**DEVELOPMENT OF ENVIRONMENTAL HEALTH, ENGINEERING FACILITIES, EQUIPMENT, SENSORS AND PUBLIC HEALTH SYSTEMS FOR TACKLING COVID-19 PANDEMIC**

**PREPARED BY**

**OMOJOLA TEMILOLUWA OLUWATOMISIN**

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**ENGR OYEBODE**

**COLLEGE OF ENGINEERING,**

**AFE BABALOLA UNIVERSITY, ADO-EKITI, EKITI STATE, NIGERIA.**

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# ABSTRACT

This paper focuses on how engineers can help in developing more health aiding equipment and facilities that will tackle pandemics like COVID-19 and will also help contain the viruses.

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# CHAPTER 1

# INTRODUCTION

## WHAT IS CORONAVIRUS?

Coronaviruses are a large family of viruses which may cause illness in animals or humans.  In humans, several coronaviruses are known to cause respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). The most recently discovered coronavirus causes coronavirus disease COVID-19.

## WHAT IS COVID-19?

COVID-19 is the infectious disease caused by the most recently discovered coronavirus. This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019.

## WHAT ARE THE SYMPTOMS OF COVID-19?

The most common symptoms of COVID-19 are fever, tiredness, and dry cough. Some patients may have aches and pains, nasal congestion, runny nose, sore throat or diarrhea. These symptoms are usually mild and begin gradually. Some people become infected but don’t develop any symptoms and don't feel unwell. Most people (about 80%) recover from the disease without needing special treatment. Around 1 out of every 6 people who gets COVID-19 becomes seriously ill and develops difficulty breathing. Older people, and those with underlying medical problems like high blood pressure, heart problems or diabetes, are more likely to develop serious illness. People with fever, cough and difficulty breathing should seek medical attention.

## HOW DOES COVID-19 SPREAD?

People can catch COVID-19 from others who have the virus. The disease can spread from person to person through small droplets from the nose or mouth which are spread when a person with COVID-19 coughs or exhales. These droplets land on objects and surfaces around the person. Other people then catch COVID-19 by touching these objects or surfaces, then touching their eyes, nose or mouth. People can also catch COVID-19 if they breathe in droplets from a person with COVID-19 who coughs out or exhales droplets. This is why it is important to stay more than 1 meter (3 feet) away from a person who is sick.

## HOW CAN THE SPREAD BE PREVENTED AND HOW CAN PEOPLE BE PROTECTED?

Stay aware of the latest information on the COVID-19 outbreak, available on the WHO website and through your national and local public health authority. Many countries around the world have seen cases of COVID-19 and several have seen outbreaks. Authorities in China and some other countries have succeeded in slowing or stopping their outbreaks. However, the situation is unpredictable so check regularly for the latest news.

You can reduce your chances of being infected or spreading COVID-19 by taking some simple precautions:

* Regularly and thoroughly clean your hands with an alcohol-based hand rub or wash them with soap and water.
Why? Washing your hands with soap and water or using alcohol-based hand rub kills viruses that may be on your hands.
* Maintain at least 1 metre (3 feet) distance between yourself and anyone who is coughing or sneezing.
Why? When someone coughs or sneezes they spray small liquid droplets from their nose or mouth which may contain virus. If you are too close, you can breathe in the droplets, including the COVID-19 virus if the person coughing has the disease.
* Avoid touching eyes, nose and mouth.
Why? Hands touch many surfaces and can pick up viruses. Once contaminated, hands can transfer the virus to your eyes, nose or mouth. From there, the virus can enter your body and can make you sick.
* Make sure you, and the people around you, follow good respiratory hygiene. This means covering your mouth and nose with your bent elbow or tissue when you cough or sneeze. Then dispose of the used tissue immediately.
Why? Droplets spread virus. By following good respiratory hygiene you protect the people around you from viruses such as cold, flu and COVID-19.
* Stay home if you feel unwell. If you have a fever, cough and difficulty breathing, seek medical attention and call in advance. Follow the directions of your local health authority.
Why? National and local authorities will have the most up to date information on the situation in your area. Calling in advance will allow your health care provider to quickly direct you to the right health facility. This will also protect you and help prevent spread of viruses and other infections.
* Keep up to date on the latest COVID-19 hotspots (cities or local areas where COVID-19 is spreading widely). If possible, avoid traveling to places  – especially if you are an older person or have diabetes, heart or lung disease.
Why? You have a higher chance of catching COVID-19 in one of these areas.

