



REVIEW

COVID-19: Are Africa's diagnostic challenges blunting response effectiveness? [version 1; peer review: 2 approved]

Francis Kobia ^{1,2}, Jesse Gitaka ^{1,3}¹Research and Innovation, Mount Kenya University, Thika, 01000, Kenya²Department of Biosciences, University of Milan - via Celoria 26, Milan, 20133, Italy³Implementation Research, Centre for Research in Tropical Medicine and Community Development, Nairobi, 00100, Kenya

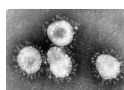
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Abstract

Since its emergence in Wuhan, China in December 2019, novel Coronavirus disease - 2019 (COVID-19) has rapidly spread worldwide, achieving pandemic status on 11th March, 2020. As of 1st April 2020, COVID-19, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), had infected over 800,000 people and caused over 40,000 deaths in 205 countries and territories. COVID-19 has had its heaviest toll on Europe, United States and China. As of 1st of April 2020, the number of confirmed COVID-19 cases in Africa was relatively low, with the highest number registered by South Africa, which had reported 1,380 confirmed cases. On the same date (also the date of this review), Africa had reported 5,999 confirmed cases, of which 3,838 (almost 65%) occurred in South Africa, Algeria, Egypt, Morocco and Tunisia, with the remaining 2,071 cases distributed unevenly across the other African countries. We speculate that while African nations are currently experiencing much lower rates of COVID-19 relative to other continents, their significantly lower testing rates may grossly underestimate incidence rates. Failure to grasp the true picture may mean crucial windows of opportunity shut unutilized, while limited resources are not deployed to maximum effect. In the absence of extensive testing data, an overestimation of spread may lead to disproportionate measures being taken, causing avoidable strain on livelihoods and economies. Here, based on the African situation, we discuss COVID-19 diagnostic challenges and how they may blunt responses.

Keywords

Covid-19, Point-of-care diagnostics, Africa, response, effectiveness



This article is included in the [Coronavirus \(COVID-19\)](#) collection.

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1. **Kennedy O. Okeyo** , Kyoto University, Kyoto, Japan
2. **Jacqueline C. Linnes** , Purdue University, West Lafayette, USA

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Jesse Gitaka (jgitaka@mku.ac.ke)

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Emergence and global spread of SARS-CoV2

In December 2019, a spate of pneumonia cases of unknown cause was observed in Wuhan, Hubei province, China (He *et al.*, 2020). Soon after, the causative agent for the novel illness was found to be a novel Coronavirus (2019-nCoV) (Lu *et al.*, 2020; Zhou *et al.*, 2020; Zhu *et al.*, 2020). Coronaviruses (CoVs), are a large group of viruses that frequently cause mild respiratory disease in humans, including common cold (Saif, 2004; NIAID, 2020). Hundreds of coronaviruses exist in wild and domestic animals. In the last 20 years, 3 highly infectious CoVs have crossed from animals into humans through spillover events and spread globally, causing severe respiratory illnesses (Andersen *et al.*, 2020; Cui *et al.*, 2019). In November 2002, severe acute respiratory syndrome (SARS), a novel respiratory disease emerged in China and rapidly moved to other countries. Its causative agent was identified as a CoV and named SARS-CoV (Drosten *et al.*, 2003; Fung & Liu, 2019). The SARS mini pandemic infected over 8,000 people and caused almost 800 deaths (Cherry, 2004). In 2012, a novel respiratory disease, named Middle East respiratory syndrome (MERS), was identified in Saudi Arabia and the causative agent identified as MERS-CoV (de Groot *et al.*, 2013; Zaki *et al.*, 2012). To date, MERS is estimated to have infected over 2,000 people and caused over 700 fatalities (Ramadan & Shaib, 2019; WHO, 2017). In December 2019, a novel respiratory disease presenting with severe unexplained pneumonia emerged in Wuhan, Hubei province - China (Huang *et al.*, 2020; Zhu *et al.*, 2020). Its causative agent was quickly identified as a novel CoV (2019-nCoV), which was named SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) (Lu *et al.*, 2020; Zhou *et al.*, 2020). The disease caused by SARS-CoV-2 was named COVID-19 by the WHO (WHO, 2020e). COVID-19 then rapidly spread within China, where it infected over 82,000 people and caused more than 3,000 fatalities, mainly in Hubei province (WHO, 2020b). The disease's spread accelerated globally, prompting the WHO to declare it a global pandemic on 11th March 2020 (Bedford *et al.*, 2020). As of 1st April 2020, over 800,000 COVID-19 cases and more than 40,000 COVID-19-associated deaths had been confirmed in 205 countries and territories. Europe and North America are currently the continents most affected by COVID-19. So far, Africa has reported the lowest number of confirmed COVID-19 cases (WHO, 2020b). As of writing, 5,999 COVID-19 cases have been reported in Africa with South Africa reporting the highest number. 5 countries (South Africa, Tunisia, Morocco, Egypt, and Algeria) account for close to 65% (3,838 cases) of the confirmed cases, with the remainder being unevenly distributed in the rest of the continent. Within the East African community, there have been a total of 222 confirmed cases (African Arguments, 2020; WHO, 2020b).

