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COMMENTARY

Coronavirus diseases 2019 (COVID-19) response: Highlights of Ghana’s scientific and technological innovativeness and breakthroughs

Réponse aux maladies à coronavirus 2019 (COVID-19) : faits marquants de l’innovation et des percées scientifique et technologique au Ghana

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Summary While more attention has been placed on scientific innovativeness and breakthroughs in the advanced countries’ attempt to contain the spread and develop vaccines for the Coronavirus Diseases 2019 (COVID-19), little attention has been paid to the few but significant innovations being achieved in some African countries. This is understandable because the scientific capacity and research infrastructure of most African countries are deficient and weak compared to other regions of the world. Nevertheless, the African country of Ghana, despite its acute healthcare and scientific infrastructure deficit, is achieving some innovative and scientific breakthrough in the COVID-19 fight. Ghanaian scientist was among the first in Africa to successfully sequenced the genome of the novel coronavirus (SARS-CoV-2). The country’s laboratory leading the fight has also introduced some innovative testing methods allowing the country to test a far greater scale per million than the rest of Africa. Besides, drones

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are being used to deliver samples to the laboratory centers for testing. Local scientists and developers have also developed rapid diagnostic test kits, ventilators, and solar-powered handwashing machines. This paper highlights Ghana’s innovativeness, scientific, and technological breakthroughs achieved so far in the fight against the pandemic.

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Résumé  Alors que l’on a accordé plus d’attention à l’innovation scientifique et aux percées réalisées dans le cadre des efforts des pays avancés pour contenir la propagation et mettre au point des vaccins contre les maladies à coronavirus 2019 (COVID-19), peu d’attention a été accordée aux innovations, peu nombreuses mais significatives, réalisées dans certains pays africains. Cela est compréhensible car les capacités scientifiques et les infrastructures de recherche de la plupart des pays africains sont déficientes et faibles par rapport à d’autres régions du monde. Néanmoins, le Ghana, malgré son déficit aigu en matière de soins de santé et d’infrastructures scientifiques, réalise une certaine percée scientifique et innovatrice dans la lutte contre COVID-19. Un scientifique ghanéen a été l’un des premiers en Afrique à se sequencer avec succès le génome du nouveau coronavirus (SARS-CoV-2). Le laboratoire du pays qui mène le combat a également introduit des méthodes de test innovantes permettant au pays de tester à une échelle par million bien plus grande que le reste de l’Afrique. En outre, des drones sont utilisés pour livrer des échantillons aux centres de laboratoire pour les tests. Les scientifiques et les développeurs locaux ont également mis au point des kits de tests de diagnostic rapide, des ventilateurs et des machines à laver les mains fonctionnant à l’énergie solaire. Ce document met en évidence la capacité d’innovation du Ghana et les percées scientifiques et technologiques réalisées jusqu’à présent dans la lutte contre la pandémie.

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Introduction
The outbreak of COVID-19 is continuing to have a damaging impact on all countries. While the pandemic has undoubtedly exposed humanity’s unpreparedness to contagion viruses, it has also provided one of the most challenging tests to the health and scientific community. As of 4 May 2020, over 3.4 million cases and over 239 thousand deaths have been reported globally—with Africa being the least impacted region regarding the infection and casualty rate (little over 30 thousand confirmed cases) [1]. This is perplexing as the African region is the most vulnerable, with a weak healthcare system and the least health infrastructure and testing capacity compared to other regions of the world. Indeed, the World Health Organization has issued a dire warning of the potential ravaging impact on Africa that is no new to infectious diseases and has since called on African countries to scale up their response and testing capacities.

One African country that has responded and is doing well regarding testing capability and showing some significant scientific and technological innovation and breakthrough is Ghana. Ghana recorded its first COVID-19 case on 12 March 2020 and has since recorded a total of 2719 cases with 18 deaths and 294 recoveries (as of 5 May 2020) [2]. Notably, however, Ghana has carried out the highest total number of COVID-19 tests in Africa (next to South Africa). More significantly, Ghana ranks first in Africa regarding the number of COVID-19 tests per million people. This has been achieved through a hybrid of enhanced and technologically driven contact tracing and testing, testing innovation, deployment of drone technology for sample haulage, and decentralization of testing laboratories.

