HYGEIA – AN AUTOMATED DISINFECTION BOOTH USING FAR UVC

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ABSTRACT

This paper addressed the current gaps of the health and safety protocols followed by the health workers and other front-line workers in conducting disinfection of self and personal protective equipment (PPE) after using it. The current disinfection system disinfects surfaces, water, air, materials, utensils, rooms, compartments, foods and other already came in various ways. Some of these include gas disinfecting, alcohol, chlorine, bleach, detergents, steams, hot water, hot gas, chemicals, UV rays and more in which according to them, still poses risk among health workers and front-line workers not during the duty but on the doping and donning of the PPE. The researchers used the Agile Scrum methodology of software development; thus, user stories were collected during stakeholders' meeting. The meeting includes the researchers, RHU personnel and the front-liners. This allows all the concerned individuals and agencies to express their concern and needs during the donning and doffing process. After the meeting, the researchers decided to develop Hygeia, a system of interconnected electronic devices that aims to automate the disinfection of booths using UVC light as disinfectant. It used the concept of IOT which Arduino Microcontroller, Raspberry Pi, Sensors, Motors, Relay, Switches, Pumps and Water Valves were used to deliver its specified functions. Daily standup meetings were conducted in order to monitor the progress of the project and if it meets the needs of the client before delivering the fully potential product.

Keywords: Micro-controllers, Internet of Things, Ultraviolet C, CoVid Response

INTRODUCTION

Coronavirus disease 2019 (COVID-19) shatter the world in the most unexpected time. This results to shortages of food and health supplies. Primarily, the world run short of on personal protective equipment which is primarily used in protecting our health and front-line workers. Heath and front-line workers in the Philippines is reusing the PPE as a solution to the shortage. After using the PPE will be washed with detergent. This procedure risks the personnel of having contact with the virus before it is being washed. Washing also causes damage to the PPE which results to a more dangerous use of PPE the next time.

The shortage of (PPE) is one of the factors that contributes to the increased number of healthcare and frontline workers being infected by the virus. World Health Organization (WHO) recently released a press report highlighting the severe shortage of personal protective equipment (PPE) that is endangering healthcare workers worldwide during the COVID-19 pandemic (Narla, S. et. Al.). This results to finding another medium in disinfection process. To meet this urgent need, healthcare institutions across the world have begun to utilize the germicidal properties of ultraviolet C (UVC) to decontaminate N95 respirators so that they can be reused. It is clearly crucial that the dose of UVC delivered is sufficient to kill any viable SARS-CoV-2, the causative virus of the COVID-19 pandemic that may be present on the respirators pandemic (Narla, S. et. al. ,2020). UVGI is a disinfection method that uses UVC radiation to inactivate microorganisms by causing DNA damage and preventing replication. Previous studies have shown that UVC can inactivate coronaviruses, including severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) (Hamzavi, Iltefat H., et al., 2020). Far-UVC is presented as a promising candidate against COVID-19 since it can inactivate pathogens including viruses and bacteria without harming mammalian skin or eyes (Haider et. al. ,2020). The radiation warps the structure of their genetic material and prevents the viral particles from making more copies of themselves (Zaria Gorvett-BBC, 2020)

The gaps of the existing PPE disinfection procedures and the recent statement of the WHO pushed the researchers to innovate an automated personnel and PPE disinfection booth that uses UVC, microcontrollers and sensors.

OBJECTIVES OF THE STUDY

This study aimed to develop a disinfection booth using far UVC. Specifically, it sought to determine the needs of the RHU and the front-liners in terms of: PPE disinfection; donning and doffing of PPE; and interventions implemented in order safely disinfect the health and front-line workers.

METHODOLOGY

The researchers used the Agile: Scrum methodology of software engineering in order to deliver the right solution to what may be the existing problems. The researchers started with the stakeholders' meetings in order to gather the possible problems they experienced in their daily doffing, donning, and disinfection procedures. After the stakeholders' meeting, the researchers conducted a sorting of user stories with priority schedules based on the preference of the stakeholders and the researchers. The sorting of stories resulted in a project backlog which became the basis of system development. Using the Gantt chart, the researchers assigned the tasks to each of the members of the team. A daily standup meeting with the scrum master was conducted to make sure that the project works accurately as scheduled and planned. Such steps were done in a loop until a potentially deliverable product will be achieved and approved by the stakeholders.

RESULTS AND DISCUSSION

1. Personal Protective Equipment (PPE) disinfection

Personal Protective Equipment (PPE), disinfection is a process that must be taken seriously. Any damage to the PPE may increase the risk of the front-liners of contracting the virus. According to the respondents, they disinfect the PPE by machine washing it using a detergent. This process may damage the garment of the PPE. If not noticed, being used with damage may decrease its capability of protecting the person using it.

