

**AFE BABALOLA UNIVERSITY, ADO EKITI**

**COLLEGE OF ENGINEERING**

**DEPARTMENT OF CHEMICAL ENGINEERING**

**A TERM PAPER ON**

**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**

The field of Infection Prevention and Control (IPC) and Personal Protective Equipment (PPE) has led to several high technology innovations. Indeed, improved protection against the various possible encountered risks is looked for, in particular at the workplace. This has generated the development of new materials and new manufacturing technologies, as well as the introduction of new applications for existing ones. However, the remaining challenges are numerous.

**This paper is focused 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**

Infection Prevention and Control is a scientific approach and practical solution to prevent harm (caused by infections) to patients and health workers. Its foundation cuts across the fields of 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 as it is crucial for both health workers and patients at every single health-care encounter. The basis of IPC is the identification and prioritization of infection risks followed by the application of resources to minimize, monitor, and control the problem.

Personal protective equipment (PPE) are designed to protect the wearer’s skin, eyes, mucous membranes, airways and clothing from coming into contact with infectious agents. Mucous membranes and skin with compromised integrity are portals of entry that are highly susceptible to infectious agents, therefore it is important that appropriate protective measures be taken. It is important to note that the use of PPE is not a substitute for proper infection prevention and control practice for example, the use of gloves is not a substitute for hand hygiene.

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**CHAPTER ONE**

**INTRODUCTION**

**WHAT IS ENGINEERING?**

Engineering covers many different types of activity. Engineers make things, make things work and make things work better. They also use their creativity to design solutions to the world’s problems and help build the future. Engineering has previously been defined by the Royal Academy of Engineering as the ‘creative application of scientific principles’, principles that are put in practice to invent, design, build, maintain and improve structures, machines, devices, systems, materials and processes. This definition of engineering is broad, intended to account for the fact that the scope of engineering is continually evolving because of the dynamic nature of engineering-related industries.

There is a diverse range of specialized engineering disciplines or fields of application, including (but not limited to):

* aerospace
* chemical and process
* civil and environmental
* computing and communication
* electrical and electronics
* energy and power
* materials and mining
* manufacturing and design
* medical and bioengineering
* transport and mechanical.

Engineers are responsible for some of the most important advances in biomedicine, and they have played a key role in building the infrastructure around us – from roads to utility networks. Engineers also play a role in the development of the food we eat and the development of new materials, such as cutting-edge foams and coatings to be used in manufacturing. With half the world living in poverty and millions of people without sufficient food or sanitation, engineering continues to have a key role to play in helping countries to progress across the world.

**WHAT IS AUTOMATION?**

Automation is the technology by which a process or procedure is performed with minimal human assistance. Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat-treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention. Automation covers applications ranging from a household thermostat controlling a boiler, to a large industrial control system with tens of thousands of input measurements and output control signals. In control complexity, it can range from simple on-off control to multi-variable high-level algorithms.

 In the simplest type of an automatic control loop, a controller compares a measured value of a process with a desired set value, and processes the resulting error signal to change some input to the process, in such a way that the process stays at its set point despite disturbances. This closed-loop control is an application of negative feedback to a system. The mathematical basis of control theory was begun in the 18th century and advanced rapidly in the 20th. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques. The benefit of automation includes labor savings, savings in electricity costs, savings in material costs, and improvements to quality, accuracy, and precision.

**WHAT ARE ELECTRO-MECHANICAL DEVICES?**

In engineering, electromechanics combines processes and procedures drawn from electrical engineering and mechanical engineering. Electromechanics focuses on the interaction of electrical and mechanical systems as a whole and how the two systems interact with each other. This process is especially prominent in systems such as those of DC or AC rotating electrical machines which can be designed and operated to generate power from a mechanical process (generator) or used to power a mechanical effect (motor). Electrical engineering in this context also encompasses electronics engineering. **Electromechanical devices** are ones which have both electrical and mechanical processes. Strictly speaking, a manually operated switch is an electromechanical component due to the mechanical movement causing an electrical output. Though this is true, the term is usually understood to refer to devices which involve an electrical signal to create mechanical movement, or vice versa mechanical movement to create an electric signal. Often involving electromagnetic principles such as in relays, which allow a voltage or current to control another, usually isolated circuit voltage or current by mechanically switching sets of contacts, and solenoids, by which a voltage can actuate a moving linkage as in solenoid valves.

