**ENGINEERING STRATEGIES FOR HANDLING COVID-19 FOR ENVIROMENTAL HEALTH AND ECONOMIC HEALTH AND ECONOMIC SUSTAINABILITY**

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**ABSTRACT**

The coronavirus disease 19 (COVID-19) is a highly transmittable and pathogenic viral infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which emerged in Wuhan, China and spread around the world. Genomic analysis revealed that SARS-CoV-2 is phylogenetically related to severe acute respiratory syndrome-like (SARS-like) bat viruses, therefore bats could be the possible primary reservoir. The intermediate source of origin and transfer to humans is not known, however, the rapid human to human transfer has been confirmed widely. There is no clinically approved antiviral drug or vaccine available to be used against COVID-19. However, few broad-spectrum antiviral drugs have been evaluated against COVID-19 in clinical trials, resulted in clinical recovery. In the current review, we summarize and comparatively analyze the emergence and pathogenicity of COVID-19 infection and previous human coronaviruses severe acute respiratory syndrome coronavirus (SARS-CoV) and middle east respiratory syndrome coronavirus (MERS-CoV). We also discuss the approaches for developing effective vaccines and therapeutic combinations to cope with this viral outbreak.

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CHAPTER ONE

**What is corona virus**

Coronaviruses are a group of related viruses that cause diseases in mammals and birds. In humans, coronaviruses cause respiratory tract infections that can range from mild to lethal. Mild illnesses include some cases of the common cold (which has other possible causes, predominantly rhinoviruses), while more lethal varieties can cause SARS, MERS, and COVID-19. Symptoms in other species vary: in chickens, they cause an upper respiratory tract disease, while in cows and pigs they cause diarrhea. There are yet to be vaccines or antiviral drugs to prevent or treat human coronavirus infections

**HISTORY OF CORONA VIRUS**

**Coronaviruses belong to the Coronaviridae family in the Nidovirales order. Corona represents crown-like spikes on the outer surface of the virus; thus, it was named as a coronavirus. Coronaviruses are minute in size (65–125 nm in diameter) and contain a single-stranded RNA as a nucleic material, size ranging from 26 to 32kbs in length (Fig. 1). The subgroups of coronaviruses family are alpha (α), beta (β), gamma (γ) and delta (δ) coronavirus. The severe acute respiratory syndrome coronavirus (SARS-CoV), H5N1 influenza A, H1N1 2009 and Middle East respiratory syndrome coronavirus (MERS-CoV) cause acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) which leads to pulmonary failure and result in fatality. These viruses were thought to infect only animals until the world witnessed a severe acute respiratory syndrome (SARS) outbreak caused by SARS-CoV, 2002 in Guangdong, China [1]. Only a decade later, another pathogenic coronavirus, known as Middle East respiratory syndrome coronavirus (MERS-CoV) caused an endemic in Middle Eastern countries [2].**

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**Fig. 1. Structure of respiratory syndrome causing human coronavirus.**

**Recently at the end of 2019, Wuhan an emerging business hub of China experienced an outbreak of a novel coronavirus that killed more than eighteen hundred and infected over seventy thousand individuals within the first fifty days of the epidemic. This virus was reported to be a member of the β group of coronaviruses. The novel virus was named as Wuhan coronavirus or 2019 novel coronavirus (2019-nCov) by the Chinese researchers. The International Committee on Taxonomy of Viruses (ICTV) named the virus as SARS-CoV-2 and the disease as COVID-19 [3], [4], [5]. In the history, SRAS-CoV (2003) infected 8098 individuals with mortality rate of 9%, across 26 contries in the world, on the other hand, novel corona virus (2019) infected 120,000 induviduals with mortality rate of 2.9%, across 109 countries, till date of this writing. It shows that the transmission rate of SARS-CoV-2 is higher than SRAS-CoV and the reason could be genetic recombination event at S protein in the RBD region of SARS-CoV-2 may have enhanced its transmission ability. In this review article, we discuss the origination of human coronaviruses briefly. We further discuss the associated infectiousness and biological features of SARS and MERS with a special focus on COVID-19.**

