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**10-PAGE TERM PAPER ON THE ASSESSMENT OF OCCUPATIONAL HAZARDS AND DEVELOPMENT OF ENGINEERING EQUIPMENT TO SUPPORT HEALTH WORKERS AGAINST COVID-19**

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 **CERTIFICATION**

This project is to certify that the work carried out was by Zidafamor Oyinmiebi of the mechanical department with matriculation number 17/ENG06/090 in partial completion of the continuous assessment (C.A) of the Engineering Law and Managerial Economics (ENG384) course under the supervision of Engr.Oyebode, AfeBabalola University, Ado Ekiti, Nigeria during the 2019/20 academic session.

Engr. Oyebode

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 **DEDICATION**

This project is dedicated to my parents and my lovely siblings. This project is ultimately dedicated to God.

 **ABSTRACT**

 The study focuses on simply engineering aid to health workers in tackling the on-going corona virus pandemic. In this study, the occupational hazards faced by health workers are accessed. It also encompasses the development of engineering equipment to aid the health workers in their battle against the virus.

 **CHAPTER 1**

 **INTRODUCTION**

‘Battle without guns’ Over 59 million health workers worldwide, the government and the masses are involved in this battle. The on-going state of emergency caused by the Corona pandemic leaves every field of life asking themselves, ‘What could we have done? And most importantly, what can we do to restore parity?’

World standard cities on lockdown, partial and total, governments in total confusion, masses can do nothing but look up to their gods and pray for the medical practitioners. By the reason of engineering, we seek ways we can assist the medical personnel which brings me to the write-up.

 **OCCUPATION**

A **job**, **employment**, **work** or **occupation**, is a [person](https://en.wikipedia.org/wiki/Person)'s role in society. More specifically, a job is an activity, often regular and often performed in exchange for [payment](https://en.wikipedia.org/wiki/Money) ("for a living"). Many people have multiple jobs (e.g., parent, homemaker, and employee). A person can begin a job by becoming an [employee](https://en.wikipedia.org/wiki/Employee), [volunteering](https://en.wikipedia.org/wiki/Volunteering), starting a [business](https://en.wikipedia.org/wiki/Business), or becoming a [parent](https://en.wikipedia.org/wiki/Parent). The duration of a job may range from temporary (e.g., hourly odd jobs) to a [lifetime](https://en.wikipedia.org/wiki/Lifetime_employment) (e.g., [judges](https://en.wikipedia.org/wiki/Judge)).

An activity that requires a person's mental or physical effort is [work](https://en.wikipedia.org/wiki/Wage_labour) (as in "a day's work"). If a person is trained for a certain type of job, they may have a [profession](https://en.wikipedia.org/wiki/Profession). Typically, a job would be a subset of someone's [career](https://en.wikipedia.org/wiki/Career). The two may differ in that one usually *retires* from their career, versus *resignation* or [*termination*](https://en.wikipedia.org/wiki/Termination_of_employment) from a job.

 **WHO IS A HEALTH WORKER**

A health worker is one who delivers care and services to the sick and ailing either directly as doctors and nurses or indirectly as aides, helpers, laboratory technicians, or even **medical** waste handlers. There are approximately 59 million **healthcare workers** worldwide.