Before the development of modern electronics, **electromechanical devices** were widely used in complicated subsystems of parts, including electric typewriters, teleprinters, clocks, initial television systems, and the very early electromechanical digital computers.

**WHAT IS ECONOMIC GROWTH?**

Economic theory suggests that growth in the economy, which is the only means of increasing the prosperity of a country, depends on the quantities of the factors of production employed – labour and capital – and the efficiency with which those quantities are utilised. Growth is sustained by increasing the amounts of labour and/ or capital that are used and by increasing the efficiency with which they are used individually and in combination to produce output. Countries in the economic development phase must focus on improving the efficiency of utilisation of labour and capital. For example, reducing the price of capital utilisation to encourage greater utilisation to better ‘sweat’ the assets, or through transport infrastructure improvements that shrink geographies, making labour more mobile and flexible. This increases the likelihood of finding a job in which they can maximize their potential, while reducing search costs for companies that can access a wider labour market. Economic development is crucial in creating the conditions necessary to achieve long run growth, particularly in developing nations.

Therefore, economic development, while difficult to precisely define, results from investment in the generation of new ideas through innovation and the creation of new goods and services, the transfer of knowledge and the development of viable infrastructure. Examples of economic development include the creation of infrastructure, not just roads and bridges, but also digital and 1communications infrastructure, and the creation of knowledge through education and training, which can be utilised by businesses to create new goods and services. Investment in research and development and support for entrepreneurship and innovation make a significant contribution to economic development, as they identify new opportunities and then bring them to market to realize value, which will in turn lead to increased productivity within an economy

**CHAPTER TWO**

**LITERATURE REVIEW**

**WHAT IS PUBLIC HEALTH?**

Public health is the science of protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases.

Overall, public health is concerned with protecting the health of entire populations. These populations can be as small as a local neighborhood, or as big as an entire country or region of the world.

Public health professionals try to prevent problems from happening or recurring through implementing educational programs, recommending policies, administering services and conducting research—in contrast to clinical professionals like doctors and nurses, who focus primarily on treating individuals after they become sick or injured. Public health also works to limit health disparities. A large part of public health is promoting healthcare equity, quality and accessibility.

**Infection Prevention and Control (IPC)**

Infection Prevention and Control is a scientific approach and practical solution to prevent harm (caused by infections) to patients and health workers. Its foundation cuts across the fields of 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 as it is crucial for both health workers and patients at every single health-care encounter. The basis of IPC is the identification and prioritization of infection risks followed by the application of resources to minimize, monitor, and control the problem.

“**Standard Precautions** “are the minimum level of IPC precautions based on risk assessment of a procedure or procedures, for the care and protection of patients and healthcare workers. It is applied to any patient regardless of their diagnosis or presumed infectious state. The goal is to reduce the risk of transmission of microbes from both recognized and unrecognized sources of infection and standard precautions should become second nature as part of healthcare practice.

The core components of standard precautions are:

* Hand hygiene
* Safe injection practices
* Respiratory hygiene/Cough Etiquette
* Appropriate Personal Protective Equipment (PPE)
* Safe sharps and waste disposal
* Environmental disinfection and sterilization of patient’s equipment
* Safe handling of linen
* Patient placement

When standard precautions are correctly implemented, the spread of infectious diseases such as the VHFs Ebola and Lassa fever can be prevented or at least decreased. Below are some recommendations of how to implement standard precautions.

Standard Precautions for the Care of All Patients in All Healthcare Settings

**Hand hygiene**: The 5 Moments for Hand Hygiene (described in more detail below in this guideline) should be observed at all the indicated moments.

* Before touching a patient
* Before performing clean/aseptic procedures
* After body fluid exposure risk (e.g. after handling any potentially contaminated equipment or material such as laundry, wastes, dishes, vomit and stool buckets, etc.)
* After touching a patient
* After touching patient’s surroundings

**Personal protective equipment (PPE):**

Personal protective equipment (PPE) refers to a range of barriers and respirators used alone or in combination to protect mucous membranes, airways, skin, and clothing from contact with infectious agents. The selection of protective equipment required depends on an assessment of the risk of transmission of microorganisms to the patient, and the risk of contamination of the healthcare practitioner’s clothing and skin by patients’ blood, body fluids, secretions or excretions.