**Comparative analysis of emergence and spreading of coronaviruses**

**In 2003, the Chinese population was infected with a virus causing Severe Acute Respiratory Syndrome (SARS) in Guangdong province. The virus was confirmed as a member of the Beta-coronavirus subgroup and was named SARS-CoV [6], [7]. The infected patients exhibited pneumonia symptoms with a diffused alveolar injury which lead to acute respiratory distress syndrome (ARDS). SARS initially emerged in Guangdong, China and then spread rapidly around the globe with more than 8000 infected persons and 776 deceases. A decade later in 2012, a couple of Saudi Arabian nationals were diagnosed to be infected with another coronavirus. The detected virus was confirmed as a member of coronaviruses and named as the Middle East Respiratory Syndrome Coronavirus (MERS-CoV). The World health organization reported that MERS-coronavirus infected more than 2428 individuals and 838 deaths [8]. MERS-CoV is a member beta-coronavirus subgroup and phylogenetically diverse from other human-CoV. The infection of MERS-CoV initiates from a mild upper respiratory injury while progression leads to severe respiratory disease. Similar to SARS-coronavirus, patients infected with MERS-coronavirus suffer pneumonia, followed by ARDS and renal failure [9].**

**Recently, by the end of 2019, WHO was informed by the Chinese government about several cases of pneumonia with unfamiliar etiology. The outbreak was initiated from the Hunan seafood market in Wuhan city of China and rapidly infected more than 50 peoples. The live animals are frequently sold at the Hunan seafood market such as bats, frogs, snakes, birds, marmots and rabbits [10]. On 12 January 2020, the National Health Commission of China released further details about the epidemic, suggested viral pneumonia [10]. From the sequence-based analysis of isolates from the patients, the virus was identified as a novel coronavirus. Moreover, the genetic sequence was also provided for the diagnosis of viral infection. Initially, it was suggested that the patients infected with Wuhan coronavirus induced pneumonia in China may have visited the seafood market where live animals were sold or may have used infected animals or birds as a source of food. However, further investigations revealed that some individuals contracted the infection even with no record of visiting the seafood market. These observations indicated a human to the human spreading capability of this virus, which was subsequently reported in more than 100 countries in the world. The human to the human spreading of the virus occurs due to close contact with an infected person, exposed to coughing, sneezing, respiratory droplets or aerosols. These aerosols can penetrate the human body (lungs) via inhalation through the nose or mouth (Firing** is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). This field seeks to close the gap between engineering and medicine, combining the design and problem solving skills of engineering with medical biological sciences to advance health care treatment, including diagnosis, monitoring, and therapy. Also included under the scope of a biomedical engineer is the management of current medical equipment within hospitals while adhering to relevant industry standards. This involves making equipment recommendations, procurement, routine testing and preventive maintenance, a role also known as a Biomedical Equipment Technician (BMET) or as clinical engineering

**CHAPTER 2**

**ELECRTRICAL/ELECTRONIC ENGINNERING IN MEDICINE**

There are different strategies that can be put in place for the enhancement of environmental health and to help in curbing pandemics, in the case of the coronavirus(COVID-19) due to the complexity of the virus it tends to affect the respiratory ducts living patients docile due to the lack of air caused by fibrosis however electronics engineering can be implemented in the case of ventilation process, machines can be built to help in assisting respiration an example of thus electrical machines is a ventilator

**WHAT IS A VENTILATOR**

A **ventilator** is a machine that provides mechanical ventilation by moving breathable air into and out of the lungs, to deliver breaths to a patient who is physically unable to breathe, or breathing insufficiently. Modern ventilators are computerized microprocessor controlled machines, but patients can also be ventilated with a simple, hand-operated bag valve mask. Ventilators are chiefly used in intensive care medicine, home care, and emergency medicine (as standalone units) and in anesthesiology (as a component of an anesthesia machine).