 **THE CORONA VIRUS**

The **2019–20 coronavirus pandemic** is an on-going [pandemic](https://en.wikipedia.org/wiki/Pandemic) of [coronavirus disease 2019](https://en.wikipedia.org/wiki/Coronavirus_disease_2019) (COVID-19), caused by [severe acute respiratory syndrome coronavirus 2](https://en.wikipedia.org/wiki/Severe_acute_respiratory_syndrome_coronavirus_2) (SARS-CoV-2). The outbreak started in [Wuhan](https://en.wikipedia.org/wiki/Wuhan), [Hubei](https://en.wikipedia.org/wiki/Hubei) province, China, in December 2019. The [World Health Organization](https://en.wikipedia.org/wiki/World_Health_Organization) (WHO) declared the outbreak to be a [Public Health Emergency of International Concern](https://en.wikipedia.org/wiki/Public_Health_Emergency_of_International_Concern) on 30 January 2020 and recognized it as a pandemic on 11 March 2020. As of 8 April 2020, approximately 1.44 million [cases](https://en.wikipedia.org/wiki/2019%E2%80%9320_coronavirus_pandemic_cases/WHO_situation_reports) of COVID-19 have been reported in [209 countries and territories](https://en.wikipedia.org/wiki/2019%E2%80%9320_coronavirus_pandemic_by_country_and_territory), resulting in approximately 83,400 [deaths](https://en.wikipedia.org/wiki/2019%E2%80%9320_coronavirus_pandemic_deaths/WHO_situation_reports). About 308,000 people have recovered.

The virus is mainly [spread](https://en.wikipedia.org/wiki/Transmission_%28medicine%29) during close contact and by [small droplets](https://en.wikipedia.org/wiki/Respiratory_droplet) produced when those infected cough, sneeze or talk. These droplets may also be produced during breathing; however, they rapidly fall to the ground or surfaces and are not generally [spread through the air over large distances](https://en.wikipedia.org/wiki/Airborne_disease). People may also become infected by touching a contaminated surface and then their face. The virus can survive on surfaces for up to 72 hours. It is most contagious during the first three days after onset of symptoms, although spread may be possible before symptoms appear and in later stages of the disease.

Common symptoms include [fever](https://en.wikipedia.org/wiki/Fever), [cough](https://en.wikipedia.org/wiki/Cough) and [shortness of breath](https://en.wikipedia.org/wiki/Shortness_of_breath). Complications may include [pneumonia](https://en.wikipedia.org/wiki/Pneumonia) and [acute respiratory distress syndrome](https://en.wikipedia.org/wiki/Acute_respiratory_distress_syndrome). The [time from exposure to onset of symptoms](https://en.wikipedia.org/wiki/Incubation_period) is typically around five days, but may range from two to 14 days. There is [no known vaccine](https://en.wikipedia.org/wiki/COVID-19_vaccine) or [specific](https://en.wikipedia.org/wiki/COVID-19_drug_development) [antiviral treatment](https://en.wikipedia.org/wiki/Antiviral_drug). Primary treatment is [symptomatic](https://en.wikipedia.org/wiki/Symptomatic_treatment) and [supportive therapy](https://en.wikipedia.org/wiki/Supportive_therapy).

Recommended [preventive measures](https://en.wikipedia.org/wiki/Preventive_healthcare) include [hand washing](https://en.wikipedia.org/wiki/Hand_washing), covering one's mouth when coughing, [maintaining distance from other people](https://en.wikipedia.org/wiki/Physical_distancing), and monitoring and [self-isolation](https://en.wikipedia.org/wiki/Self-isolation) for people who suspect they are infected. Authorities worldwide have [responded](https://en.wikipedia.org/wiki/National_responses_to_the_2019%E2%80%9320_coronavirus_pandemic) by implementing [travel restrictions](https://en.wikipedia.org/wiki/Travel_restrictions_related_to_the_2019%E2%80%9320_coronavirus_pandemic), quarantines, curfews, [workplace hazard controls](https://en.wikipedia.org/wiki/Workplace_hazard_controls_for_COVID-19), and facility closures.

The pandemic has led to severe global [socioeconomic disruption](https://en.wikipedia.org/wiki/Socio-economic_impact_of_the_2019%E2%80%9320_coronavirus_pandemic), the [postponement or cancellation of sporting, religious, and cultural events](https://en.wikipedia.org/wiki/List_of_events_affected_by_the_2019%E2%80%9320_coronavirus_pandemic), and widespread fears of supply shortages resulting in [panic buying](https://en.wikipedia.org/wiki/Panic_buying). [Schools and universities have closed](https://en.wikipedia.org/wiki/Impact_of_the_2019%E2%80%9320_coronavirus_pandemic_on_education) either on a nationwide or local basis in 193 countries, affecting approximately 99.4 per cent of the world's student population. [Misinformation about the virus](https://en.wikipedia.org/wiki/Misinformation_related_to_the_2019%E2%80%9320_coronavirus_pandemic) has spread online, and there have been [incidents of xenophobia and discrimination](https://en.wikipedia.org/wiki/List_of_incidents_of_xenophobia_and_racism_related_to_the_2019%E2%80%9320_coronavirus_pandemic) against Chinese people, other people of East and Southeast Asian descent and appearance, and others from areas with significant virus cases. Due to reduced travel and closures of heavy industry, there have been decreased air pollution and carbon emissions, having a beneficial effect on the environment.