Practice staff should make a risk assessment of the planned procedure/action and select PPE, depending on:

1. The nature of the procedure
2. The risk of exposure to blood, body fluids, mucous membranes and non-intact skin
3. The risk of contamination.

***TYPES OF PROTECTIVE CLOTHING***

**Gloves:**

Gloves should be worn for:

1. Invasive procedures
2. Contact with sterile sites
3. Contact with non-intact skin/mucous membranes
4. All actions that have been assessed as carrying a risk of exposure to blood, body fluids, secretions/excretions, or to sharps or contaminated instruments (including handling of laboratory specimens).
* Gloves are single use items and should conform to European Community Standards.
* Gloves should be changed between different treatment activities for the same patient.
* Sensitivity to natural rubber latex in patients/carers should be documented, and alternatives to natural rubber latex gloves must be available. Nitrile gloves are a good alternative for latex sensitive individuals. ¬ Glove use does not remove the need to comply with hand hygiene. Hands should be cleaned prior to putting on gloves and hand hygiene (handwashing/alcohol hand rub) must be performed immediately after glove removal.
* Handwashing with soap and water is advised when gloves are removed because of a tear or a puncture and the staff member has had contact with blood or another body fluid; this situation is considered to be equivalent to a direct exposure to blood or another body fluid.
* Gloves should be disposed of into the appropriate waste stream.

**Non-Sterile Gloves** should be used when hands may come into contact with body fluids or equipment contaminated with body fluids, or touching mucous membranes for example handling specimens.

**Sterile Gloves** should be used when the hand is likely to come into contact with normally sterile areas or during the introduction of an invasive device or during any surgical procedure.

**Disposable plastic aprons** should be worn when there is a risk that clothing may be exposed to blood, body fluids, secretions or excretions, with the exception of sweat. Plastic aprons should be worn as single-use items and then discarded into the appropriate waste stream.

**Full-body fluid repellent gowns** should be worn where there is a risk of extensive splashing of blood, body fluids, secretions or excretions, with the exception of sweat, onto the skin or clothing of healthcare practitioners.

**Face masks (surgical) and eye protection (visor/goggles)** should be worn where there is a risk of blood, body fluids, secretions or excretions splashing into the face and eyes.

**Surgical Masks**

Surgical masks should be worn by practice staff where there is a risk of droplet transmission e.g. corona virus, influenza.

* Masks should be fitted correctly to be effective.
* Replace the mask if it becomes wet or soiled.
* Remove mask by pulling on the strings – do not touch the front of the mask, as this is likely to be heavily contaminated.
* Dispose of the mask into the healthcare risk waste stream.
* Perform hand hygiene after mask is removed.

***REMOVING PPE***

To reduce contamination of clothes/hands/environment:

* When removing gloves do so with a technique that avoids contamination of the hands and the environment. Remove until both gloves are inside out, then discard into the appropriate waste stream.
* The outer, “contaminated” side of the apron/gown is turned inward and rolled into a bundle before discarding into the appropriate waste stream.
* Remove mask by breaking the ties (do not touch the front of the mask).
* Discard all PPE into the appropriate waste stream.
* PPE that is blood stained or contaminated with body fluids should be placed into the healthcare risk waste stream.
* PPE that is not blood stained or contaminated with body fluid may be placed into the domestic/non-healthcare risk waste stream.

**Always perform hand hygiene after PPE is removed.**

**CHAPTER THREE**

**METHODOLOGY**

 **Intersecting Electrical and Mechanical Development to develop better devices**

As medical devices become increasingly complex in functionality, medical device companies seek reliable partners for their medical electronics projects. Hardware engineering is often required for many of the medical devices we develop for our clients. Since both are crucial to the development of a device, we have created systems to help clients during their device’s development process.