Ventilators are sometimes called respirators, a term commonly used for them in the 1950s (particularly the "Bird respirator”). However, in contemporary hospital and medical terminology, a respirator is a protective face mask

**FUNCTION OF ELECTRIC IN MEDICINE**

**Electronics for Medicine, commonly known as "E for M," was a pioneering company in medical electronics. Founded in the 1950s by Martin Scheiner to make instrumentation for recording physiological signals from the heart, it was based in Westchester County, New York.[1]**

**Its product line ultimately included instrumentation for all cardiac-related medical procedures,[2] including electrocardiography, electrophysiology, echocardiography, and patient monitoring. Its DR and VR series physiological recorders were used in almost every cardiac catheterization laboratory from the 1950s well into the 1980s, and are widely mentioned in cardiology papers of that era (e.g.,[3]). It was initially developed for André Cournand of Columbia University, who shared the Nobel Prize for Medicine with Dickinson W. Richards and Werner Forssmann for work exploring the interior of the heart.**

**In 1979, the company was sold to Honeywell, and its name was changed to E for M/Honeywell. Scheiner shared more than $1 million of the proceeds of the sale with employees, gifting them $50 for each month they worked for E for M.[4] It was later sold to PPG Industries, and disappeared a few years after**

**HISTORY OF VENTILATORS**

The history of mechanical ventilation begins with various versions of what was eventually called the [iron lung](https://en.wikipedia.org/wiki/Negative_pressure_ventilator%22%20%5Co%20%22Negative%20pressure%20ventilator), a form of noninvasive negative pressure ventilator widely used during the [polio](https://en.wikipedia.org/wiki/Poliomyelitis%22%20%5Co%20%22Poliomyelitis) epidemics of the twentieth century after the introduction of the "Drinker respirator" in 1928, improvements introduced by [John Haven Emerson](https://en.wikipedia.org/wiki/John_Haven_Emerson%22%20%5Co%20%22John%20Haven%20Emerson) in 1931, and the [Both respirator](https://en.wikipedia.org/wiki/Both_respirator%22%20%5Co%20%22Both%20respirator) in 1937. Other forms of noninvasive ventilators, also used widely for polio patients, include [Biphasic Cuirass Ventilation](https://en.wikipedia.org/wiki/Biphasic_Cuirass_Ventilation%22%20%5Co%20%22Biphasic%20Cuirass%20Ventilation), the rocking bed, and rather primitive positive pressure machines.

In 1949, John Haven Emerson developed a mechanical assister for anaesthesia with the cooperation of the anaesthesia department at [Harvard University](https://en.wikipedia.org/wiki/Harvard_University%22%20%5Co%20%22Harvard%20University). Mechanical ventilators began to be used increasingly in anaesthesia and intensive care during the 1950s. Their development was stimulated both by the need to treat polio patients and the increasing use of [muscle relaxants](https://en.wikipedia.org/wiki/Muscle_relaxant%22%20%5Co%20%22Muscle%20relaxant) during anaesthesia. Relaxant drugs paralyse the patient and improve operating conditions for the surgeon but also paralyse the respiratory muscles.



An East-Radcliffe respirator model from the mid-twentieth century

In the United Kingdom, the East Radcliffe and Beaver models were early examples. The former used a [Sturmey-Archer](https://en.wikipedia.org/wiki/Sturmey-Archer%22%20%5Co%20%22Sturmey-Archer) bicycle [hub gear](https://en.wikipedia.org/wiki/Hub_gear%22%20%5Co%20%22Hub%20gear) to provide a range of speeds, and the latter an automotive [windscreen wiper](https://en.wikipedia.org/wiki/Windscreen_wiper%22%20%5Co%20%22Windscreen%20wiper) motor to drive the bellows used to inflate the lungs.[[5]](https://en.wikipedia.org/wiki/Ventilator%22%20%5Cl%20%22cite_note-pmid13320798-5) Electric motors were, however, a problem in the operating theatres of that time, as their use caused an explosion hazard in the presence of flammable anaesthetics such as [ether](https://en.wikipedia.org/wiki/Diethyl_ether%22%20%5Co%20%22Diethyl%20ether) and [cyclopropane](https://en.wikipedia.org/wiki/Cyclopropane%22%20%5Co%20%22Cyclopropane). In 1952, Roger Manley of the [Westminster Hospital](https://en.wikipedia.org/wiki/Westminster_Hospital%22%20%5Co%20%22Westminster%20Hospital), London, developed a ventilator which was entirely gas-driven and became the most popular model used in Europe. It was an elegant design, and became a great favourite with European anaesthetists for four decades, prior to the introduction of models controlled by electronics. It was independent of electrical power and caused no explosion hazard. The original Mark I unit was developed to become the Manley Mark II in collaboration with the Blease company, which manufactured many thousands of these units. Its principle of operation was very simple, an incoming gas flow was used to lift a weighted bellows unit, which fell intermittently under gravity, forcing breathing gases into the patient's lungs. The inflation pressure could be varied by sliding the movable weight on top of the bellows. The volume of gas delivered was adjustable using a curved slider, which restricted bellows excursion. Residual pressure after the completion of expiration was also configurable, using a small weighted arm visible to the lower right of the front panel. This was a robust unit and its availability encouraged the introduction of positive pressure ventilation techniques into mainstream European anesthetic practice.