 **CHAPTER TWO**

**ACCESSMENT OF OCCUPATIONAL HAZARDS FACED BY HEALTH WORKERS**

**OCCUPATIONAL HAZARDS**

An **occupational hazard** is a [hazard](https://en.wikipedia.org/wiki/Hazard) experienced in the workplace. Occupational hazards can encompass many types of hazards, including [chemical hazards](https://en.wikipedia.org/wiki/Chemical_hazard), [biological hazards](https://en.wikipedia.org/wiki/Biological_hazards) (biohazards), [psychosocial hazards](https://en.wikipedia.org/wiki/Psychosocial_hazards), and [physical hazards](https://en.wikipedia.org/wiki/Physical_hazards). In the [United States](https://en.wikipedia.org/wiki/United_States), the [National Institute for Occupational Safety and Health](https://en.wikipedia.org/wiki/National_Institute_for_Occupational_Safety_and_Health) (NIOSH) conduct workplace investigations and research addressing workplace health and safety hazards resulting in guidelines.[[1]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-1) The [Occupational Safety and Health Administration](https://en.wikipedia.org/wiki/Occupational_Safety_and_Health_Administration) (OSHA) establishes enforceable standards to prevent workplace injuries and illnesses.[[2]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-2) In the EU a similar role is taken by [EU-OSHA](https://en.wikipedia.org/wiki/EU-OSHA).

Occupational hazard as a term signifies both long-term and short-term risks associated with the workplace environment and is a field of study within [occupational safety and health](https://en.wikipedia.org/wiki/Occupational_safety_and_health) and [public health](https://en.wikipedia.org/wiki/Public_health).[[3]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-3) Short term risks may include physical injury, while long-term risks may be increased risk of developing [cancer](https://en.wikipedia.org/wiki/Cancer) or [heart disease](https://en.wikipedia.org/wiki/Cardiovascular_disease)

 **TYPES OF OCCUPATIONAL HAZARDS**

**Chemical hazards**

Chemical hazards are a subtype of occupational hazards that involve dangerous [chemicals](https://en.wikipedia.org/wiki/Chemical_substance). Exposure to chemicals in the workplace can cause acute or long-term detrimental health effects. There are many classifications of hazardous chemicals, including [neurotoxins](https://en.wikipedia.org/wiki/Neurotoxin), immune agents, dermatologic agents, [carcinogens](https://en.wikipedia.org/wiki/Carcinogen), reproductive toxins, systemic toxins, [asthmagens](https://en.wikipedia.org/wiki/Asthmagen), pneumoconiosis agents, and sensitizers.[[4]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-4)

NIOSH sets [recommended exposure limits](https://en.wikipedia.org/wiki/Recommended_exposure_limit) (REL's) as well as recommends preventative measures on specific chemicals in order to reduce or eliminate negative health effects from exposure to those chemicals.[[5]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-5) Additionally, NIOSH keeps an index of chemical hazards based on their [chemical name](https://en.wikipedia.org/wiki/Chemical_nomenclature),[[6]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-6) [Chemical Abstracts Service](https://en.wikipedia.org/wiki/Chemical_Abstracts_Service) Registry Number (CAS No.),[[7]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-7) and RTECS Number.[[8]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-8)