SARS-CoV-2 transmission and pathogenesis

SARS-CoV2, is an enveloped single stranded positive sense RNA virus belonging to the family *Coronaviridae* and genus *Betacoronavirus* (Lai *et al.*, 2020). The SARS-CoV-2 virion ranges between 50-200nm in diameter and houses a 29,881 bp genome (Chen *et al.*, 2020a; Chen *et al.*, 2020b). Among other genes, the SARS-CoV-2 genome encodes 4 structural

proteins named spike (S), envelope (E), membrane (M) and nucleocapsid (N). The N protein holds the viral genome while S, M and E construct the viral envelope, where S mediates viral entry into the host cell (Wu *et al.*, 2020). SARS-CoV-2 is easily transmissible. According to the WHO, the main mode of COVID-19 transmission is direct/indirect human-human contact, where the virus is transmitted in respiratory droplets or via contact routes. Droplet transmissions happen when one gets into close proximity, (typically within a meter) with an individual exhibiting respiratory symptoms, such as sneezing or coughing. Indirect transmission may occur when one touches objects handled by an infected individual and then touches their mouth, nose or eyes. Transmission has also been reported to occur via airborne droplet transmission. In such cases, the virus is contained in droplet nuclei, which are typically <5µm in diameter and can remain airborne for extended periods. Airborne transmission can occur over distances beyond 1 meter but such nuclei are typically generated by processes that generate aerosols, usually patient care procedures (WHO, 2020d). As such, social distancing, rigorous hand washing, and avoiding touching the face have been recommended as means of minimizing transmission risk (WHO, 2020a). Once SARS-CoV-2 has gained access to the host's respiratory mucosa, it enters the host cells through an interaction between its S protein and the host cell's ACE2 (angiotensin-converting enzyme 2) receptors (Hoffmann *et al.*, 2020). Unlike other coronaviruses that cause upper respiratory tract disease only, SARS-CoV-2 is capable of colonizing the lower respiratory tract as well (Heymann & Shindo, 2020). After infection, the virus incubates for a median period of about 5 days before the onset of symptoms and almost all infections become symptomatic by day 11 (Lauer *et al.*, 2020; Rothan & Byrareddy, 2020). Symptoms include fever, fatigue, headache, dry cough, diarrhea and lymphopenia. While most patients experience mild symptoms that they overcome without need for hospital care, some experience serious complications including severe pneumonia, acute respiratory distress syndrome (ARDS), acute cardiac injury and acute ground glass opacity (GGO) that may necessitate life support (Heymann & Shindo, 2020; Rothan & Byrareddy, 2020).

COVID-19 diagnostic testing

COVID-19 diagnostic testing is recommended for individuals that satisfy the suspect case definition (Leitmeyer *et al.*, 2020). According to the WHO organization, the decision to test should be based on clinical signs, epidemiological factors and the possibility of infection (Leitmeyer *et al.*, 2020), such as contact with an infected individual. The WHO (WHO, 2020c) defines a suspect case as one that:

- a) Shows symptoms of acute respiratory illness i.e. fever and at least one respiratory disease symptom e.g. coughing and shortness of breath, and has travelled or resided in an area with community COVID-19 transmission in the 14 days prior to symptoms onset; or,
- b) Shows acute symptoms of any respiratory illness and has been in contact with a confirmed or suspected case in the 14 days prior to the onset of symptoms; or,

- c) Shows symptoms of acute respiratory illness i.e. fever and at least one respiratory disease symptom e.g. coughing and shortness of breath and requires hospitalization in the absence of alternative diagnosis that fully accounts for the symptoms.

Suspected cases should then be validated by laboratory tests. This is routinely done by carrying out nucleic acid amplification tests (NAAT). Currently, RT-PCR detection of unique sequences of the viral genome is the gold standard for COVID-19 testing where the N, E, S and RdRP (RNA-dependent RNA polymerase) genes are targeted. Sample handling should be carried out in a BSL-2 biosafety cabinet under strict adherence to personal protective equipment (PPE) guidelines. However, RT-PCR is labor intensive, severely constraining the capacity for quick turnaround times from sample collection to results transmission. In many contexts, getting results takes days (NPR, 2020). As a consequence, laboratory testing of suspect cases is characterized by long wait periods and an exponential increase in demand for tests. To address this bottleneck, rapid diagnostic tests with turnaround times ranging between 10 and 30 minutes have been developed, even though most of these are currently undergoing clinical validation and therefore not in routine use (ECDC, 2020).

COVID-19 testing for surveillance and pandemic control

In addition to suspect case diagnosis, widespread COVID-19 testing is critical for disease monitoring and surveillance. Such testing is recommended so as to meet the following objectives (WHO, 2020c):

- a) Monitor disease trends in contexts of rapid person-person virus spread.
- b) Quickly identify cases in countries/regions where the virus is not circulating.
- c) Generate epidemiological data for risk assessment regionally, nationally or globally.
- d) Generate epidemiological data to guide government responses in terms of policy, resource mobilization and distribution.