The 1955 release of [Forrest Bird](https://en.wikipedia.org/wiki/Forrest_Bird%22%20%5Co%20%22Forrest%20Bird)'s "Bird Universal Medical Respirator" in the United States changed the way mechanical ventilation was performed, with the small green box becoming a familiar piece of medical equipment.[[6]](https://en.wikipedia.org/wiki/Ventilator%22%20%5Cl%20%22cite_note-AboutBird-6) The unit was sold as the Bird Mark 7 Respirator and informally called the "Bird". It was a [pneumatic](https://en.wikipedia.org/wiki/Pneumatics%22%20%5Co%20%22Pneumatics) device and therefore required no [electrical power](https://en.wikipedia.org/wiki/Electrical_power%22%20%5Co%20%22Electrical%20power) source to operate.

In 1965, the Army Emergency Respirator was developed in collaboration with the Harry Diamond Laboratories (now part of the [U.S. Army Research Laboratory](https://en.wikipedia.org/wiki/United_States_Army_Research_Laboratory%22%20%5Co%20%22United%20States%20Army%20Research%20Laboratory)) and [Walter Reed Army Institute of Research](https://en.wikipedia.org/wiki/Walter_Reed_Army_Institute_of_Research%22%20%5Co%20%22Walter%20Reed%20Army%20Institute%20of%20Research). Its design incorporated the principle of fluid amplification in order to govern pneumatic functions. Fluid amplification allowed the respirator to be manufactured entirely without moving parts, yet capable of complex resuscitative functions. Elimination of moving parts increased performance reliability and minimized maintenance. The mask is composed of a [poly(methyl methacrylate)](https://en.wikipedia.org/wiki/Poly%28methyl_methacrylate%29%22%20%5Co%20%22Poly%28methyl%20methacrylate%29) (commercially known as [Lucite](https://en.wikipedia.org/wiki/Poly%28methyl_methacrylate%29%22%20%5Co%20%22Poly%28methyl%20methacrylate%29)) block, about the size of a pack of cards, with machined channels and a cemented or screwed-in cover plate. The reduction of moving parts cut manufacturing costs and increased durability.

The bistable fluid amplifier design allowed the respirator to function as both a respiratory assistor and controller. It could functionally transition between assistor and controller automatically, based on the patient's needs. The dynamic pressure and turbulent jet flow of gas from inhalation to exhalation allowed the respirator to synchronize with the breathing of the patient.

Intensive care environments around the world revolutionized in 1971 by the introduction of the first SERVO 900 ventilator (Elema-Schönander). It was a small, silent and effective electronic ventilator, with the famous SERVO feedback system controlling what had been set and regulating delivery. For the first time, the machine could deliver the set volume in volume control ventilation.

Ventilators used under increased pressure (hyperbaric) require special precautions and few ventilators can operate under these conditions. In 1979, Sechrist Industries introduced their Model 500A ventilator which was specifically designed for use with [hyperbaric chambers](https://en.wikipedia.org/wiki/Hyperbaric_chamber%22%20%5Co%20%22Hyperbaric%20chamber).