This is evidence that workplace exposure to hazards such as silica dust, engine exhausts or welding fumes, among others are associated with increased prevalence of [heart disease](https://en.wikipedia.org/wiki/Heart_disease).[[9]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:2-9) Other workplace hazards have been shown to increase risk of [pulmonary heart disease](https://en.wikipedia.org/wiki/Pulmonary_heart_disease), [stroke](https://en.wikipedia.org/wiki/Stroke), and [high blood pressure](https://en.wikipedia.org/wiki/Hypertension).[[9]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:2-9)

**Biological hazards**

[Biological](https://en.wikipedia.org/wiki/Biology) agents, including [microorganisms](https://en.wikipedia.org/wiki/Microorganism) and [toxins](https://en.wikipedia.org/wiki/Toxin) produced by living organisms, can cause health problems in workers. [Influenza](https://en.wikipedia.org/wiki/Influenza_virus) is an example of a biohazard which affects a broad population of workers.[[10]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-10)

Those who work outdoors encounter numerous biological hazards, including bites and stings from [insects](https://en.wikipedia.org/wiki/Insect), [spiders](https://en.wikipedia.org/wiki/Spider), [snakes](https://en.wikipedia.org/wiki/Snake) and [scorpions](https://en.wikipedia.org/wiki/Scorpion),[[11]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-11)[[12]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-12)[[13]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-13) [contact dermatitis](https://en.wikipedia.org/wiki/Contact_dermatitis) from exposure to [urushiol](https://en.wikipedia.org/wiki/Urushiol) from poisonous [*Toxicodendron*](https://en.wikipedia.org/wiki/Toxicodendron) plants,[[14]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:0-14) [Lyme disease](https://en.wikipedia.org/wiki/Lyme_disease),[[15]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-15) [West Nile virus](https://en.wikipedia.org/wiki/West_Nile_virus),[[16]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:1-16) and [coccidioidomycosis](https://en.wikipedia.org/wiki/Coccidioidomycosis).[[17]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-17) According to [NIOSH](https://en.wikipedia.org/wiki/National_Institute_for_Occupational_Safety_and_Health), outdoor workers at risk for these hazards "include farmers, foresters, landscapers, groundskeepers, gardeners, painters, roofers, pavers, construction workers, laborers, mechanics, and any other workers who spend time outside."[[14]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:0-14)

Health care professionals are at risk to exposure to [blood-borne illnesses](https://en.wikipedia.org/wiki/Blood-borne_disease) (such as [HIV](https://en.wikipedia.org/wiki/HIV), [hepatitis B](https://en.wikipedia.org/wiki/Hepatitis_B), and [hepatitis C](https://en.wikipedia.org/wiki/Hepatitis_C))[[18]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-18) and particularly to [emerging infectious diseases](https://en.wikipedia.org/wiki/Emerging_infectious_disease), especially when not enough resources are available to control the spread of the disease.[[19]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-19) [Veterinary health](https://en.wikipedia.org/wiki/Veterinary_medicine) workers, including [veterinarians](https://en.wikipedia.org/wiki/Veterinary_physician), are at risk for exposure to [zoonotic](https://en.wikipedia.org/wiki/Zoonosis) disease.[[20]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-20) Those who do clinical work in the field or in a laboratory risk exposure to West Nile virus if performing [necropsies](https://en.wikipedia.org/wiki/Autopsy) on birds affected by the virus or are otherwise working with infected tissue.[[16]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-:1-16)

Other occupations at risk to biological hazard exposure include [poultry workers](https://en.wikipedia.org/wiki/Poultry_farming), who are exposed to bacteria;[[21]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-21) and [tattooists](https://en.wikipedia.org/wiki/Tattoo_artist) and [piercers](https://en.wikipedia.org/wiki/Body_piercing), who risk exposure to blood-borne pathogens.[[22]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-22)

**Psychosocial hazards**

Psychosocial hazards are occupational hazards that affect someone's social life or psychological health. Psychosocial hazards in the workplace include [occupational burnout](https://en.wikipedia.org/wiki/Occupational_burnout) and occupational stress, which can lead to burnout.[[23]](https://en.wikipedia.org/wiki/Occupational_hazard#cite_note-23)

**Physical hazards**

Hazards are a subtype of occupational hazards that involve [environmental hazards](https://en.wikipedia.org/wiki/Environmental_hazard) that can cause harm with or without contact. Physical hazards include [ergonomic hazards](https://en.wikipedia.org/wiki/Ergonomic_hazard), [radiation](https://en.wikipedia.org/wiki/Radiation), heat and cold stress, vibration hazards, and noise hazards.