Protection measures for persons who are in or have recently visited (past 14 days) areas where COVID-19 is spreading

* Follow the guidance outlined above (Protection measures for everyone)
* Self-isolate by staying at home if you begin to feel unwell, even with mild symptoms such as headache, low grade fever (37.3 C or above) and slight runny nose, until you recover. If it is essential for you to have someone bring you supplies or to go out, e.g. to buy food, then wear a mask to avoid infecting other people.
Why? Avoiding contact with others and visits to medical facilities will allow these facilities to operate more effectively and help protect you and others from possible COVID-19 and other viruses.
* If you develop fever, cough and difficulty breathing, seek medical advice promptly as this may be due to a respiratory infection or other serious condition. Call in advance and tell your provider of any recent travel or contact with travelers.
Why? Calling in advance will allow your health care provider to quickly direct you to the right health facility. This will also help to prevent possible spread of COVID-19 and other viruses.

# CHAPTER 2

# LITERATURE REVIEW

Engineering is the use of scientific principles to design and build machines, structures, and other items, including bridges, tunnels, roads, vehicles, and buildings.

Engineers, bioengineers work to [help improve the lives of patients](https://www.asme.org/engineering-topics/articles/bioengineering/bioengineers-are-enhancing-quality-of-healthcare) living with various conditions in a variety of ways, including through the design of new digital tools, software platforms, instruments and other devices. In essence, the practice of bioengineering refers to the design and creation of technologies that aid the health care process in some way. For example, commonplace medical devices that can be credited to the bioengineering field include MRI machines and dialysis machines. Innovation in this area of engineering will no doubt continue in accordance with the development of technology — improving health care and patient outcomes in the process.

This technology has an important potential role in supporting the health and wellbeing of an ageing population. Modern medicine and healthcare rely heavily on engineering to deliver improved prevention, diagnosis and treatment of illness.

Development put into simple terms may be defined as the act or process of growing or causing something to grow or become larger or more advanced.

Health is "a state of complete physical, mental, and social well-being and not merely the absence of disease" according to the World Health Organization (WHO). Physical is about the body. Mental is about how people think and feel.

Health development is the process of constant, progressive enhancement of the health status of a population. The notion of development as a managed process has been derived from work in the field of economic and social development studies, and is now being applied to health systems.

The relationship between the health of a population and the state of development of a society is complex and varies over time. Throughout history, improved health has been one of the main benefits of development. This benefit results partly from an increase in income and partly from scientific progress in the fight against disease and disability. This second factor is increasingly important compared to simple economic growth. Reciprocally, health could be expected to have a favorable effect on development, although this effect is more difficult to detect. Nevertheless, health can be considered part of a society's capital stock, as long as the essential differences between this type of capital and physical capital are recognized. These differences, in turn, provide an insight into the health services market and, in particular, into the tendency to spend more and more resources on health. It is necessary to respect the intrinsic value of human capital, rather than focusing strictly on the economic productivity that may be derived from it, in order to prevent discrimination against children, the elderly, the poor, or the disabled.

Public health systems are commonly defined as “all public, private, and voluntary entities that contribute to the delivery of essential public health services within a jurisdiction.” This concept ensures that all entities’ contributions to the health and well-being of the community or state are recognized in assessing the provision of public health services. The public health system includes

* Public health agencies at state and local levels
* Healthcare providers
* Public safety agencies
* Human service and charity organizations
* Education and youth development organizations
* Recreation and arts-related organizations
* Economic and philanthropic organizations
* Environmental agencies and organizations

# CHAPTER 3

# METHODOLOGY

## HOW HAS ENGINEERING HELPED MEDICINE AND HEALTH SCIENCES (MHS)

Engineering in MHS can also be called biomedical engineering or healthcare engineering.

