

**A REPORT ON**

**THE DEVELOPMENT OF AUTOMATED MACHINE AND ELECTRO-MECHANICAL DEVICES FOR PRODUCTION OF INFECTION PREVENTION AND CONTROL (IPC) AND PERSONAL PROTECTIVE EQUIPMENT (PPE) FOR PUBLIC HEALTH AND ECONOMIC GROWTH IN NIGERIA**

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**ABSTRACT**

This paper explains how the development of automated machines and electro-mechanical devices can aid the production of personal protective equipment for public health and economic growth in Nigeria, whilst reviewing the current COVID-19 pandemic and partial (in some cases total) lockdown of activities in states across the country; As well as how the incorporation of digital technology can improve the healthcare system in the country.

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**INTRODUCTION**

**Infection Prevention and Control**

Infection prevention and control (IPC) is a scientific approach and practical solution designed to prevent harm caused by infection to patients and health workers. It is grounded in infectious diseases, epidemiology, social science and health system strengthening. IPC occupies a unique position in the field of patient safety and quality universal health coverage since it is relevant to health workers and patients at every single health-care encounter.  
  
No country, no health-care facility, even within the most advanced and sophisticated health-care systems, can claim to be free of the problem of healthcare-associated infections. The need for having IPC programs nationally and at the facility level is reinforced within the WHO 100 Core Health Indicators list.  
  
A new IPC unit has therefore been set up within the WHO Service Delivery and Safety (SDS333) department to provide a comprehensive, integrated IPC function focused on strengthening national and international IPC capacity and implementing safe practices at the point of care. This unit will build upon the foundations and achievements of the Clean Care is Safer Care program (2005-2015) and the strong leadership and technical expertise demonstrated by the existing WHO infection prevention team, most recently during the Ebola virus disease response and early recovery work.  
  
The IPC global unit will lead WHO’s work on IPC and will work collaboratively with related units in SDS, in particular the Patient Safety & Quality unit and the newly created unit dealing with Quality Universal Health Coverage, as well as with other related departments and units at the three levels of WHO.

**Personal Protective Equipment (PPE)**

Personal Protective Equipment (PPE) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities. "Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, or masks, and others. PPE suits can be similar in appearance to a cleanroom suit.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering controls and administrative controls are not feasible or effective to reduce these risks to acceptable levels. PPE is needed when there are hazards present. PPE has the serious limitation that it does not eliminate the hazard at the source and may result in employees being exposed to the hazard if the equipment fails.

Any item of PPE imposes a barrier between the wearer/user and the working environment. This can create additional strains on the wearer; impair their ability to carry out their work and create significant levels of discomfort. Any of these can discourage wearers from using PPE correctly, therefore placing them at risk of injury, ill-health or, under extreme circumstances, death. Good ergonomic design can help to minimize these barriers and can, therefore, help to ensure safe and healthy working conditions through the correct use of PPE.

Practices of occupational safety and health can use hazard controls and interventions to mitigate workplace hazards, which pose a threat to the safety and quality of life of workers. The hierarchy of hazard controls provides a policy framework which ranks the types of hazard controls in terms of absolute risk reduction. At the top of the hierarchy are elimination and substitution, which remove the hazard entirely or replace the hazard with a safer alternative. If elimination or substitution measures cannot apply, engineering controls and administrative controls, which seek to design safer mechanisms and coach safer human behaviour, are implemented. Personal protective equipment ranks last on the hierarchy of controls, as the workers are regularly exposed to the hazard, with a barrier of protection. The hierarchy of controls is important in acknowledging that, while personal protective equipment has tremendous utility, it is not the desired mechanism of control in terms of worker safety.

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**Fig.1: Removable Anti-droplet Cap Fig.2: Fully Protected Health Worker**

**COVID-19 PANDEMIC**

Looking at the immediate situation across the world at the moment, which is the COVID-19 pandemic. We should first get knowledge about what it is.

**Coronavirus disease (COVID-19)** is an infectious disease caused by a newly discovered coronavirus.

Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness.

The best way to prevent and slow down transmission is to be well informed about the COVID-19 virus, the disease it causes and how it spreads. Protect yourself and others from infection by washing your hands or using an alcohol-based rub frequently and not touching your face.

The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes, so it’s important that you also practice respiratory etiquette (for example, by coughing into a flexed elbow).

At this time, there are no specific vaccines or treatments for COVID-19. However, many ongoing clinical trials are evaluating potential treatments.

