of qRT-PCR lies in its ability to quantify the viral presence. The principle of qRT-PCR assays involves following the R.T. of RNA into cDNA. Therefore, useful detection chemistry is needed to report the presence of PCR products. An instrument that will monitor the amplification in real-time is also required, and appropriate software for quantitative analysis (*25*).

2.5.3. Droplet digital PCR

The ability of droplet digital PCR (ddPCR) to measure the levels of amplifiable targets precisely makes it an essential technique for measuring and determining copy number alterations (CNAs) in genomic biomarkers (*29*). Yu *et al*. (*30*) stated that COVID-19 was diagnosed in China using a digital PCR kit from one of their studies. The kit detects the ORFlab gene, N gene, and a positive reference gene. Ten copies/test was the detection limit (*30*). Studies have shown that digital droplet PCR (ddPCR) possess some advantages over RT-PCR in terms of absolute quantification and more sensitivity for virus detection (*31*). Yu *et al*. (*30*) reported that both RT-PCR and ddPCR showed reliable accuracy in samples with high viral load and negative examples, but digital droplet PCR (ddPCR) was better at detection in samples that possessed low viral load.

Out of all these laboratory diagnostic methods, Africa has concentrated firstly on qRT-PCR and the RT-PCR. There has not been much evidence of the laboratory techniques used in African from selected published reviewed papers. Likewise, there is a shortage of information on the use of ddPCR in Africa for the diagnosis of COVID-19 (*30*). This has a significant challenge on the determination of the virus by not combining other methods for proper diagnosis; this could affect the accurate transmission picture of the virus in each country from Africa. There will likely be records of false positivity and negativity by the quality of the diagnostic protocols. Though qRT-PCR has helped in detecting the virus in suspected COVID-19 patients for differential diagnosis of the unknown respiratory syndrome, screening of asymptomatic individuals and rescreening of confirmed COVID-19 patients that have receives treatment for the infection to be tested positive before being discharged. For the understanding of the pathogenesis of the circulating viral strains in Africa, cell culture should be encouraged, and facilities should be provided (*31*). This will help Africa to have a better understanding of the pathogenesis of the circulating strain as much as enhancing antiviral research.

The better the understanding of the community-community-transmission rate, the more rural diagnosis should be carried out. Therefore, validation of the rapid antigen test is essential in this case because of their reduced sensitivity. But if the validation is appropriately carried out, it will, in turn, help the rural community in the detection of COVID-19 infection (*31*).

3. Challenges of laboratory diagnosis of COVID-19 in Africa

3.1. Africa health system

The health systems in Africa are strained and have minimal capacity to control the pandemic (*32*). Apart from this endemic infectious disease, the health systems in Africa are facing both communicable and non-communicable diseases, including injury, anaemia, malaria, HIV/AIDs, tuberculosis, and cancer. As a result, the health systems in Africa are stretched thin, to begin with, and there is very little access to the room to absorb the COVID-19 pandemic (*33*). Besides, Africa has the lowest capacity to provide critical care in the world. A recent analysis showed that countries with the highest numbers of intensive care beds per capital do not include any country from Africa (*33*). In Liberia, there are no intensive care units (ICU) with ventilators, for example. Uganda has 0.1 ICU bed/100,000 population. But, the United States has 34.7 beds/100,000 population (*24*). The potential to treat severe forms of COVID-19 depends on the availability of ventilators, electricity, and oxygen because this infectious disease could lead to respiratory failure requiring ventilation support (*33*). The challenges could be summarized under the headings, such as lack of sufficient human personnel, poor budget allocation to the health sector, and weak management and leadership policies (*32*).

3.2. Insufficient human resources

The problem of insufficient human resources comes first in Africa health sectors. There is the problem of a low number, uneven distribution, and immigration of African exports to European and Asian countries (*34*). Also, poor delivery of services due to incessant strikes, weak government policies for civil servants, poor work attitude are some of the problems facing African health sectors (*35*). The WHO organization have also identified that the sub-Sahara African countries are facing a shortage of health care providers, and proper attention has not to be given by the African governments. These problems may lead to poor treatment outcomes and an inability to fulfil health goals nationally and globally (*35*).

Also, most of the hospitals in Africa are faced with limited skilled healthcare personnel in which there have been mass inflows of both asymptomatic and symptomatic patients. With time, this will later overwhelm the inadequate health infrastructure available in Africa. Also, this will make it difficult to spare medical personnel to leave their health posts to conduct field tests. Limited health care personnel pose limitations to the distribution of test kits needed for the diagnosis can delay the service for laboratory testing of suspected patients (*36*).