The purpose of Healthcare Engineering is to improve human health and well-being through engineering approaches. Almost all engineering disciplines (e.g., Biomedical, Chemical, Civil, Computer, Electrical, Environmental, Industrial, Information, Materials, Mechanical, Software, and Systems Engineering) have made significant contributions and brought about advances in healthcare. Contributions have also been made by healthcare professionals (e.g., physicians, dentists, nurses, pharmacists, allied health professionals, and health scientists) who are engaged in supporting, improving, and/or advancing healthcare through engineering approaches. Healthcare Engineering is a multi-disciplinary specialty that focuses on advancing healthcare through engineering approaches involving both healthcare and engineering professionals. Healthcare Engineering is expected to play a role of growing importance as healthcare continues to be one of the world's largest and fastest-growing industries where engineering is a major factor of advancement through creating, developing, and implementing cutting-edge devices, systems, and procedures attributed to breakthroughs in electronics, information technology, miniaturization, material science, optics, and other fields, to address challenges associated with issues such as the continued rise in healthcare costs, the quality and safety of healthcare, care of the aging population, management of common diseases, the impact of high technology, increasing demands for regulatory compliance, risk management, and reducing litigation risk. As the demand for engineers continues to increase in healthcare, Healthcare Engineering will be recognized as the most important profession where engineers make major contributions directly benefiting human health.

Healthcare Engineering covers the following two major fields:

I. Engineering for Healthcare Intervention: Engineering involved in the development or provision of any treatment, preventive care, or test that a person could take or undergo to improve health or to help with a particular health problem.

II. Engineering for Healthcare Systems: Engineering involved in the complete network of organizations, agencies, facilities, information systems, management systems, financing mechanisms, logistics, and all trained personnel engaged in delivering healthcare within a geographical area.

Healthcare Engineering professionals are mainly: (a) engineers from all engineering disciplines such as Biomedical, Chemical, Civil, Computer, Electrical, Environmental, Industrial, Information, Materials, Mechanical, Software, and Systems Engineering, and (b) healthcare professionals such as physicians, dentists, nurses, pharmacists, allied health professionals, and health scientists, who are engaged in supporting, improving, and/or advancing any aspect of healthcare through engineering approaches, in accordance with the above definition of Healthcare Engineering. Since some healthcare professionals engaged in Healthcare Engineering may not be considered to be “engineers”, “Healthcare Engineering professional” is a more appropriate term than “Healthcare Engineer”.

Engineers from almost all engineering disciplines (such as Biomedical, Chemical, Civil, Computer, Electrical, Environmental, Industrial, Information, Materials, Mechanical, Software, and Systems Engineering) are always in demand in healthcare. It is a common misconception that only engineers with a background in Biomedical Engineering, Clinical Engineering, or related areas may work in healthcare. However, there is a need for courses and certificate type of programs that prepare non-biomedical engineering students and practicing engineers for service in healthcare. On the other hand, healthcare professionals (physicians, dentists, nurses, pharmacists, allied health professionals, etc.) may benefit from training to apply engineering to their practice, problem solving, and advancing healthcare. Due to the rapid advance of technology, continuing education plays a crucial role in ensuring Healthcare Engineering professionals’ continued competence.

## HOW WILL ENGINEERING HELP TACKLE THE COVID-19?

As engineers we are trained to innovative and find adequate solutions to problems in the world.

COVID-19 is a problem and we have a role to play in ensuring the virus is well managed and contained.

From its origins in Wuhan, China to the UK, the novel coronavirus is causing disruption and applying pressure to healthcare systems across the world. With our NHS under extreme strain at the moment, it's important that we're doing all we can to help flatten the curve and significantly decrease the number of cases we are seeing.

Many businesses have temporarily shut or are working with a skeleton staff to limit the spread of the virus. But, for those in engineering, you might find yourself with an increased workload, because engineers have certain facilities and skills that could help our National Health Service tackle COVID-19. Here, I will be discussing what admirable actions engineering companies have already taken, and what you can do to help make a difference.

## Three things that engineering companies can do to help fight COVID-19

Engineering companies are gearing up to help tackle the pandemic, and while we have seen all kinds of creative solutions to key problems, here are just three:

### Design and manufacture respiratory equipment

The symptoms of the novel coronavirus have created a unique and urgent demand for many crucial pieces of healthcare equipment. For one, the need for respiratory ventilators is rapidly increasing as more and more hospitals find themselves without the resources to cope with a huge number of COVID-19 cases.

In fact, these lifesaving pieces of equipment are so essential right now that the government has issued a plea for companies who can supply ventilators or ventilator components to offer their services.

### Provide personal protective equipment (PPE)

We are all feeling the immense pressure to take care when venturing out of the house and to only do so when necessary. But the doctors and nurses who are working on the frontline can't stay home, so it's absolutely crucial that they have the right personal PPE to keep them safe from the virus while assisting those suffering from the symptoms of COVID-19.