However, how extensively governments rollout testing for surveillance purposes is dependent on each country's prevailing circumstances and preferred COVID-19 control strategy. For instance, aggressive, widespread testing in South Korea early in their epidemic, including the deployment of drive-through testing (Kwon *et al.*, 2020) has been credited with effective spread control, avoiding the need for lockdown (Colbourn, 2020). While in Italy, where medical services were rapidly overwhelmed by a high influx of severe COVID-19 cases, testing was restricted only to those with severe symptoms and needing hospitalization (Onder *et al.*, 2020). This approach misses the vast majority of COVID-19 cases (estimated at around 80%) because they are mild or asymptomatic and tends to overestimate the disease's fatality rate (ISPI, 2020). This approach

has also been blamed for contributing to the continued spread of COVID-19 as undiagnosed cases drive persistent community transmission (Paterlini, 2020). Testing the entire population of the Italian village of Vo'Euganeo, and isolation of all positive cases has been reported to have helped eliminate COVID-19 from the village (Day, 2020). Mass testing has been suggested as a means to quickly stop the COVID-19 epidemic in the UK (Peto, 2020) and delayed roll out of large-scale testing is considered to have blinded the US to its worsening COVID-19 situation (Cohen, 2020; New York Times, 2020). In Germany, large-scale testing has been credited for limiting disease spread and the low fatality rate reported by Germany relative to its neighbors (Financial Times, 2020a). While many countries are ramping up surveillance testing, there are no guidelines for large-scale testing and decisions are based on individual countries' assessments.

Challenges of COVID-19 testing in African contexts

The benefits of large-scale COVID-19 testing have been demonstrated in several countries. However, most low-middle income countries (LMICs), including the majority of African countries, lack capacity for large scale testing. These countries are facing numerous challenges in their efforts to diagnose suspect cases, trace contacts for further testing and roll out surveillance testing. For instance, as a consequence of inadequate testing capacity, at the time of preparing this review Kenya had carried out 2,563 tests only, of which 122 returned positive (MOH - Kenya, 2020). While Kenya's ministry of health has indicated it is embarking on mass testing (Xinhua, 2020), many challenges remain, including test kit shortages that have been reported in many parts of Africa (VOA, 2020) as a result of high global demand.

A major diagnostic challenge stems from the nature of RT-PCR tests, the gold standard in COVID-19 testing. COVID-19 RT-PCR test kits are expensive, making the cost of large-scale testing prohibitive for LMICs. Additionally, the test requires expensive equipment, including PCR machines and adequately equipped BSL-2 labs. These factors, and the need for highly trained personnel, mean that in most African countries, very few centers have the capacity to run COVID-19 tests. Furthermore, completing a COVID-19 RT-PCR test is a multi-step process that begins with sample collection, often at a point of care that is far away from the country's test center(s). The sample must then be carefully packaged and transported to the distant testing site under conditions that protect sample integrity. At the lab, laborious sample preparation, including RNA extraction is done, followed by reaction mix preparation and RT-PCR (NPR, 2020). This multi-step, labor intensive process results in huge backlogs, severely slowing suspect case testing and limiting capacity for mass testing. While these challenges are global, countries with stronger research capacities have significantly higher test rates as private and academic research institutions help in testing (Financial Times, 2020c). In fact, RT-PCR diagnostic capacity is severely limited in most African countries, with the number of qualified testing labs ranging between 1 and 3 in 40 African countries. To address this shortfall, the WHO-Afro and Africa Task Force for Coronavirus (AFTCOR)

are keen to increase this number and bring testing capacity to all 55 African countries (Nkengasong & Mankoula, 2020). Owing to these challenges, many LMICs governments must prioritize testing of suspect cases and traced contacts. In turn, inadequate testing severely occludes the proper understanding of prevalence and incidence of COVID-19, raising the risk of undetected community spread. Furthermore, a blinded view of COVID-19 means that government responses may not be commensurate with the actual situation. For instance, measures may be relatively weak where stronger measures would have been taken had the actual situation been captured. Likewise, measures may be too stringent in some contexts if identical risk is assumed countrywide in the absence of mass surveillance data. Hence, limited diagnostic capacity blinds governments' COVID-19 assessments, limiting the country's abilities to deploy limited resources to maximum effectiveness.

Surmounting COVID-19 diagnostic challenges

COVID-19 diagnostic challenges are not unique to African countries and LMICs. Consequently, numerous private and public institutions have developed rapid diagnostic tests (RDTs) aimed at speeding and expanding testing, crucial factors in the struggle to slow COVID-19 spread. RDTs, which are largely based on immunoassays, may be direct, through detection of SARS-CoV-2 antigens or indirect, through detection of anti-SARS-CoV-2 antibodies (ECDC, 2020). Advantages of RDTs include ease of use as they do not require special equipment or highly trained personnel and stability at room temperature, removing the need for constant refrigeration/freezing. RDTs are therefore highly suited for point of care diagnosis (POCD) and are highly amenable to deployment in low resource settings, removing the need for sample transportation. Several COVID-19 RDTs, capable of giving results in 10-30 minutes are now commercially available or in development (ECDC, 2020). In many African contexts, RDTs would reduce the time needed to get test results from days to minutes. Therefore, RDTs offer a means to aggressively deploy mass testing across Africa. However, the cost of RDTs for mass testing may still be prohibitively high, calling for homegrown solutions.