Beyond the testing feat, Ghanaians scientists were among the first in Africa to successfully sequenced genomes of the SARS-CoV-2 (the virus responsible for COVID-19). This significant milestone was attained entirely by local scientists using established local capacity [3]. Local technology developers also have, among other things, developed rapid testing kits, ventilators, and solar-powered handwashing machines, some of which are currently under the validation and approval phase by the Ghana Standard Authority. The country has also scaled up the domestic production of Personal Protective Equipment’s (PPEs) and facemasks. This paper aims to highlight the scientific and technological innovation and breakthroughs achieved so far by Ghana in the COVID-19 fight.

The scientific and technological innovation and breakthroughs
As the old expression goes, “necessity is the mother of invention.” The scientific and technology community in Ghana has responded to the call to be self-reliant in the
fight against COVID-19 and has since shown and deployed some novel approach and innovativeness worth highlighting.

The 'pool testing' technique

With the initial low testing capacity and the limited test kits, including the shortage of swabs needed for the standard test, Ghanaian scientists at the University of Ghana Noguchi Memorial Institute for Medical Research (NMIMR) resorted to the innovative ‘pool testing’ method. Although pooling methods is not new as it has been used in blood banks in the past elsewhere, its innovativeness for testing ribonucleic acid in Ghana is novel. According to the Virologists at NMIMR, four main types of ribonucleic acid specimens or samples have been used in Ghana to test for the COVID-19: swab from the nose, a swab from the throat, sputum from the throat, and finally nasal lavage (a method where saltwater is introduced in the nose to be blown out) [4]. To utilize the reagents or chemicals in a very efficient manner, NMIMR pool the specimen or combines a large number of different samples and tested in a single test. If a positive result is confirmed in the mini-pool, individual testing is then carried out on the reserved samples included in the pool. This innovativeness has increased the testing capacity of the country exponentially. A calculation by the Complexity Science Hub Vienna finds that pooling tests could increase COVID-19 test efficiency by a factor of 10 (Fig. 1) [5].

Drone technology for expedite haulage of samples and PPEs

As part of Ghana’s swift response to contain the COVID-19, it became the first country in the world to introduce the use of drone technology to expedite the transport of COVID-19 test samples to laboratory centers [6]. The autonomous drones are used to haul samples taken from suspected persons in the remote parts of the country to testing facilities in the country’s two major cities (Accra and Kumasi). The test results are then delivered via Short Message Service (SMS). The drone technology secured last year for the haulage of medical supplies to remote clinics across the country allowed for quick response to the pandemic in remote areas of the country by drastically reducing the transport time. For instance, a round-trip day journey is reduced to under 30 minutes. Currently, the drone fleet is equipped to transport up to 15,000 test samples a day (in 300 flights) from two collection points (Fig. 2). “It is the first time that autonomous drones have been used to make regular long-range deliveries into densely populated urban areas, and paves the way for drone technology to play a new role in the fight against COVID-19” [7].

The COVID-19 Tracker App

To help identify symptoms and prioritize contact tracing and testing of people in high-risk communities and those who have come into contact with confirmed individuals, Ghana became one of the few countries to deploy technology to limit the spread of COVID-19. It developed and deployed a digital tool to help individuals assess and self-report symptoms of COVID-19 directly to the health institutions. The easy to use internet software app named “GH COVID-19 Tracker” could be downloaded as a mobile app or from an official link [8]. The tracker with instruction in six languages, including all the major local dialects, is also accessible on messaging platforms using the short code (*769#). Beyond tracking and tracing the spread of the pandemic, the tracker uses crowd-sourcing data to provide information on the potential locations of confirmed persons to help health authorities determine high-risk individuals and communities [9].