This has created an immediate demand for medical equipment, including N95 fluid-resistant face masks, disposable gloves, and surgical gowns and aprons that can help to limit the spread between doctors and coronavirus patients. In fact, these are considered so crucial in protecting healthcare professionals from contracting the virus themselves that GPs are beginning to call for the same protective measures to be brought into place rather than PPE just being offered to hospital staff.

### Build temporary hospitals or donate materials

We seem to be following Wuhan's pattern of infection and the lifespan of the coronavirus, so it's expected that we will very shortly reach a peak where temporary hospitals are going to have to be built to cope with the rising number of cases. And, while NHS Nightingale has already been built in London to cope with the demand for care, there are still other things we can be doing to maximise the number of people getting access to treatment.

For example, donating any empty shipping containers to the healthcare system can mean there are many more temporary intensive care units (ICUs) for patients in life-threatening states to be treated. Along with this, being able to offer any other helpful materials and manpower to help make these will be appreciated.

## How engineering companies are already helping

With an increased demand for everything from temporary hospitals to PPE and lifesaving medical equipment, many engineering companies have already started to lend a hand to help provide these critical supplies. For example, Dyson and Airbus have been given the green light to begin creating up to 30,000 ventilators to help the NHS fight COVID-19 as part of The Ventilator Challenge UK consortium's plan.

There have now been multi-million-pound orders of the ventilators from the government who are wholeheartedly backing the prototypes. However, it's clear that these two companies cannot make the necessary number of ventilators on their own, and therefore will need to work alongside other members of the consortium.

Overseas, efforts have certainly ramped up, with the Massachusetts Institute of Technology (MIT) teaming up with an Italian design company to create pre-fabricated ICUs made from shipping containers to deal with the rapidly increasing number of COVID-19 cases.

These have been designed so that they can be joined together to create mobile field hospitals, and are supposedly very easy to arrange while having the same properties of containing infection as hospitals do. And, this can be easily replicated in the UK if we have enough donations from companies with empty shipping containers.

The printing industry is also providing a lot of help in equipping the NHS to fight this virus, with 3D printing company Stratasys producing 5,000 disposable face masks for hospitals in the US.

If you're able to offer similar services within the UK, take a leaf out of Stratasys' book and be sure to publish the full production and assembly plan somewhere public. As well as encouraging others in your position to do the same, it could also mean businesses that are able to help with any stage of your production process will be able to get in touch and volunteer their resources or assistance.

Similarly, if your manufacturing or cleaning company is temporarily closing down, donating any critical PPE supplies to healthcare professionals can ensure both the mental and physical health of these workers is supported while tackling the coronavirus.

## How to ensure your workers are protected during COVID-19

While you'll be busy innovating and working as quickly as possible to bring out resources that will help our healthcare system to respond quickly to COVID-19, it's important that you're protecting your own employees from the virus.

For one, any non-essential work should be ceased and any workers that don't need to be in to help with the production of critical supplies should be sent home. In general, the government guidelines are advising people to stay at home for a three-week period, and this is particularly crucial if workers are experiencing any of the symptoms of COVID-19, no matter how mild.

But, for those who are still in work, it's important they are following health and safety guidelines to limit the spread of infection through asymptomatic individuals.

You can do this by imposing rules that ensure employees are always kept two metres apart , and wear gloves and facemasks if they are working among others. As COVID-19 is believed to be primarily transmitted by touching surfaces contaminated with the virus and then touching your eyes, nose or mouth, it's important you and your staff are covering these areas of skin. You will also need to provide plenty of hand washing facilities, including hand sanitising stations where sinks and soap aren't available.

For full details of guidance and support for both employees and employers working during this time, please read and implement the government's advice.

We are all being faced with a unique business challenge in one way or another but, when you work in engineering, you might be able to use your resources and skills to help tackle this pandemic. Whether you find inspiration from what other firms are doing, or you feel encouraged to help in another way, our healthcare system is sure to appreciate any assistance you can give.

Much in the same vein, the world is in desperate need of ingenious solutions to widespread issues such as supply shortages of medical equipment. Here are 11 ways the engineering community has stepped up to the challenge.