**Symptoms**

The COVID-19 virus affects different people in different ways

Common symptoms include:

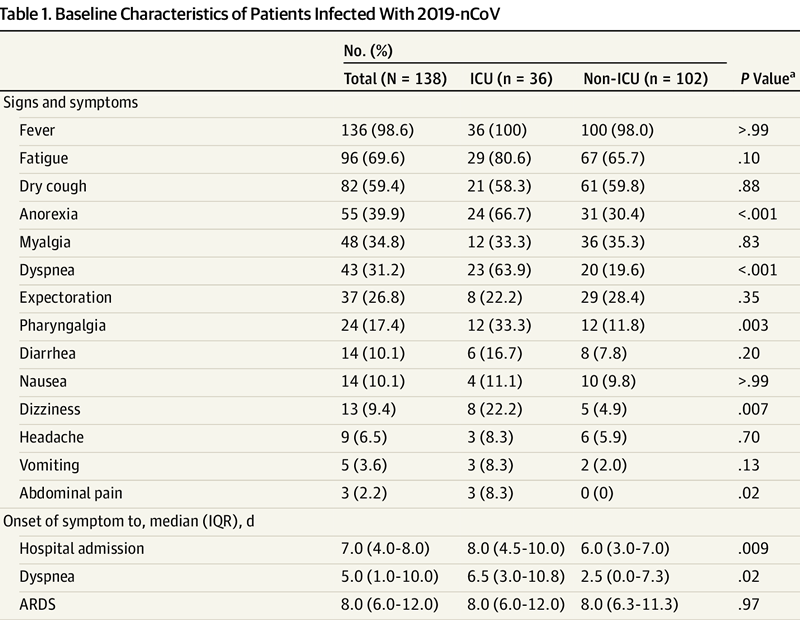
* fever
* tiredness
* dry cough.

Other symptoms include:

* shortness of breath
* aches and pains
* sore throat
* and very few people will report diarrhoea, nausea or a runny nose.

People with mild symptoms who are otherwise healthy should self-isolate and contact the COVID-19 information line for advice on testing and referral.

People with fever, cough or difficulty breathing should call their doctor and seek medical attention.

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**Prevention**

To prevent infection and to slow transmission of COVID-19, do the following:

* Wash your hands regularly with soap and water, or clean them with alcohol-based hand rub.
* Maintain at least 1-metre distance between you and people coughing or sneezing.
* Avoid touching your face.
* Cover your mouth and nose when coughing or sneezing.
* Stay home if you feel unwell.
* Refrain from smoking and other activities that weaken the lungs.
* Practice physical distancing by avoiding unnecessary travel and staying away from large groups of people.

**LITERATURE REVIEW**

Due to the ongoing COVID-19 pandemic, the requests for PPE has skyrocketed. Also, because of the current lockdown, production rates of these equipment and materials will be strongly affected. Thus, the Federal Government will have to look into the development of Automated Electro-Mechanical Machines that can boost the production rate of PPE, as well as other Digital Infrastructure to improve healthcare systems.

Considering that there are various types of PPE with different functions, a wide variety of Artificial Intelligent would be required to function in different aspects of PPE production.

**Types of PPE**

Various types of PPE are available for use in the workplace. The Health and Safety Executives. Potential users should be involved in the selection of equipment they will be expected to wear and if possible, more than one model should be made available to them.

The different types of PPE include:

* Head and scalp protection;
* Respiratory protection;
* Eye protection;
* Hearing protection;
* Hand and arm protection;
* Foot and leg protection;
* Body protection;
* Height and access protection.

**Availability of PPE and Medical Supplies to Public Health**

Manufacturers and supply chains across the country should be mobilized to produce more personal protective equipment (PPE) and medical devices needed in the fight against COVID-19.

Ventilators, face shields and masks are among the most critical supplies needed by hospitals and health care providers, along with hospital gowns, gloves, hand sanitizer.

So far, the federal government is projecting a stimulus package of 1 trillion naira ($2.7 billion) will be provided for the purchase of PPE and medical supplies from Local and International suppliers.

Central Bank of Nigeria will provide 100-billion naira for businesses to retool their manufacturing operations for COVID-19 equipment.

**Locally Available PPE and Other Medical Supplies**

**Ventilators**

Federal Ministry of Science and technology, disclosed plans to start the local production of ventilators and also disinfectant spraying devices as the nation continues to battle COVID-19.

The ventilators are locally produced by the National Agency for Science and Engineering Infrastructure (NASENI).

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NASENI is the agency for research, development, and production of capital goods, machines and equipment. The ventilators produced will give aide to infected patients in Nigeria with breathing difficulties. Also, spraying devices will be used to disinfect streets and reduce the rate of contracting the virus. This will support the government in fighting the pandemic disease.