2. Risks faced by health and front-line workers in donning and doffing of PPE

In the current practice, donning and doffing were done in the usual way. Touching and the improper handling of the PPE during the process increased the chance of the health and front-line workers contacting the virus. According to the head of the RHU, more front-line workers are still infected by the virus even if they are wearing PPE during work, and one of the factors that cause the problem is the donning and doffing process.

3. Interventions implemented in order safely disinfect the health and front-line workers

According to the respondents, as per practiced, the they rely on handwashing and taking a bath after the donning and doffing. In this case, to them, they already have the possibility of contacting the virus like in opening and closing the doors, turning on and off the shower knobs and other parts that they are going to touch during the process.

4. User Story and Module

Table 1 exhibits the full user stories gathered. The figure above specifically shows that the stakeholders want to have a disinfection system that could disinfect the whole person, including the PPE with less human intervention. Touching the PPE during the donning and doffing process is a big risk to them.

To minimize it, it is safer to do the donning and doffing procedures in a room where disinfection is running upon the entry of the personnel. Further, they also stated that machines and handwashing are still a risk for the personnel.

They wanted another disinfection system that could prevent damage to PPE. To them, washing the PPE sometimes causes damage to the materials and may expose the personnel to a greater risk the next time it will be use.

Table 1
User Story and Module

Story No.	Priority No.	Story	Modules to be developed
1	1	We want to have a disinfection system that could disinfect the whole person including the PPE with less human intervention.	Development of the following: A chamber that has entrance and exit doors that opens automatically. This uses sensors; and Automated showers and soap dispenser for contactless personnel disinfection.
2	2	Machine and handwashing are still a risk for the personnel. We want another disinfection system that could prevent damage to PPE.	Development of the automated UVC disinfection modules: PPE disinfection Shower room disinfection Dressing room disinfection
	3	Light indicators and whole chamber disinfection.	Warning lights that indicate if the personnel entry is allowed or not, or if the chamber is occupied or vacant. Disinfection of the whole chamber.

As a response to the user stories, the researchers developed modules that has the following:

- a chamber that has entrance and exit doors that opens automatically. This uses sensors;
- automated showers and soap dispensers for a contact less personnel disinfection;
- automated UVC disinfection following modules:
- PPE disinfection;
- shower room disinfection;
- dressing room disinfection;

- warning light that indicates if the personnel entry is allowed or not, or if the chamber is occupied or vacant; and
- disinfection of the whole chamber.

The figure below illustrates how the whole system works.

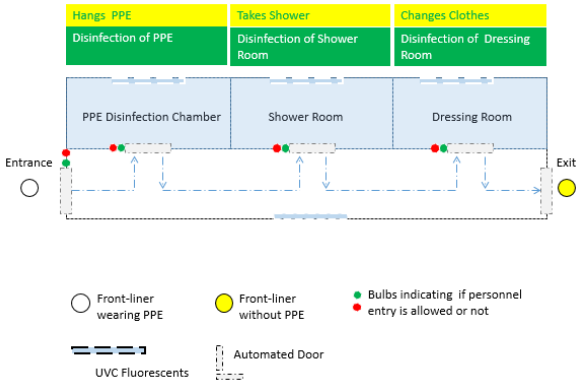

Figure 1: Hygeia Prototype

Hygeia has both entrance and exit doors including a warning light indicator that shows if an entry is allowed or not. If the entry is allowed, the moment that personnel stand in the doors of the chamber, the door will automatically open. The personnel will conduct the donning and doffing of PPE and put hangs it on the PPE disinfection chamber. The moment, the personnel left the PPE hanging area, Hygeia will start the disinfection via UVC. Next is the personnel will go to the shower room. All components such as doors, shower, soap, shampoo are automated. After taking the shower the personnel will proceed to the dressing room and finally takes the exit. After taking the exit, the hygeia will start disinfecting the whole chamber including its rooms.

CONCLUSION

With the problems encountered during the donning, doffing and disinfection process, the researchers and the respondents came up in a conclusion of developing an effective automated disinfection system with less human intervention using state of the art technologies. The series of meetings with the stakeholders resulted to a list of stories, priority numbers and modules to be developed in order to deliver the right product according to their specifications.

RECOMMENDATION

Technology has proven its key role in protecting and improving lives. Technology innovation maximizes the use of technology to further extend its full potential. With proper funding, researchers hope to implement the system to help protect the front-liners.

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