Expert engineers have designed electronic and electromechanical systems with performance, reliability, cost, manufacturing, and regulatory compliance in mind. A team of experienced engineers offer specialized skills and abilities for a wide range of medical device electromechanical development projects, focusing on a product scale from table top sized equipment to implantable devices.

 Hand hygiene is one of the most effective ways to prevent transmission of health care-associated infections. Electronic systems and tools are being developed to enhance hand hygiene compliance monitoring. Our systematic review assesses the existing evidence surrounding the adoption and accuracy of automated systems or electronically enhanced direct observations and also reviews the effectiveness of such systems in health care settings. We systematically reviewed PubMed for articles published between January 1, 2000, and March 31, 2013, containing the terms hand and hygiene or hand and disinfection or handwashing. Resulting articles were reviewed to determine if an electronic system was used. We identified 42 articles for inclusion. Four types of systems were identified: electronically assisted/enhanced direct observation, video-monitored direct observation systems, electronic dispenser counters, and automated hand hygiene monitoring networks. Fewer than 20% of articles identified included calculations for efficiency or accuracy. Limited data are currently available to recommend adoption of specific automatic or electronically assisted hand hygiene surveillance systems. Future studies should be undertaken that assess the accuracy, effectiveness, and cost-effectiveness of such systems. Given the restricted clinical and infection prevention budgets of most facilities, cost-effectiveness analysis of specific systems will be required before these systems are widely adopted.

Prevention through Design (PtD), as a principle, is an achievable solution to improve worker health and safety. Reducing hazards before any electrical exposure happens in the workplace should be a top priority for industry safety professionals. PtD includes all efforts to prevent injuries by reducing exposure to hazards primarily through design efforts rather than just administrative controls or personal protective equipment. It applies not only to products and equipment, but also processes and procedures used in the workplace.

With PtD, new technologies and products reduce human exposure to hazards to achieve higher levels of safety, and it makes electrical infrastructure safer to anyone entering the facility for the duration of its lifecycle. Product development by way of PtD can also simultaneously increase productivity, as it encourages designers to consider ways to limit worker exposure to electrical hazards throughout the product lifecycle. This can make both normal operation and maintenance activity faster and less complicated for operators and electrical workers.

It’s important to continually identify and assess potential hazards. As advances in technology occur and new products are released, new ways to mitigate old hazards will become viable. Designed-in control measures are more effective and provide greater business value than other administrative approaches such as training or PPE alone.

**STRATEGIC OBJECTIVES:**

WHO’s strategic objectives for this response are to:

• Interrupt human-to-human transmission including reducing secondary infections among close contacts and health care workers, preventing transmission amplification events, and preventing further international spread;

• Identify, isolate and care for patients early, including providing optimized care for infected patients;

• Identify and reduce transmission from the animal source;

• Address crucial unknowns regarding clinical severity, extent of transmission and infection, treatment options, and accelerate the development of diagnostics, therapeutics and vaccines;

• Communicate critical risk and event information to all communities and counter misinformation;

• Minimize social and economic impact through multisectoral partnerships.

\*This can be achieved through a combination of public health measures, such as rapid identification, diagnosis and management of the cases, identification and follow up of the contacts, infection prevention and control in health care settings, implementation of health measures for travelers, awareness-raising in the population and risk communication.

The WHO recommends the following controls in healthcare settings for epidemics and pandemics (WHO 2014).

* *Administrative*: appropriate infrastructure, clear policies, laboratory testing, appropriate triage and placement of patients, adequate staff-to-patient ratios and training of staff.
* *Environmental and engineering*: space to allow social distance of at least 1 m, well-ventilated isolation rooms, availability and proper use of PPE.

The ECDC technical report (ECDC 2020c)for administrators and healthcare professionals provides guidance for preparedness; triage, initial contact and assessment in primary and emergency care; patient transport; environmental cleaning; and waste management. Some of the recommended measures include:

* Designation of a full-time staff member as the lead for IPC and preparedness for COVID-19, responsible for the relevant education and training of staff.
* Respiratory hygiene measures (covering mouth/nose with a tissue or elbow when coughing or sneezing, wearing medical masks in certain cases, performing hand hygiene, staff self-isolating if suspected of being infected).
* Allocating additional facilities to cohort cases with mild symptoms.
* Availability of isolation rooms, appropriate PPEs (ECDC 2020d), adequate laboratory support, etc.
* Appropriate use of PPEs.
* Regular cleaning followed by disinfection.