**CHAPTER 3**

**IMPORTANCE OF COMMUNICATION, CONNECTIVITY(5G) AND ROBOTICS IN HANDLING A PANDEMIC**

The world is considered a global village, due to the ease of access to information and connectivity but it also isn’t the only reason the world is a global village. Other examples of why the world can be considered a global village is trade, ease of transportation thus factors can be detrimental in a case of a pandemic especially if the virus is easily transmitted, various precautions can be taking to reduce the impact of such pandemics like social distancing and basic hygiene but such measures aren’t enough. For the safety of the health workers and citizens connectivity and robotics comes into play.

**WAYS 5G AND ROBOTICS CAN BE APPLIED IN THE MEDICAL FIELD**

**Remote surgery and patient care**

Many believe that 5G will revolutionize how medical staff perform surgery and administer medical treatments. These innovations include “tele-presence,” where a surgeon watch a real-time operation and can provide expert support, and “tele-surgery,” where the doctor actually operates the surgical device remotely.

4G networks are not suitable for these types of applications because the lag time between input and output can sometimes be as long as 2 seconds—a delay long enough to prove devastating in an operating room.

5G, on the other hand, aims to reduce latency to an almost instantaneous 2 milliseconds between devices.

Further, as 5G services expand for the medical field, it may no longer be necessary for patients to be transported a specific clinic or specialist. Instead, they can undergo a remote consultation, saving both doctor and patient time and making it possible for individuals who struggle to receive care to be more appropriately treated.

Recently, the first laparoscopy surgical procedure—in which a fiber-optic instrument is inserted through the abdominal wall—was performed at the Skolkovo Innovation Center in Moscow using 5G. The procedure, which involved the use of a laparoscope and 4K camera connected to the 5g network, resulted in the successful removal of a cancer tumor.

**Medical data**

Finally, 5G promises to transform medical field by drastically increasing the amount and quality of valuable medical data that can be gathered and processed at high speed. From medical records to larger image files from MRI or CAT scans, a single patient can generate hundreds of gigabytes of data each day. The transfer of this data can be hugely aided by the implementation of a 5G, improving care by reducing the time it takes to reach a diagnosis and to begin treatment.

In addition, surgeons can receive real-time data from their patients during surgery, and medical specialists will all be able to work together from across the world.

**Pathology and diagnoses**

A few weeks ago, [Samsung Medical Center (SMC) and Korean telecom KT Corporation announced their partnership to develop 5G medical services](https://www.prnewswire.com/news-releases/kt-and-samsung-medical-center-to-build-5g-smart-hospital-300989452.html%22%20%5Ct%20%22_blank) to support the development of smart hospitals, including improving pathology services, or the study of a disease or ailment’s causes and effects.

KT has built an enterprise-dedicated 5G network at SMC, which includes a 5G-powered digital pathological analysis. According to the companies, the digital pathological analysis is a world-first example of using 5G technology for on-site medical problems.

Previously, diagnostic pathology at the Korean hospital involved sending tissues taken from the patient during surgery to pathologists in an adjacent room, a process that required roughly 20 minutes and made on-site group analyses a challenge.

Now, doctors will be able to utilize the high speed and low latency of the 5G network to efficiently and quickly access pathological data obtained during surgery, as well as access relevant materials and files from anywhere in the world, which ensures better medical services. Obtaining this information quickly is critical in determining the conditions of patients during a procedure.

In China, [ZTE and China Telecom are claiming to have developed China’s first 5G remote diagnosis of the new coronavirus pneumonia](https://www.rcrwireless.com/20200127/5g/zte-china-telecom-complete-5g-remote-diagnosis-new-coronavirus%22%20%5Ct%20%22_blank) backed up with the latest 5G technology.

The pneumonia-like virus was first reported in Wuhan, China, on December 31, 2019, and has subsequently spread to various other countries, causing worldwide concern.