Since the outbreak of COVID-19, ventilators are scarce in the world as countries all over the globe battle the unprecedented global crisis. According to the ministry, locally producing ventilators in Nigeria is well calculated and a good idea.

Also, a man identified as Muhammad Yunusa from Gombe State developed a ventilator locally as a personal contribution towards the fight against COVID-19. It was sourced locally and confirmed to be working perfectly.

**Face Masks**

Jubilee Syringe Manufacturing Company is the largest disposable syringe factory in Africa, with the capacity to produce 350 million to 400 million units of 2ml, 5ml, and 10ml disposable syringes annually. With the demand for face-mask taking the centre stage and with shortages seen all over the nation, the Jubilee Syringe Company has commenced the production of face masks to stem the prospects of COVID-19 infections**.**

**METHODOLOGY**

**Digital Transformation in Health Care**

The spread of COVID-19 is stretching operational systems in health care and beyond. We have seen shortages of everything, from masks and gloves to ventilators, and from emergency room capacity to ICU beds to the speed and reliability of internet connectivity. The reason is both simple and terrifying: Our economy and health care systems are geared to handle linear, incremental demand, while the virus grows at an exponential rate. Our national health system cannot keep up with this kind of explosive demand without the rapid and large-scale adoption of digital operating models.

While we race to dampen the virus’s spread, we can optimize our response mechanisms, digitizing as many steps as possible. This is because traditional processes; those that rely on people to function in the critical path of signal processing are constrained by the rate at which we can train, organize, and deploy human labour. Moreover, traditional processes deliver decreasing returns as they scale. On the other hand, digital systems can be scaled up without such constraints, at virtually infinite rates. The only theoretical bottlenecks are computing power and storage capacity nut those can be resolved. Digital systems can keep pace with exponential growth.

Importantly, AI for health care must be balanced by the appropriate level of human clinical expertise for final decision-making to ensure we are delivering high quality, safe care. In many cases, human clinical reasoning and decision making cannot be easily replaced by AI, rather AI is a decision aid that helps human improve effectiveness and efficiency.

Digital transformation in health care has been lagging other industries. Our response to COVID-19 today has shown the importance of adopting and scaling of virtual and AI tools.

**Better integration of Artificial Intelligence into the public health response should be a priority.**

Hospital systems around the should leverage AI-powered sensors to support triage in sophisticated ways. Chinese technology company Baidu developed a no-contact infrared sensor system to quickly single out individuals with a fever, even in crowds. Beijing’s Qinghe railway station is equipped with this system to identify potentially contagious individuals, replacing a cumbersome manual screening process. Similarly, Florida’s Tampa General Hospital deployed an AI system in collaboration with “Care.ai” at its entrances to intercept individuals with potential COVID-19 symptoms from visiting patients. Through cameras positioned at entrances, the technology conducts a facial thermal scan and picks up on other symptoms, including sweat and discolouration, to ward off visitors with fever.

The Nigerian government should as well employ such technological advances to help curb the spread of COVID-19 Virus. With the lockdown ongoing, engineering firms in fields ranging from; Computer, Electrical Electronics and Mechatronics Engineering should be charged with the development of such systems. Firms that would be involved in the design and production should also do so following strict HSE measures to ensure maximum safety and avoid the risk of contracting the COVID-19 virus.

An ERDF-funded project is helping to tackle the COVID-19 crisis in Italy. New sensors created by the project allow healthcare staff to monitor patients suffering from the disease at a distance.

The biosensors, created by the MEDIWARN project, can monitor a patient’s vital signs such as heartbeat, respiratory rate, blood pressure and body temperature. It is difficult and dangerous for medical and nursing staff to monitor COVID-19 patients in person. Patients infected and symptomatic need to be isolated in rooms with negative pressure. The new sensors allow staff to more easily monitor such patients from another room.

A similar project can be started in Nigeria by the Federal Government in collaboration with the private sector for the same purpose. Such a project would make it is easier for the Public Health system to carry out their duties at low risk of contracting the virus at hand. Also, the sensors can be exported to neighbouring countries to counter-balance the rate of imports against exports in the country.

Beyond screening, AI is being used to monitor COVID-19 symptoms, provide decision support for CT scans, and automate hospital operations. Meanwhile, Zhongnan Hospital in China uses an AI-driven CT scan interpreter that identifies COVID-19 when radiologists aren’t available. China’s Wuhan Wuchang Hospital established a smart field hospital staffed largely by robots. Patient vital signs were monitored using connected thermometers and bracelet-like devices.

Intelligent robots can be utilized in delivering medicine and food to patients, alleviating physician exposure to the virus and easing the workload of health care workers experiencing exhaustion.