The COVID-19 diagnostic challenges faced by African nations highlight long-running diagnostic challenges for a wide range of diseases. Part of our group's research has been the development of RDTs and POCDs for various diseases, including placental malaria and bacterial infections. We contend that an effective means of achieving mass testing at the required scale, is to fund the development COVID-19 RDTs locally, to meet local demand – bearing in mind that the knowledge and relevant local and international collaborations are already in place. Such solutions should then be aggressively deployed for points of care and home use, particularly in rural settings. In fact, this strategy is being used by Senegal, which together with UK collaborators, is developing an affordable COVID-19 RDT (expected to cost \$1 per test) for home use in African countries (Financial Times, 2020b). Similar approaches by other African countries would provide local solutions to the continent's test needs while supporting Africa's research and innovation.

COVID-19 point of care testing strategies

Evidently, COVID-19 testing by RT-PCR is not applicable in most parts of Africa considering that vast populations live in rural settings with poor transport and communication infrastructure. RT-PCR requires expensive equipment, skilled personnel, reagents and reliable power supplies. Additionally, the long turnaround time of 4-24 hours (and days in some contexts) (NPR, 2020), may discourage many from seeking tests. Thus, there is an urgent need for deployable, COVID-19 point of care tests satisfying the ASSURED requirements of an ideal diagnostic test. Meaning that such tests should be Affordable, Sensitive, Specific, User-friendly, Rapid, Equipment-free, and Delivered to those in need (Mabey *et al.*, 2004; Urdea *et al.*, 2006). Efficient and accurate testing will enable early diagnosis of Covid-19 for timely clinical care and tracing of contacts for isolation and quarantine measures. The need for prompt reliable testing is made dire by findings that COVID-19 positive people with mild or no symptoms may actually harbor high viral loads in the throat and may transmit it by 'viral shedding' (Woelfel *et al.*, 2020).

Different strategies exist for point of care testing, all with inherent merits and demerits: 1) Use of antibody testing. As the body mounts an immune response, antibodies against SARS-CoV-2 antigens are generated. These antibodies may serve as indicators of infection. However, since detectable antibodies may lag behind the appearance of clinical symptoms, most infections will be missed, causing a high rate of false negatives. Conversely, persistence of antibodies after virus elimination from the body may result in a high rate of false positives. Moreover, a high cross reactivity of SARS-CoV-2 and SARS-CoV S protein against plasma samples from 15 patients has been observed, which may impact test interpretation (Lv *et al.*, 2020). However, in spite of these drawbacks, antibody tests will still be useful in community surveillance of exposed populations and this information will be useful in determining the extent of 'herd' immunity and guide tailored public health interventions. 2) Antigen point of care tests overcome the problems inherent in antibody tests by showing evidence of viral proteins, thereby indicating ongoing virus infection. However, such tests will not be as sensitive as to RT-PCR and their clinical utility is yet to be determined, especially in the context of other CoVs. Several of these tests, for example Spike Dart from E25Bio (The Boston Globe, 2020), are currently under evaluation for FDA approval. In Europe, antibody and antigen tests are now commercially available (ECDC, 2020). 3) Molecular based testing based on isothermal amplification such as RT-LAMP and CRISPR based SHERLOCK (Specific High Sensitivity Enzymatic Reporter UnLOCKing) (Kellner *et al.*, 2019; Zhang *et al.*, 2020) have the potential for bridging the gaps left by antibody based tests but pose unique challenges for field deployment. These require heating, reagents that may need a cold chain and some degree of sample preparation. Past experiences with LAMP, which has been used for malaria, TB and several other infectious diseases demonstrate that important implementation bottlenecks need to be overcome to move these from research settings to routine use. The GeneXpert platform based

Xpert® Xpress SARS-CoV-2 test by Cepheid, has received emergency use approval by the FDA (Cepheid, 2020). Fortunately, this platform has widespread use for TB diagnosis in Africa and repurposing it for COVID-19 will fast track testing. However, supply chain management challenges previously experienced during TB testing will need to be overcome for meaningful operation.

Other near point of care tests include radiological imaging with Chest CT-scan. This approach has been shown to be highly sensitive (at 97%) but poorly specific (at 48%) in a Chinese study (Ai *et al.*, 2020). CT-Scan, unlike RT-PCR enables shorter result times especially when coupled with artificial intelligence (AI) enabled image analysis and interpretation. But this technology is highly limited to higher level hospitals in most African countries, with very low numbers of radiologists and poor adoption of AI. This technology may not be sufficient in addressing the COVID-19 diagnosis challenges in Africa.