Development of Rapid Diagnostic Test (RDT) kits and ventilators

To augment the country’s testing capacity, ensure rapid testing results, and resourced the hospitals to deal with critical patients, scientists and technology developers in the country have locally developed RDT kits and ventilators. Researchers at the Kwame Nkrumah University of
Science and Technology and Incas Diagnostics collaborated with scientists at the Kumasi Centre for Collaborative Research (one of Ghana’s major testing centers), to locally developed RDT kits. This "COVID-19 IgG/IgM Rapid Test (Whole Blood/Serum/Plasma) is a rapid chromatographic immunoassay for the qualitative detection of IgG and IgM antibodies to SARS-CoV-2 in human whole blood, serum or plasma to augment the diagnosis of primary and secondary COVID-19 infections currently being done in Ghana" [10].

The kit, which can produce results between 15–20 minutes, will be used as complementary to the current standard Polymerase Chain Reaction (PCR) testing procedure [11].

Ghanaian scientists have also achieved another breakthrough by developing low-cost automated respirators to support the healthcare delivery of COVID-19 patients. A prototype of the ventilator, which is currently under various stage of evaluation and validation by the standards authority [12].

The invention of solar-powered automated handwashing machine and electronic bucket

Motivated by the global call to regularly wash hands with soap under running water to minimize the spread of the virus, a Ghanaian inventor has invented a solar-powered automated handwashing machine. The machine, which uses solar and minimalizes the risk of self-contamination when washing hands has received a certification from the Standards Authority to start mass production [13]. The remote sensor of the machine allows for a 15-second gap before between discharge of soap and water to hands into the barrel. A single machine can be used by at least 150 peoples before refill.

Construction of infectious diseases control centers and hospitals

At the peak of the pandemic outbreak in Wuhan, China marveled the world by constructing a 1000 bed emergency hospital within ten days. While no African country can be compared to China regarding construction capacity, Ghana’s effort to contain the pandemic has seen the country begun the construction of 100-bed infectious diseases and isolation centers to be completed just within six weeks. Further, with COVID-19 exposing the healthcare system and infrastructure, the government has committed to invest in healthcare infrastructure to support the COVID-19 fight urgently and has since committed to the construction of 94 hospitals, including 88 standard 100-bed facilities and six regional hospitals within 12 months. Besides, three infectious disease control centers are to be built for each of the zones in the country to improve the country’s testing capacities with regard to contagious diseases [14].

Domestic production of PPEs and facemasks

In response to the global disruption, hoarding, and shortage in supply of PPEs and facemasks, the government has collaborated with local manufacturers to domestically produce millions of PPEs for the COVID-19 frontline health workers. As of 26 April 2020, the country had domestically produced and supply 905,031 nose masks, 31,630 medical scrubs, 31,472 gowns, 46,870 head cover, and 83,500 N-95 facemasks [15]. The Food and Drugs Authority has also given approval and guidelines for homemade facemasks. The specification is as follows:

- dimensions:
  - length: cheek-to-cheek: 10 inches,
  - width: 6 inches,
  - thickness: three layers: not less than (NLT) 0.759 mm,
  - porosity: ≥ 10000 Pascalii;
- splash test (alcohol-based aerosol spray): no stain of alcohol-based aerosol should be seen at the reverse side of the face mask;
- filtration of bacteria: reduction of NLT 3 log.

Discussion

The COVID-19 pandemic has aroused the scientific and technological ingenuity in Ghana. The country has so far
achieved some significant innovativeness and breakthroughs never expected from a developing country with greater healthcare infrastructure and scientific deficit. Ghana’s feat demonstrates that all hope is not lost on the African continent regarding scientific contribution and innovativeness to contain the pandemic. COVID-19 should be an opportunity for African countries to upgrade their health infrastructure and build a firewall against infectious diseases.

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**Disclosure of interest**

The authors declare that they have no competing interest.

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