3.3. Poor budget allocation to the health system

Poor budget allocation to the health system is another significant challenge for the African health care system, and this has become a chronic problem, and this is even more severe with the present economic issue as a result of the lockdown (*37*). Out-of-pocket payments (OOPs), a regressive mode of funding, have been responsible for 40% of total healthcare funding in 50% of African countries (*38*). Even after several declarations by African heads of states of improved financing of the healthcare system, the allocated funds remain inadequate in the majority of the countries (*37*).

The high cost of healthcare delivery, lack of financial sustainability, and absence of economic autonomy by the health care system are also contributing factors to the financial challenges of the health care system (*39*). The available budget to the healthcare system is a determinant factor in the success of the fight against the COVID-19 pandemic. Therefore, an improved budgetary allocation is vital.

3.4. Leadership and management problem

Poor leadership and management have had their toll on all sectors of governance, and the health sector had a significant share of it. It has been identified that the training, development, selection, and preparedness for a leadership position is one of the complex problems facing the future of the healthcare system in Africa countries (*41*). Unfamiliarity with the techniques of leadership, lack of political will, inefficient healthcare program integration, poor government policies, and corruption have been identified as the problems facing health care leadership and management structure (*40*). To effectively fight the menace of poor leadership, commitment to work, team spirit, job satisfaction, integrity, and dedication are expected of every potential leader.

3.5. Unavailability of the test kit

The swab and reagents that are needed to carry out the test for COVID-19 are in short supply for most of the African countries, and the kit cannot manufacture our own. A large amount of some of these supplies would have imported from China and some European countries. However, these countries are in small quantities, for they too are affected by this virus. So that is a big challenge, and it can lead to an increase in the number of infected in the region (*33*).

3.6. Inadequate personal protective equipment (PPE)

Africa is exceptionally vulnerable because we are unable to manufacture enough PPE for this infection. The purchase of personal equipment such as masks, hand glove, and others are in short supply across the world. There is a competition on the protective purchase of this equipment with developed countries. That is the most unfortunate situation with this pandemic, and it is affecting every part of the world. For the outbreak of the Ebola virus in Africa, we counted on Europe or the U.S. to import supplies. But everybody is affected at the same time, and it becomes a big challenge (*33*).

3.7. Sample collection and analysis

Sample collection and analysis are critical steps in detecting the virus. The collection of samples for the laboratory must be done following the world health organization standard. The diagnostic test consists of a swab, a long stick with a piece of cotton or gauze at the end, taken from the throat and nose of the suspect case. The collection is the beginning of the process. Subsequent steps are essential, too. There are cases where samples are stated inadmissible. For example, it's only useable if it's accompanied by the right documentation (*42*).

Sample collection is challenging because of the nasal swab that is not made of cotton; it is long and flexible and can extend to the ear. Apart from the possibility of damaging the nose or ear, it could also inhibit sample collection and testing. Analysis in the lab requires expertise too, with accuracy and precision in terms of time and sample temperature (*42*).

3.8. Transportation

The samples must be controlled with the utmost caution. Unfortunately, we have come across cases where the person transporting the material mishandle it (*43*). It is also vital to respect the timeframe for carrying the sample, in particular, to make sure that it is stored and transported at a standard temperature of 2-8°C. If it is placed outside this standard temperature, it no longer conforming to the ideal. It must also be transported correctly and not put in a horizontal position or upside down. For this reason, it is essential to set the samples in a rack that shows the direction of storage with an arrow to keep them upright throughout the journey. Materials and specimens to be used in the laboratory should be placed in a secondary container to minimize breakage, spill, or contamination during transportation within and between laboratories (*33*).

3.9. A limited power supply

The already dilapidated power supply system contributes to the challenges facing laboratory diagnosis in Africa. Regular power cuts pose a further challenge to the national health system infrastructure. Limited energy access or reduction in supply hours would affect healthcare facilities such as testing, cooling systems, medical devices, and equipment (*44*).

4. The implication of the challenge

4.1. Test kit

Insufficiency of test kit can lead to a lot of casualties in Africa. As of May 28, 2020, the number of confirmed cases of COVID-19 in African region was 124,733, with a total death of 3,700. A total of 54 infected countries were reported in Africa with Egypt, Algeria, South Africa, and Cameroon leading the chart of most confirmed cases (*45*). The number of confirmed COVID-19 cases in Africa is not a true reflection of the outbreak due to insufficient kits. These issues may lead to misdiagnosis of the patient, inadequate treatment, and increased mortality rate. The laboratory personnel may tend to manage some of the malfunction test kits to avoid interruption in daily data to be compiled. This may lead to the inability to determine the true prevalence and spread o of the diseases. In addition, it results in a high mortality rate.