For the sake of this study, we shall limit these types of hazards to the hazards faced by health workers tackling COVID-19.

In the battle against the virus, health workers are exposed to

1. The virus itself
2. Being agents of spread themselves
3. Other occupational hazard ie falls, injury etc.

 **CHAPTER THREE**

**ENGINEERING EQUIPMENTS AND HOW THEY SUPPORT HEALTH WORKERS**

**EQUIPMENTS**

**Equipment** most commonly refers to a set of [tools](https://en.wikipedia.org/wiki/Tool) or other objects commonly used to achieve a particular objective. Different [jobs](https://en.wikipedia.org/wiki/Job) require different kinds of equipment.

**ENGINEERING EQUIPMENT**

This refers to the tools or set of tools and/or other objects used to achieve engineering objectives.

Engineering emerging technologies could aid health workers in many ways including the eight listed below

### Remote Healthcare

**Remote patient monitoring** speeds up testing for the infection, followed by tracing and isolating potential carriers. Analysing behavioural and **biometric** data from wearable improves the accuracy of detecting positive cases of COVID-19. With public health experts reiterating the need for social distancing, **tele-nursing** and **telemedicine** applications fill the gap created by a shortage of medical professionals. Connected health platforms allow doctors and patients to remotely engage via **online conversational interfaces** and **digital medical assistance**.

Below are 6 of the most relevant solutions that enable a faster and more efficient response to the COVID-19 pandemic in the fields of:

* Remote Monitoring
* Telehealth
* Respiratory Monitoring
* Digital Stethoscope
* Mental Health Chat bots
* Wearable Sensors

### Prevention Measures

Inside hospitals, doctors, nurses, and health staff use **interactive real-time mobile apps** to stay updated about infected patients and their treatment. **Face masks** are essential for ensuring that health workers face minimal risk of contracting the virus while performing their jobs. There is already great pressure on manufacturers of **antiviral soaps**and**sanitizers** to produce sufficient numbers in order to keep prices in check. Other **autonomous disinfecting** and **sanitizing machines** or **equipment** needs to be deployed at affected clusters. Below are 5 of the most relevant solutions that enable a faster and more efficient response to the COVID-19 pandemic:

* Disease Surveillance
* Air Filtration Systems
* Disinfectants
* Spit Disposal
* Antiviral Masks

### Diagnostic Solutions

The WHO urges all health authorities to test, detect, trace, and isolate those found to have contracted the coronavirus. **Home testing** and **diagnostic kits** are essential to slow the spread of the virus. When large-scale quarantine measures are in place, **virtual care**, **virtual medical visits**, and **interactive patient engagement platforms** allow people to obey the measures imposed. **Chatbots** and **symptom checking mobile apps** dispense information swiftly and in interesting ways. Contactless temperature reading guns ensure front line responders are not at risk.

We look into 5 of the most relevant solutions that enable a faster and more efficient response to the COVID-19 pandemic, including the areas of:

* Mobile Diagnostics
* Telehealth
* Remote Patient Diagnosis
* Disease Detection Kits
* Continuous Temperature Monitoring

### Hospital Care

Hospitals require focused preparation and support to achieve intended patient outcomes. **Artificial ventilators** and **bed-side health analytics** significantly improve patient management. Nurses and doctors working on the front lines require **safety goggles**, **gowns**, **gloves**, **shields**, and **surgical-grade essentials**. These include **blood testing kits** and **devices for monitoring** respiratory rate, oxygen saturation, and for efficiently testing stool samples. **Robots** that navigate inside hospitals transport essential tools and medications free up time for nurses to focus on their essential tasks.