Given these considerations, it is clear that the current gold standard tools, RT-PCR and radiological imaging, cannot adequately meet Africa's COVID-19 diagnosis challenges in the low resource settings that characterize most hospitals in sub-Saharan Africa. Indeed, as the pandemic situation evolves with control goals focusing on both containment and mitigation (Parodi & Liu, 2020; WHO, 2020f), capacity for large-scale diagnosis at most if not all levels of health care systems will be vital for sustainable control. Crucially, as treatment

solutions for the disease become available, prompt diagnosis will be essential in ensuring prompt treatment and determining isolation/quarantine decisions.

Conclusion

COVID-19 has severely tested the adequacy of global diagnostic preparedness and ability to rapidly develop point of care tests for emerging infections. The prompt release of SARS-Cov-2 whole genomic sequence data by Chinese scientists helped with development of RT-PCR protocols that have been used worldwide. However, as the pandemic evolves, it is increasingly important to develop point of care tests that will facilitate proper last mile epidemiology, inform treatment and public health interventions. These POC tests will leverage available molecular platforms such as CRISPR, or be based on antigen or antibody detection. Critically, it should be understood that these strategies have inherent merits and demerits and synergy will only be achieved where all are used appropriately. Additionally, the COVID-19 pandemic has highlighted the need for development and growth of in-continent POC diagnostics development capacity ranging from assay development, device fabrication, prototyping, validation, implementation research and entrepreneurial ecosystems including venture capitalization and regulation.

Data availability

Underlying data

No data are associated with this article.

References

African Arguments: **Coronavirus in Africa Tracker: How many covid-19 cases & where? [Latest] - African Arguments.** 2020; (Accessed: 1 April 2020).

Reference Source

Ai T, Yang Z, Hou H, *et al.*: **Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases.** *Radiology.* 2020; 200642.

[PubMed Abstract](#) | [Publisher Full Text](#)

Andersen KG, Rambaut A, Lipkin WI, *et al.*: **The proximal origin of SARS-CoV-2.** *Nat Med.* Nature Publishing Group, 2020; **89**(1): 44–48.

[Publisher Full Text](#)

Bedford J, Enria D, Giesecke J, *et al.*: **COVID-19: towards controlling of a pandemic.** *Lancet.* Lancet Publishing Group, 2020; **395**(10229): 1015–1018.

[PubMed Abstract](#) | [Publisher Full Text](#)

Cepheid: **Xpert® Xpress SARS-CoV-2 has received FDA Emergency Use Authorization.** 2020; (Accessed: 6 April 2020).

Reference Source

Chen L, Liu W, Zhang Q, *et al.*: **RNA based mNGS approach identifies a novel human coronavirus from two individual pneumonia cases in 2019 Wuhan outbreak.** *Emerg Microbes Infect.* Taylor and Francis Ltd, 2020a; **9**(1): 313–319.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Chen N, Zhou M, Dong X, *et al.*: **Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study.** *Lancet.* Lancet Publishing Group, 2020b; **395**(10223): 507–513.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Cherry JD: **The chronology of the 2002-2003 SARS mini pandemic.** *Paediatr Respir Rev.* W.B. Saunders, 2004; **5**(4): 262–9.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Cohen J: **“Were behind the curve”: U.S. hospitals confront the challenges of large-scale coronavirus testing.** *Science.* American Association for the

Advancement of Science (AAAS), 2020.

[Publisher Full Text](#)

Colbourn T: **COVID-19: extending or relaxing distancing control measures.** *Lancet Public Health.* The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY-NC-ND 4.0 license, 2020; pii: S2468-2667(20)30072-4.

[PubMed Abstract](#) | [Publisher Full Text](#)

Cui J, Li F, Shi ZL: **Origin and evolution of pathogenic coronaviruses.** *Nat Rev Microbiol.* Nature Publishing Group, 2019; **17**(3): 181–192.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Day M: **Covid-19: identifying and isolating asymptomatic people helped eliminate virus in Italian village.** *BMJ.* British Medical Journal Publishing Group, 2020; **368**: m1165.

[PubMed Abstract](#) | [Publisher Full Text](#)

de Groot RJ, Baker SC, Baric RS, *et al.*: **Middle East respiratory syndrome coronavirus (MERS-CoV): announcement of the Coronavirus Study Group.** *J Virol.* American Society for Microbiology, 2013; **87**(14): 7790–2.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Drosten C, Günther S, Preiser W, *et al.*: **Identification of a novel coronavirus in patients with severe acute respiratory syndrome.** *N Engl J Med.* 2003; **348**(20): 1967–76.

[PubMed Abstract](#) | [Publisher Full Text](#)

ECDC: **An overview of the rapid test situation for COVID-19 diagnosis in the EU/EEA.** 2020.

[Publisher Full Text](#)

Financial Times: **Germany conducting more than 50,000 coronavirus tests a day.** 2020a; (Accessed: 4 April 2020).

Reference Source

Financial Times: **UK-Senegal partnership to trial 10-minute coronavirus test.**

2020b; (Accessed: 4 April 2020).

[Reference Source](#)

Financial Times: **Universities tapped in drive to step up Covid-19 testing.** 2020c; (Accessed: 4 April 2020).