1. Italy's reverse-engineered 3D-printed ventilators

After the outbreak soared to uncontrollable levels in Italy this month, Dr Daniele Macchini famously [wrote](https://www.weforum.org/agenda/2020/03/suddenly-the-er-is-collapsing-a-doctors-stark-warning-from-italys-coronavirus-epicentre/) that a scarcity in the medical equipment required treating patients means that "every ventilator becomes like gold."



2. The snorkeling mask ventilator

Only a few days after helping an Italian hospital by playing their part in fixing the broken supply chain for ventilators, the same group of engineers shared a [3D printed design](https://www.isinnova.it/easy-covid19/) for an [adapter that converts snorkel masks into ventilators](https://interestingengineering.com/watch-this-3d-printed-adaptor-transform-snorkeling-mask-into-ventilator?utm_source=Facebook&utm_medium=Article&utm_campaign=organic&utm_content=Mar24&fbclid=IwAR1mdK_ZaQ6d8Ki7TitZY35uL3k6ekQVkSXUNuXHct-o0Zgh2ZbiqXgsAtI).



Through the use of the adapter, a converted "Easybreath" snorkel mask becomes a functional C-PAP mask for oxygen therapy — a treatment that is critical for the recovery of people with severe cases of COVID-19.

As the volunteer company, called Isinnova, told [Futurism](https://futurism.com/neoscope/3d-printed-adapter-snorkelling-mask-into-ventilator), "Easybreath" snorkel-maker Decathlon "was immediately willing to cooperate" on the design. As Isinnova points out, however, "neither the mask nor the link is certified and their use is subject to a situation of mandatory need."

3. Robots helping populations affected by the pandemic worldwide

Countries throughout the world are deploying robots to help amidst the growing crisis. In Bangkok, Chulalongkorn University has teamed up with Advanced Info Service (AIS) to develop robots that utilize 5G technology to monitor coronavirus patients while keeping doctors in the loop from afar. As [Business Insider](https://www.businessinsider.com/robots-fighting-coronavirus-in-china-us-and-europe-2020-3?IR=T#the-robots-can-take-patients-temperatures-and-protect-the-safety-of-healthcare-workers-by-reducing-interactions-with-sick-people-22) points out, the city of Wuhan, where the outbreak started, is using robots to spray disinfectant throughout urban spaces.

4. Coronavirus isolation pods made by Mexican engineer

Special fully-sealed isolation pods were recently created by Mexican engineer Fernando Aviles for safely transporting COVID-19 patients. The specially-designed pods are equipped with air pumps that create a negative pressure within the sealed space.

The negative pressure means that, even if the plastic lining of the pod is torn during the transfer of a patient, any fluids will remain inside the isolation pod — an ingenious method for stopping the spread of the infectious disease amongst healthcare workers.

5. UV light-emitting disinfection robots

UV light disinfectant robots weren't specifically developed for the COVID-19 pandemic and they haven't been definitively proven to be effective at eradicating the virus (SARS COV-2) from surfaces — and yet, demand has skyrocketed to the point that companies are sending truckloads of the machines to different countries worldwide.

 Hospitals worldwide seem to be trusting that this is true, as demand is sky-high for the robots which use eight light bulbs to emit concentrated UV-C ultraviolet light over hospital surfaces. This type of light has been shown to destroy viruses, bacteria, and other harmful microbes by damaging their DNA and RNA so that they can no longer multiply.

6. Spain to use AI and robots to quadruple testing capacity

As well as a great necessity for ventilators, and hospital beds, there is also a need to test huge numbers of people while keeping up with the growing number of infections. In Spain, they have turned to AI and robotics to enhance the country's testing capability.

According to [Bloomberg](https://www.bloomberg.com/news/articles/2020-03-21/spanish-coronavirus-deaths-jump-to-1-326-from-1-002), Spain has been testing between 15,000 and 20,000 people a day. Now, the country will use robots and AI to quadruple that capacity.

“A plan to automate tests through robots has been already designed, and Spain has committed to buying four robots that will allow us to execute 80,000 tests per day,” Raquel Yotti, head of Madrid-based Health Institute Carlos III, explained at a health ministry press conference Saturday.

# CHAPTER 4

# CONCLUSION AND REFERNCE

Amidst reports of cases rising worldwide and widespread uncertainty over when and how the pandemic will be controlled, it is encouraging to see scientific and engineering communities come together to save lives by tackle the COVID-19 pandemic head-on.

We as engineers are encouraged to use our knowledge to find more effective solutions to the pandemic.

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