4.2. Personal protective equipment

World Health Organization has warned that severe and mounting disruption to the global supply of personal protective equipment (PPE) such as face shields, surgical masks, diagnostic swabs, ventilator components and reusable N95 respirators – caused by rising demand, panic buying, hoarding, and misuse – is putting lives at risk from the new coronavirus and other infectious diseases (*46*). According to findings, before the COVID-19 pandemic, the only country producing the PPE in Africa is South Africa. The shortage of PPE has given a lot of local industries, uprising companies, and small-scale firms to start the production of the PPE without proper precautions. It is well known that Africa did not have a trade of PPE before now, and the shortage has made many to start production. This is risky because the person producing it might also be an asymptomatic COVID-19 patient or might have come in touch with someone with it. This will increase the rate of spread of this SARS-COV-2 and also increased the mortality rate (*46*). These make African more vulnerable to this disease than any other continent. The shortage may lead to a reduction in the workforce of the laboratory personnel to avoid their lives being endangered. It may also lead to the management of PPE without proper care and making more lives vulnerable to these diseases.

4.3. Transportation

Africa has a high risk for the introduction of the novel coronavirus disease 2019 (COVID-19), because of the high volume of air traffic (*via* importing) and trade between China and Africa (*3*). Based on their analysis, the WHO International Health Regulations Monitoring and Evaluation Framework; Egypt, Algeria, and South Africa had the highest importation risk and a moderate to high capacity to respond to outbreaks. Also, Nigeria, Ethiopia, Sudan, Angola, Tanzania, Ghana, and Kenya had medium risk with variable size and high vulnerability (*3*). In the model, the risk mainly originates from Guangdong, Fujian, and Beijing. The study illuminates a valuable tool that can help countries in Africa prioritize and allocate resources as they prepare to respond to the potential exposure and spread of COVID-19 (*9*). This might also be a severe implication to laboratory personnel because most of the laboratory tools are imported from distant countries, and even most of the countries the goods will pass through are on lockdown. There might be a need for the approval of high governance body to allow the movement of the products, and there might be a delay which will elongate the work of laboratory personnel (*18*). If there is damage in the laboratory kits, it may not be easy to repair because of transportation issues, and this will reduce the workforce of the laboratory personnel, lengthening diagnosis, and increase the spread. Transportation of laboratory samples will be one of the utmost problems facing Africa. There is a timeframe for transporting specimens. If the samples are placed outside the ideal temperature, the example no longer conforms to the standard, which may cause a problem when analyzing or interpreting the sample results (*9*).

4.4. Skilled laboratory personnel

In African countries, there is inadequate laboratory personnel that understand the use of COVID-19 laboratory diagnostic tools. Some of these countries did not have this equipment before the start of COVID-19 pandemics, and nations that have the equipment have few-laboratory personnel. So, there will be a need to provide more laboratory diagnostic tools with sufficient and quality laboratory personnel. This will allow a rush-training to employ more people to work as laboratory personnel. The training might not be adequate, because the rate of assimilation of everyone is different. Besides, this may pose a threat to the lives of people, and misinterpretation of laboratory results might be frequent (*47*).

4.5. Power supply

In some countries in Africa, there is limited or no power supply. This allows the laboratory to make use of the power generator, and the power generator may heighten risk because of its carbon monoxide emission. This will also cripple telecommunication and ICT services. These would also delay minute to minutes monitoring and reporting (*48*).

5. Conclusion

This study has shown that tackling COVID-19 pandemic in Africa requires effective laboratory diagnosis. However, as noted from this review Africa as a continent has depended majorly on only two laboratory diagnostic methods (RT-PCT and qRT-PCR) for detecting COVID-19 infection. This showed us a limitation to the effective elaborate laboratory diagnosis of the vast African populace. Specifically, the insufficiency in test kits, personal protective equipment, limited skilled personnel, inadequate power supply, and bad transportation system have all impaired the accurate diagnosis of COVID 19 infection. These challenges could have led to misdiagnosis of patients, slow rate of diagnosis of suspected cases, increased number of infected persons, inadequate treatment, and ultimately increased mortality rate.

Having noted all these challenges, it is therefore imperative that Africa responds quickly to provide sufficient standard laboratory diagnostic tools. Also, more diagnostic techniques should be employed as alternatives and support to the existing methods. Moreover, laboratory personnel should be adequately trained to execute accurate diagnosis. There should be improved remuneration for health workers generally and better funding of the health sector. These will help to reduce the spread of SARS-CoV-2, and the mortality rate will be reduced consequently.

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