 As of March 2020, there is reduced access to PPE and hand hygiene materials across the globe, therefore, rational use of PPE and hand hygiene materials for the care and management of COVID-19 is encouraged (WHO 2020). For staff this involves selecting the proper PPE and being trained in how to put on, remove and dispose of it.

Optimal PPE availability can be achieved through the following steps:

* *Minimizing the need for PPE* by means of telemedicine, using physical barriers (glass or plastic windows) to reduce exposure, restricting staff’s presence in the rooms of COVID-19 patients (also consider bundling activities), restricting visitors’ access to facilities, and providing clear instructions regarding PPE use and hand hygiene.
* *Ensuring rational and appropriate use of PPE* (staff using specific PPE for various types of care, efficient allocation of masks, coordinated PPE supply chain management mechanisms).

If PPE stocks are insufficient, staff should be allocated to perform a procedure, or set of procedures in designated areas.

Other recommendations for hospitals include developing a strategy for patient volume and complexity including provisions for geographical cohorting and supplies conservation; readjusting staff’s schedules with appropriate compensation strategies; monitoring staff for signs or symptoms of infection; ensuring transparent communication and providing moral support (Chopra et al. 2020). Bolstering the general approach to routine respiratory viruses is another recommended direction as it will simultaneously improve care for current patients, make work safer for clinicians and help to prevent nosocomial transmission of COVID-19 (Klompas 2020).

**CHAPTER FOUR**

**ANALYSIS OF RESULT**

 Substituting a manual process that relies primarily on administrative controls like PPE and training with an automated process that leverages engineering controls designed into a system can provide an enhanced level of safety, increase the reliability of the process and decrease the risk of exposure to electrical hazards. This is critically important, especially for a process that is performed multiple times per day.

 Based on the research on Infection Protection and Control (IPC), Personal protective equipment (PPE) is a critical component in the hierarchy of controls used to protect healthcare personnel from influenza and other viral respiratory diseases. Understanding the functional issues related to the design of PPE as well as the factors that impact use are critical to ensuring that healthcare personnel are adequately protected, comfortable, and able to perform their jobs. Important advances have been made in some areas since the 2008 IOM report, but other areas, particularly regarding improvements in gowns, gloves, face masks, and face shields, need to be more fully addressed. Much research has been done regarding filtration of respirator media, but ways to improve fit, including new technologies specifically for filtering facepiece respirators, need more research because face seal leakage greatly exceeds filter penetration in the overall TIL of respirators. The physiological impact of respirators has been studied in-depth, but research in this area is lacking for other types of PPE. Integration issues concerning PPE and medical equipment and the impact on operational performance have not been adequately studied. Effective decontamination methods that do not impact the physical characteristics of respirators have been studied for some types of respirators, but with inconclusive results. Finally, the characteristics of a respirator that would specifically address the needs of healthcare personnel (e.g., patient–provider interaction, comfort, reduced physiological burden) have been identified. Addressing these issues is important for developing PPE for healthcare personnel that is safe, effective, and comfortable.

 Based on the results of the Prevention Epicenters Program and related research, efforts to improve the use of PPE for contact precautions should include methods to improve adherence to recommended protocols for PPE use, improved PPE design that facilitates donning, patient care activities, and doffing, as well as further research into the risks, benefits, and best practices of PPE use.

First, improving adherence to recommended protocols for PPE use should involve HCP education, training, demonstrations of competency, monitoring, and creating a patient care environment that facilitates the appropriate use of PPE. HCP should be educated about the importance of transmission in healthcare settings, the role of HCP contamination in transmission events, and methods for reducing that risk. Furthermore, schools for healthcare providers (e.g., medical and nursing schools) are critical places for early career engagement and instruction in transmission dynamics and the importance and use of PPE for creating a safe work environment.

Second, PPE design for both routine and specialized use should help HCP provide optimal care for patients, rather than diverting their attention during patient care while attempting to remember multiple steps and awkward actions needed for safe PPE use. Multidisciplinary partnerships, including industry partners, human factors engineers, healthcare epidemiologists, and HCP, can provide the diverse expertise for evaluating and improving PPE design and finding effective solutions to improve performance and usability in healthcare settings.