[Reference Source](#)

Fung TS, Liu DX: **Human Coronavirus: Host-Pathogen Interaction.** *Annu Rev Microbiol.* Annual Reviews, 2019; 73: 529–557.

[PubMed Abstract](#) | [Publisher Full Text](#)

He F, Deng Y, Li W: **Coronavirus disease 2019: What we know?** *J Med Virol.* Wiley, 2020.

[PubMed Abstract](#) | [Publisher Full Text](#)

Heymann DL, Shindo N; WHO Scientific and Technical Advisory Group for Infectious Hazards: **COVID-19: what is next for public health?** *Lancet.* Lancet Publishing Group, 2020; 395(10224): 542–545.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Hoffmann M, Kleine-Weber H, Schroeder S, *et al.*: **SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor.** *Cell.* Elsevier BV, 2020.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Huang C, Wang Y, Li X, *et al.*: **Clinical Features of Patients Infected With 2019 Novel Coronavirus in Wuhan, China.** *Lancet.* Lancet Publishing Group, 2020; 395(10223): 497–506.

[PubMed Abstract](#) | [Publisher Full Text](#)

ISPI: **Covid-19 and Italy's Case Fatality Rate: What's the Catch?** 2020; (Accessed: 3 April 2020)

[Reference Source](#)

Kellner MJ, Koob JG, Gootenberg JS, *et al.*: **SHERLOCK: Nucleic Acid Detection With CRISPR Nucleases.** *Nat Protoc.* Nature Publishing Group, 2019; 14(10): 2986–3012.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Kwon KT, Ko JH, Shin H, *et al.*: **Drive-Through Screening Center for COVID-19: A Safe and Efficient Screening System against Massive Community Outbreak.** *J Korean Med Sci.* 2020; 35(11): e123.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Lai CC, Shih TP, Ko WC, *et al.*: **Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and Coronavirus disease-2019 (COVID-19): The Epidemic and the Challenges.** *Int J Antimicrob Agents.* Elsevier B.V., 2020; 55(3): 105924.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Lauer SA, Grantz KH, Bi Q, *et al.*: **The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application.** *Ann Intern Med.* 2020.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Leitmeyer K, *et al.*: **Laboratory testing for coronavirus disease 2019 (COVID-19) in suspected human cases.** 2020; (Accessed: 3 April 2020).

[Reference Source](#)

Lu R, Zhao X, Li J, *et al.*: **Genomic Characterisation and Epidemiology of 2019 Novel Coronavirus: Implications for Virus Origins and Receptor Binding.** *Lancet.* Lancet Publishing Group, 2020; 395(10224): 565–574.

[PubMed Abstract](#) | [Publisher Full Text](#)

Lv H, Wu NC, Tsang OTY, *et al.*: **Cross-reactive antibody response between SARS-CoV-2 and SARS-CoV infections.** *bioRxiv.* 2020; Cold Spring Harbor Laboratory.

[Publisher Full Text](#)

Mabey D, Peeling RW, Ustianowski A, *et al.*: **Diagnostics for the developing world.** *Nat Rev Microbiol.* 2004; 2(3): 231–240.

[PubMed Abstract](#) | [Publisher Full Text](#)

MOH - Kenya: **COVID-19: MINISTRY OF HEALTH - REPUBLIC OF KENYA.** 2020; (Accessed: 4 April 2020).

[Reference Source](#)

New York Times: **The Lost Month: How a Failure to Test Blinded the U.S. to Covid-19.** 2020; (Accessed: 4 April 2020).

[Reference Source](#)

NIAID: **Coronaviruses | NIH : National Institute of Allergy and Infectious Diseases.** 2020; (Accessed: 1 April 2020).

[Reference Source](#)

Nkengasong JN, Mankoula W: **Looming threat of COVID-19 infection in Africa: act collectively, and fast.** *Lancet.* 2020; 395(10227): 841–842. Lancet Publishing Group.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

NPR: **Why It Takes So Long To Get Most COVID-19 Test Results: Shots - Health News: NPR.** 2020; (Accessed: 3 April 2020).

[Reference Source](#)

Onder G, Rezza G, Brusaferro S: **Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy.** *JAMA.* 2020.

[PubMed Abstract](#) | [Publisher Full Text](#)

Parodi SM, Liu VX: **From Containment to Mitigation of COVID-19 in the US.**

JAMA. 2020; American Medical Association.

[PubMed Abstract](#) | [Publisher Full Text](#)

Paterlini M: **Covid-19: Over 300 Italian doctors and scientists call for more testing.** *BMJ.* British Medical Journal Publishing Group, 2020; 368: m1274.

[PubMed Abstract](#) | [Publisher Full Text](#)

Peto J: **Covid-19 mass testing facilities could end the epidemic rapidly.** *BMJ.* British Medical Journal Publishing Group, 2020; 368: m1163.