Also, an app can be developed, allowing users to self-report symptoms, alerting them if they leave a “quarantine zone” to curb the impact of “super-spreaders” who would otherwise go on to infect large populations.

**FACTORY AUTOMATION**

Recent advances in the internet of things (IoT) have resulted in an explosion of new products and applications for automation, including smart homes and cities, autonomous vehicles, fastening solutions, remote security and surveillance systems, wearables and other healthcare devices, and smart factories.

Some of the enabling technologies include ultra-high bandwidth Wi-Fi; Bluetooth and other wireless technologies; artificial intelligence and machine learning; efficient and high-density power sources; advanced or miniaturized sensors; and high-precision actuation devices. In an industrial environment, manufacturing engineers are faced with myriad choices for new and emerging robotic products and technologies that provide various degrees of automation.

**Benefits of Factory Automation**

There are several good reasons for introducing automation into the manufacturing process. Although automation can result in numerous benefits, there are usually one or two compelling reasons that drive the decision-making process that should be well understood at the outset.

One of the best arguments for the introduction of factory automation is to improve workplace safety. Certain assembly or machining operations cannot be safely accomplished for a variety of reasons. Some manufacturing operations require operation at extreme temperatures or in the presence of hazardous chemicals. Other operations may require workers to lift or handle heavy or large parts or use hazardous tools. Because of limited space on the factory floor, some operations may require work in confined spaces or in the presence of moving mechanical assemblies. Automation has the power to eliminate personnel from hazardous situations.

Another good argument for robotic manufacturing is tasks that are difficult or nearly impossible to perform without the aid of a machine. These tasks might include the assembly or inspection of miniaturized parts or parts that are too large or bulky, making them difficult to see or handle. Other assembly operations may require the placement of parts that demand a high degree of precision.

Robotic machines can perform repetitive tasks with a high degree of precision and repeatability. Advanced robots that are equipped with machine vision and learning systems can adapt to wide tolerances and part variances to ensure proper placement of components. This can result in high-quality assembly operations and low production waste.

Robotic machines can also run for longer periods and can perform many tasks faster than humans. Furthermore, well-maintained robotic machines have less downtime than human operators—they do not call in sick, do not fatigue and do not typically require training. This can translate into fewer manufacturing cells needed to produce a given quantity of a product, shorter production lead times and schedules, and improved availability of manufactured goods.

Each of the previously mentioned benefits, including improvements to safety, performance, productivity, and quality, contributes to reduced labour, material, and operational costs. While lowering production costs is an important consideration and overall goal, it should not be the overriding factor in the decision to automate manufacturing processes, as the introduction of automated production machinery will at first be expensive and may require equipment or process tuning for maximum productivity.

**Degrees of Automation**

A manufacturing line can incorporate several cells that perform operations that incorporate various degrees of automation, ranging from manual to human-assist (or semi-automated), to fully-automated processes.

In most modern manufacturing operations, there are no fully manual processes, as tools and machinery are used to align or position parts before fastening or joining. Manual operations can be enhanced with automatic feeder systems that supply and align parts or fasteners to tools and equipment in a repeatable manner. Human-assist systems are usually robotic systems that are semi-autonomous and require human-in-the-loop interactions. Many of these systems, termed collaborative robots, operate hand-in-hand with their human operators to perform tasks that a human alone cannot perform. Example applications include machine vision systems or adaptive robots that can assist humans by lifting heavy objects.

Fully automated systems are autonomous and perform well on highly-repeatable tasks that require high speed, or on tasks that must be performed in environments that may be off-limits for humans. Because of safety considerations, autonomous robots must be segregated from the human workforce. They are at a disadvantage because they cannot easily be used for tasks that require a significant amount of adaptability, flexibility or skill.

It is important to understand how the current manufacturing cells operate and interact, then extrapolate or model the operation of the manufacturing line after the introduction of automation. In this manner, the entire manufacturing line can be optimized to achieve production, quality and cost goals. For example, the introduction of automation in one manufacturing cell could increase the throughput of parts and assemblies, causing a bottleneck in downstream, slower manufacturing cells. The additional expense would be incurred by modernizing the slower downstream operations or warehousing surplus workpieces.

**Introduction of Factory Automation Technology**

Since all factories and manufacturing operations are different, there is, unfortunately, no universal methodology for introducing automation into manufacturing. The implementation of factory automation requires participation from several different departments within a factory, and the manufacturing engineer must consider several factors related to facilities and equipment, personnel availability and training, safety, production, and quality goals, and financial and budgetary limitations. The following list describes some important considerations and questions that should be answered to ensure an optimum and appropriate degree of factory automation.