Third, our understanding of transmission events in healthcare settings is limited, and further research that links transmission risk to best practices in patient care, including PPE use, is needed. Common transmission events are unrecognized because acquisition of pathogens by HCP or patients is usually not clinically apparent or has delayed clinical manifestation (e.g., after the patient is discharged from a facility). More detailed studies in real-world and simulated environments, including the use of surrogate markers, will be valuable in describing transmission dynamics, the role of HCP self-contamination in the spread of pathogens, and the effectiveness of different PPE strategies and care processes in preventing transmission. Specifically, assessing the contribution of PPE among multiple concurrent infection control interventions is an ongoing challenge. Mathematical modeling can be used to predict the effect of individual components of bundled interventions, but these models depend on appropriately detailed data points to parameterize important variables. The marriage of modeling with observational data collection might be an avenue whereby interventions could be evaluated. Sequencing of isolates to verify transmission events would give greater clarity to when transmission events are occurring and potentially aid in identifying the source of patient or HCP acquisition. Furthermore, a better understanding of the contribution of colonization status, shedding, and high-risk patient–HCP interactions could provide important insights for optimizing PPE use and design for all types of healthcare delivery.

All healthcare settings can benefit from improvements in PPE use and design. Post-acute care settings, such as nursing homes and high-acuity skilled nursing facilities, have high rates of multidrug-resistant organism (MDRO) colonization and transmission that can affect the regional control of MDROs. Due to the higher prevalence of MDRO colonization, patient care workflow processes, communal living, and other factors, these settings need tailored approaches to prevent transmission, including strategies such as using PPE based on resident risk factors rather than pathogen-specific indications.

Engineers have historically played a very important role in the process of global economic development and the public health. The improvement of infrastructure often acts as a catalyst for reducing the significance of factors inhibiting development, such as the spread of waterborne and other contagious diseases. At the same time, it strengthens the impact of those factors that can speed up the development process, such as improved transport links that in turn contribute to growth in trade, enhance the prospects for access to schooling and encourage labour mobility. Investment in communications networks, enabling access to information, the internet and mobile telephony also plays a key role in economic development and growth.

**CHAPTER FIVE**

**CONCLUSION:**

 This term paper was aimed to briefly discuss 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. It gives a briefly detailed review of what Infection Prevention and Control (IPC) is all about and discussed on development of Automated machine and Electro-Mechanical devices for Production of Infection Prevention and Control (IPC) and Personal Protective Equipment (PPE)

 In summary, Automated machines and Electro-mechanical devices play major roles in the development of PPE which plays an important role in preventing pathogen transmission in healthcare settings, but its optimal design and use need to be informed by dedicated research to achieve the reliability and effectiveness needed to protect patients and HCP. Current Prevention Epicenters projects on PPE explore improvements in the use and refinements in the design of PPE and foster innovation and research to reduce the risk of transmission of infectious diseases between HCP and patients

**RECOMMENDATION:**

 Successful IPC programs in health care facilities are based on understanding the facility’s problems or needs, prioritizing activities, and using available resources effectively. Resources are always limited, so careful planning, implementation, and evaluation of IPC activities are essential, whether in a small clinic or a busy district hospital. In many settings, infection surveillance systems, microbiology laboratory resources to identify the cause of health care-associated infections (HAIs), and treatment options for infections are limited. Thus, IPC is not only the most cost-effective option, but also the best strategy available to protect patients and limit the spread of disease within health care facilities. At its best, an IPC program consists of a selected group of trained HCWs who engage and educate staff in all areas and at all levels to play an active role in preventing the spread of infections among patients, fellow workers, and themselves. (WHO 2011). Therefore, I recommend that students should engage more in such programs to gain necessary knowledge from such programs.

Also, in the health sectors:

* Continue and Expand Research on PPE for Healthcare Personnel
* Examine the Effectiveness of Face Masks and Face Shields as PPE
* Develop and Certify PAPRs for Healthcare Personnel
* Improve Fit Test Methods and Evaluate User Seal Checks

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