[PubMed Abstract](#) | [Publisher Full Text](#)

Ramadan N, Shaib H: **Middle east respiratory syndrome coronavirus (MERS-COV): A review.** *Gems.* European Academy of HIV/AIDS and Infectious Diseases, 2019; 9(1): 35–42.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Rothan HA, Byrareddy SN: **The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak.** *J Autoimmun.* Academic Press, 2020; 102433.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Saif LJ: **Animal coronaviruses: lessons for SARS - Learning from SARS - NCBI Bookshelf.** 2004; (Accessed: 1 April 2020).

[Reference Source](#)

The Boston Globe: **Cambridge biotech seeks OK for coronavirus test that delivers results in 15 minutes.** 2020; (Accessed: 6 April 2020).

[Reference Source](#)

Urdea M, Penny LA, Olmsted SS, *et al.*: **Requirements for high impact diagnostics in the developing world.** *Nature.* 2006; 444 Suppl 1: 73–79.

[PubMed Abstract](#) | [Publisher Full Text](#)

VOA: **African Nations Try to Overcome Shortage of COVID-19 Test Kits | Voice of America - English.** 2020; (Accessed: 4 April 2020).

[Reference Source](#)

WHO: **WHO | Middle East respiratory syndrome coronavirus (MERS-CoV) – Lebanon.** *WHO.* World Health Organization, 2017.

[Reference Source](#)

WHO: **Coronavirus disease (COVID-19) advice for the public.** 2020a; (Accessed: 2 April 2020).

[Reference Source](#)

WHO: **Coronavirus disease (COVID-19) Situation Dashboard.** 2020b; (Accessed: 1 April 2020).

[Reference Source](#)

WHO: **Global Surveillance for human infection with coronavirus disease (COVID-19).** *Interim Guidance.* 2020c; 27–29.

[Reference Source](#)

WHO: **Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations.** 2020d; (Accessed: 2 April 2020).

[Reference Source](#)

WHO: **Naming the coronavirus disease (COVID-19) and the virus that causes it.** World Health Organization, 2020e; (Accessed: 1 April 2020).

[Reference Source](#)

WHO: **WHO announces COVID-19 outbreak a pandemic.** World Health Organization, 2020f.

[Reference Source](#)

Woelfel R, Corman VM, Guggemos W, *et al.*: **Clinical presentation and virological assessment of hospitalized cases of coronavirus disease 2019 in a travel-associated transmission cluster.** *medRxiv.* Cold Spring Harbor Laboratory Press, 2020.

[Publisher Full Text](#)

Wu C, Liu Y, Yang Y, *et al.*: **Analysis of therapeutic targets for SARS-CoV-2 and discovery of potential drugs by computational methods.** *Acta Pharm Sin B.* Elsevier BV, 2020.

[PubMed Abstract](#) | [Free Full Text](#)

Xinhua: **Kenya embarks on mass testing for COVID-19 - Xinhua | English.news.cn.** 2020; (Accessed: 4 April 2020).

[Reference Source](#)

Zaki AM, van Boheemen S, Bestebroer TM, *et al.*: **Isolation of a Novel Coronavirus From a Man With Pneumonia in Saudi Arabia.** *N Engl J Med.* Massachusetts Medical Society, 2012; 367(19): 1814–1820.

[PubMed Abstract](#) | [Publisher Full Text](#)

Zhang Y, Odiwuor N, Xiong J, *et al.*: **Rapid Molecular Detection of SARS-CoV-2 (COVID-19) Virus RNA Using Colorimetric LAMP.** *medRxiv.* Cold Spring Harbor Laboratory Press, 2020; 2.

[Publisher Full Text](#)

Zhou P, Yang XL, Wang XG, *et al.*: **A Pneumonia Outbreak Associated With a New Coronavirus of Probable Bat Origin.** *Nature.* Nature Research, 2020; 579(7798): 270–273.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

Zhu N, Zhang D, Wang W, *et al.*: **A Novel Coronavirus From Patients With Pneumonia in China, 2019.** *N Engl J Med.* Massachusetts Medical Society, 2020; 382(8): 727–733.

[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

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Jacqueline C. Linnes 

Purdue University, West Lafayette, IN, USA

The authors provide a concise and thorough review covering COVID-19 emergence, pathogenicity, transmission and diagnostic methods, as well as challenges faced by African countries. The authors indicate that current gold standard testing methods such as RT-PCR and Chest CT scans are not accessible options given the long turnaround time (RT-PCR) and limited available personnel and implementation for these technologies. The authors describe the need for funding local development and production of RDTs to detect COVID-19 in order to achieve widespread availability and testing. The present form of the manuscript should be published given its valuable contributions for scientific review and policy but could be further improved with minor changes described below:

In section "SARS-CoV-2 transmission and pathogenesis", the authors indicate that "...almost all infections become symptomatic by day 11 (Lauer *et al.*, 2020; Rothan & Byrareddy, 2020)." However, current research (after this review was submitted, e.g. Arons *et al.*, 2020¹) indicates that many cases are asymptomatic. It would be better to qualify the statement so as not to imply that asymptomatic infection is rare.