* Safety: Environment, health and safety professionals should identify tasks within the factory that are performed under hazardous conditions or that have a high incidence of injury.
* Difficult tasks: Industrial engineering analyzes tasks that take a considerable amount of time to perform, or involve parts that are too difficult to inspect or process without automation.
* Quality: Identify tasks and operations that often fail to meet quality requirements, or result in a very high scrap rate.
* Repetitive or monotonous tasks: Tasks that are highly repetitive or monotonous might easily be replaced with robots that lower overall production costs and improve accuracy.
* Technological maturity: Ensure that parts and assemblies will not undergo significant design changes or are not obsolescent before savings from automation can be realized.
* Facilities: Plant engineering should identify floor space within the factory to house automated equipment. For completely autonomous operations, especially those involving large, high-speed robots, the factory floor must be completely segregated from humans.
* Personnel: Allocate skill sets among the engineers and technicians who will program and maintain the automated equipment, and reassign or retrain displaced employees.
* Finance: Corporate management should determine budgets, costs and the financial implications for introducing automation.

As evident from the above, the decision to introduce factory automation involves the entire company.

If the Federal Government can better push the narrative of Factory Automation, it’ll grossly boost the manufacturing industry in the country thus causing positive economic growth.

**Analysis of big data relating to citizens' movement, disease transmission patterns and health monitoring could be used to aid prevention measures.**

In recent years, the world has witnessed the rise of SARS, Zika virus, Ebola and now COVID-19. Epidemics are a rising threat.

Cities across the world have made infrastructure innovation a priority to safeguard their physical systems so they can stay robust and antifragile during natural disasters such as earthquakes, tsunami and hurricanes. But pandemics have shown that these methods aren’t enough when it comes to ensuring connectivity and accessing our society during biological disasters.

The primary challenge now, at the time of this crisis, is to integrate and streamline digital infrastructure at various stages of the public health response, particularly in the context of epidemic forecasting and decision-making. In the years since SARS, a new age digital era has emerged; artificial Intelligence and the Internet of Things (IoT) could be instrumental in keeping this new virus within reasonable limits.

**Predicting and modelling outbreaks**

In the ongoing COVID-19 pandemic, we are witnessing three major occurrences across the globe:

1. Wider acceptance of online services;

2. A humongous requirement for internet services for conventional industries;

3. Boosted connectivity among diverse types of industries.

These three data streams provide important, real-time data about travel patterns that spread disease and longitudinal alterations in populations at risk, which until recently have been very difficult to quantify on schedules related to a fast-moving pandemic. With an exponential rise in mobility and growing global connectivity, this information will be critical to planning surveillance and containment strategies.

Digital infrastructure plays a pivotal role in predicting and modelling outbreaks. Take AI-supported services for a lung CT scan: the AI is premeditated to quickly detect lesions of likely coronavirus pneumonia; to measure its volume, shape and density; and to compare changes of multiple lung lesions from the image. This provides a quantitative report to assist doctors in making fast judgements and thus helps expedite the health evaluation of patients.

**Mapping citizens**

The government should look into developing the digital infrastructure and engineering capabilities to face the pandemic and alleviate the spread of COVID-19 through community-driven contact-tracing technologies. These enable citizens to react assertively and promptly to pandemic diseases with a set of digital tools to help spread timely and precise information to its citizens.

The government should also encourage private companies to develop innovative tools that make use of hundreds of millions of facial recognition cameras and people reporting their body temperature and medical condition. Through these authorities can quickly identify suspected coronavirus transporters and identify anyone with whom they have come into contact. An array of mobile apps warns citizens about their proximity to infected patients.

**CONCLUSION AND RECOMMENDATION**

**Conclusion**

Given the fast-spreading COVID-19 virus, social-distancing is bound to slow down production rates of the same PPE required to help combat such infectious diseases.

Resilience and commitment from the Government will have to be ensured to avoid an extreme outbreak and economic breakdown in the Nation.

**Recommendation**

The government should consider these recommendations, some of which were stated in Chapter 3 of this report. The recommendations are summarized below:

* Better integration of Artificial Intelligence into the public health response should be a priority.
* Factory Automation
* Analysis of big data relating to citizens' movement, disease transmission patterns and health monitoring could be used to aid prevention measures.
* A new mathematical model uses information theory to improve epidemiological predictions
* App-based contact tracing may significantly reduce the pandemic spread in many countries
* A pandemic drone can be designed to monitor people with infections could limit fatality in hotspots
* Experimental Artificial Intelligence tool that predicts which patients develop respiratory disease
* Digital Transformation in Health Care System