* Hospital Robots
* 3D Printed Ventilator Valve
* Artificial Cough Device
* AI Algorithms For Patient Monitoring
* Anti-Pathogen Fabric

### Public Safety During Pandemic

**AI**-based and**predictive analytics**, **visual representations**, and **simulations** of any potential outbreak are powerful tools to inform the public about their safety during an epidemic. Technologies to track the mobility of infected cases and **robotic disinfection systems** help minimize the risk of the virus spreading to frontline workers. **Specialized isolation units** complement public health systems when hospitals reach their capacity. Doctors and nurses use **mobile apps to manage stress** and to have effective downtime.

* Drone-based Delivery of Medical Supplies
* Specialized Isolation Units
* Mobile Support Applications for Health Workers
* Visualization & Prediction of Epidemic Outbreaks
* Robots for Patrolling & Disinfecting

### Industry Adapting To The Lockdown

For factories and businesses, lockdown situations present extreme challenges and result in heavy losses. Fitting **sensors to track** their entire supply chain enables factories to plan production targets. With most people required to stay indoors, **automated guided vehicles**and**drones** potentially fill the gaps of moving items around a factory floor. Critical components and machines in a factory use **expert-assisted augmented reality (AR)** to facilitate a reduction in the number of workers required inside a factory. Overall, factories that **digitize**, across their supply chains, remain better prepared to deal with and prepare for unexpected events, like the coronavirus pandemic.

The wide range of applications includes:

* Digital Factory
* Human In The Loop Technology
* Real-Time Supply Chain Monitoring
* Augmented Reality Collaboration
* Industrial Cleaning
* Industrial Cyber-security
* Industrial Autonomous Vehicles
* Fleet Management

### Cities Adapting To The Lockdown

**Image and video analytics** play an important role in helping cities manage and handle the challenges posed by the pandemic and the resulting lockdown. With billions of people living under forced quarantine, some hospitals and governments use **geofencing techniques** to ensure infected people obey the restrictions. **Mobile applications** update citizens about outbreaks with **interactive maps** and engage with the public about other policy issues. **Off-site construction** and **urban farming** potentially play an important role in ensuring temporary structures and basic food supply to cities. With grocery and other essential retail stores under risk of having an outbreak **self-checkout** and **cashier-less outlets** help people manage lockdowns in big cities.

* Smart Surveillance
* Location-Based Systems
* Online Civic Services
* Indoor Farming
* Autonomous Stores
* Prefabricated & Modular Construction
* Sickness Mapping

### Individuals Adapting To The Lockdown

Mobile and **smartphone-based applications** are being used to connect with loved ones during these testing times. Some schools are already using **e-learning platforms** to complete their syllabus for this academic year or term. Offices, forced to temporarily close, are finding **innovative online tools** to connect and collaborate with their employees. Even before the outbreak, **streaming** and entertainment apps on smartphones were useful for passing time.

By making it easier to practice social distancing and self-isolation, technology enables people to normally carry on their lives, as much as is possible during a lockdown.

* Shared Streaming & Entertainment
* Remote Work
* Loneliness Management
* Stress & Anxiety Reduction
* Online Learning
* Online Food & Grocery Delivery
* Indoor Workouts

##  How to Flatten the Curve?

This is an unprecedented situation for many of us across the world. The SARS outbreak in the early 2000s claimed 774 lives. That toll was enough to drive research & development and easier healthcare solutions. The fact that several mobile health, e-health, diagnostics, and remote health start-ups and companies are able to respond during a real epidemic is encouraging. With tens of thousands of deaths already because of the coronavirus, we expect to see numerous new companies offering technology-driven solutions to help doctors, nurses, other health workers, and the larger public.

 **CHAPTER FOUR**

 **CONCLUSION**

They’re many ideal emerging technologies that could be developed to aid health workers in the battle against the corona virus. The chapters above are a good testament to that.

**CHAPTER FIVE**

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