In the COVID-19 point of care testing strategies, it is possible that a confirmatory testing protocol for RDTs could be implemented if specificity is insufficient. This could be done with with a second RDT against different antibody reactivities the way that HIV test protocols are commonly performed. Even in the case of imperfect tests, extensive testing is better than none at all.

The conclusion should definitively answer the title question: Are Africa's diagnostic challenges blunting response effectiveness? The authors have described diagnostic challenges and how they have limited effectiveness in other situations, but have not answered whether the diagnostic challenges specifically are currently limiting response effectiveness in Africa.

The conclusion indicates need for increased capacity for "assay development, device fabrication, prototyping, validation, implementation research and entrepreneurial ecosystems" (which I agree with) but the review does not highlight how this might be done and could benefit from examples

of success overcoming these challenges in the diagnostics or other fields.

The “ECDC: An overview of the rapid test situation for COVID-19 diagnosis in the EU/EEA. 2020” link currently goes to the wrong location but should go to the website:

<https://www.ecdc.europa.eu/en/publications-data/overview-rapid-test-situation-covid-19-diagnosis-eueea> or the PDF itself:

<https://www.ecdc.europa.eu/sites/default/files/documents/Overview-rapid-test-situation-for-COVID-19-diagnosis-EU-EEA.pdf>

References

1. Arons MM, Hatfield KM, Reddy SC, Kimball A, et al.: Presymptomatic SARS-CoV-2 Infections and Transmission in a Skilled Nursing Facility. *N Engl J Med*. 2020. [PubMed Abstract](#) | [Publisher Full Text](#)

Is the topic of the review discussed comprehensively in the context of the current literature?

Yes

Are all factual statements correct and adequately supported by citations?

Yes

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Yes

Competing Interests: I am the co-founder and part owner of OmniVis LLC, a startup company developing point-of-care diagnostics for detection of infectious diseases including HIV, malaria, cholera, and COVID-19.

Reviewer Expertise: development of point-of-care diagnostics for infectious diseases, microfluidics, biosensors,


I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 04 May 2020

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Kennedy O. Okeyo 

Institute for Frontier Life and Medical Sciences, Kyoto University, Kyoto, Japan

The present review by the authors provides important information on diagnostic challenges facing African countries in their combat against the ongoing COVID-19 pandemic. The paper reviews the history of the COVID-19 and traces its spread to Africa, details the mechanisms of transmission and pathogenesis of the disease in a concise and easy-to-understand style, and provides an in-depth examination of the diagnostic challenges Africa faces in assessing the full scale of the pandemic in the continent. The authors contend that most African countries lack the capacity to administer mass screening to ascertain the extent of the disease spread, and call for support toward the development of homegrown RDTs and POCTs as a strategy to achieve mass screening of COVID-19 in Africa.

Overall, the paper succeeds in presenting a concise review of COVID-19 situation in Africa, identifies diagnostic challenges and suggests POCTs as a widely deployable testing approach which, if implemented for mass screening, can be effective for monitoring the spread of the ongoing pandemic.

Hence, I find the paper to be of reasonable priority in view of the current situation, and recommend its publication even in the present form. I believe that paper contains scientifically valuable information and would be an important resource for scientists as well as policy makers in the battle against the ongoing scourge not only in Africa but worldwide.

However, in revising the article for publication, the authors may wish to consider the following minor comments/corrections:

1. The authors ought to mention the impact of mass screening/diagnostics on the existing weak health infrastructure in Africa. The success story from South Korea arose out of a highly coordinated system of diagnosis, isolation and treatment, but this may not be possible with the underdeveloped healthcare infrastructure in Africa. One concern would be that identifying positives without appropriate follow up measures can lead to public fear and stigmatization, which might undermine the intended purpose of mass screening.
2. Poor research funding has always been cited as a major hindrance to the development of homegrown scientific solutions in Africa. The authors ought to comment on the challenges facing the suggested development of RDT/POC in Africa, most notably, lack of financial support and political goodwill. Specific to the present COVID-19 case, would it be faster and cheaper importing the diagnostic tools, as is already being done by some countries?
3. The authors may wish to put "**COVID-19 point of care testing strategies**" section before "**Surmounting COVID-19 diagnostic challenges**" section, for consistency with the conclusion.
4. The authors ought to provide a clear-cut answer to the question "**Are Africa's diagnostic challenges blunting response effectiveness?**" which appears in the title. It would be nice to reassess and address the question by providing an answer to it in the conclusion part.
5. It would be informative to provide a list of some of the RDTs/POCTs available for rapid deployment or, alternatively, cite this paper (access via the URL below) which provides an updated list of POCTs.

<https://aasopenresearch.org/articles/3-8/v1>

6. The link for the reference below is not correct. Please check.

Ref: ECDC: An overview of the rapid test situation for COVID-19 diagnosis in the EU/EEA. 2020.

The link provided in the manuscript opens up this page:

<https://www.medrxiv.org/content/10.1101/2020.03.18.20038059v1>

Is the topic of the review discussed comprehensively in the context of the current literature?

Yes

Are all factual statements correct and adequately supported by citations?

Yes

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Bioengineering, Biotechnology, Biomechanics, Microfluidics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.