Since the outbreak, ZTE and China Telecom have been moving quickly. First, the two built interconnected 5G indoor base stations on January 25, connecting the conference room for remote diagnosis and treatment in West China Hospital to the remote diagnosis and treatment system; and then, completed the construction, optimization, speed test and commissioning of the 5G indoor distribution system at another core point of the remote diagnosis and treatment system the following day.

In arrangement with the Sichuan Health and Health Commission, the 5G remote consultation system will access 27 hospitals that have accepted and treated patients. ZTE will then build China’s first 5G remote diagnosis coronavirus infection system covering the Sichuan province, city and county to provide a single network for remote diagnosis in front-line hospitals.

**Staff-patient communication**

[AT&T is working with The Lawrence J. Ellison Institute for Transformative Medicine of USC to open a “smart” facility](https://www.prnewswire.com/news-releases/uscs-ellison-institute-leverages-state-of-the-art-wireless-networks-to-build-next-generation-smart-facility-that-enhances-connections-between-researchers-and-patients-300981677.html%22%20%5Ct%20%22_blank) to further advance the multidisciplinary cancer research ecosystem. One of the partnerships goals is to use the telecom’s 5G network to ‘revolutionize the communication between researchers and patients.’

According a press release, the pair will accomplish this by equipping the building with multi access edge computing (MEC), artificial intelligence (AI) and various other technology from AT&T to power the facility

Conclusion and perspective

The novel coronavirus originated from the Hunan seafood market at Wuhan, China where bats, snakes, raccoon dogs, palm civets, and other animals are sold, and rapidly spread up to 109 countries. The zoonotic source of SARS-CoV-2 is not confirmed, however, sequence-based analysis suggested bats as the key reservoir. DNA recombination was found to be involved at spike glycoprotein which assorted SARS-CoV (CoVZXC21 or CoVZC45) with the RBD of another Beta CoV, thus could be the reason for cross-species transmission and rapid infection. According to phylogenetic trees, SARS-CoV is closer to SARS-like bat CoVs. Until now, no promising clinical treatments or prevention strategies have been developed against human coronaviruses. However, the researchers are working to develop efficient therapeutic strategies to cope with the novel coronaviruses. Various broad-spectrum antivirals previously used against influenza, SARS and MERS coronaviruses have been evaluated either alone or in combinations to treat COVID-19 patients, mice models, and clinical isolates. Remdesivir, Lopinavir, Ritonavir, and Oseltamivir significantly blocked the COVID-19 infection in infected patients. It can be cocluded that the homologus recombination event at the S protein of RBD region enhanced the transmission ability of the virus. While the decision of bring back the nationals from infected area by various countries and poor screening of passengers, become the leading cause of spreading virus in others countries.

Most importantly, human coronaviruses targeting vaccines and antiviral drugs should be designed that could be used against the current as well as future epidemics. There are many companies working for the development of effective SARS-CoV-2 vaccines, such as Moderna Therapeutics, Inovio Pharmaceuticals, Novavax, Vir Biotechnology, Stermirna Therapeutics, Johnson & Johnson, VIDO-InterVac, GeoVax-BravoVax, Clover Biopharmaceuticals, CureVac, and Codagenix. But there is a need for rapid human and animal-based trails as these vaccines still require 3–10 months for commercialization. There must be a complete ban on utilizing wild animals and birds as a source of food. Beside the development of most efficient drug, a strategy to rapidly diagnose SARS-CoV-2 in suspected patient is also required. The signs and symptoms of SARS-CoV-2 induced COVID-19 are a bit similar to influenza and seasonal allergies (pollen allergies). Person suffering from influenza or seasonal allergy may also exhibit temprature which can be detected by thermo-scanners, hence the person will become suspected. Therefore, an accurate and rapid diagnostic kit or meter for detection of SARS-CoV-2 in suspected patients is required, as the PCR based testing is expensive and time consuming. Different teams of Chinese doctors should immediately sent to Eurpean and other countries, especially spain and Italy to control the over spread of COVID-19, because Chinese doctors have efficiently controlled the outbreak in china and limited the mortality rate to less than 3% only. The therapeutic strategies used by Chinese, should also be followed by other countries.

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Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest.

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