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Implementation of Persuasive System for Promoting Occupational Safety in Health Care Environment.

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ABSTRACT

Healthcare professionals operate in environments characterized by high physical and psychological demands, often leading to occupational hazards such as fatigue, musculoskeletal disorders, and exposure to harmful agents. This study presents the design and development of a persuasive system aimed at enhancing occupational safety in healthcare settings through real-time monitoring, personalized feedback, and context-aware interventions. By integrating wearable sensor technologies, environmental monitoring devices, and institutional health data, the system continuously evaluates practitioners' risk exposure and behavioral patterns. Grounded in persuasive technology principles, it delivers timely, non-intrusive interventions tailored to individual roles, activities, and risk levels. The system architecture supports modular deployment and real-time decision-making, ensuring adaptability across diverse healthcare contexts. The system was developed using an agile, human-centered design methodology, involving iterative prototyping and stakeholder feedback from healthcare professionals, The tools employed are NexJS, Cascade Style Sheet (CSS) for the front end, then MongoDB, RESEND and React mail for the backend. Initial validation through simulated clinical workflows demonstrated improved awareness, compliance with safety guidelines, and increased practitioner engagement. The findings suggest that embedding persuasive elements into occupational health systems can significantly enhance proactive safety behaviors and contribute to the overall well-being and performance of healthcare workers.

KEYWORDS: Occupational safety, persuasive systems, healthcare environment, real-time monitoring, wearable sensors, context-aware intervention, behavior change, medical practitioners, workplace safety, human-centered design.

1.0 INTRODUCTION

Occupational safety in healthcare environments is a critical yet often under-addressed aspect of health system performance. Medical practitioners, including doctors, nurses, and support staff, are routinely exposed to a range of occupational hazards such as prolonged physical exertion, infectious agents, ergonomic stress, and psychological fatigue. These risks not only compromise the well-being of healthcare workers but can also impact patient care quality and institutional efficiency. Despite the existence of safety protocols and regulatory guidelines, compliance remains inconsistent due to high workload, lack of real-time feedback, and limited awareness of cumulative risks. Recent advances in ubiquitous computing, wearable technologies, and intelligent systems have opened new avenues for proactive occupational safety solutions. In parallel, persuasive technologies systems designed to change user attitudes or behaviors through personalized, non-coercive strategies have gained traction in domains such as health promotion and behavior change. However, their application in promoting occupational safety within healthcare settings remains relatively unexplored.

This research presents the design and development of a persuasive system that leverages real-time monitoring, personalized feedback, and context-aware interventions to promote safer behaviors among healthcare professionals. The proposed system integrates wearable sensor data, environmental monitoring, and contextual task information to assess risk levels dynamically. It then delivers timely, adaptive interventions aimed at encouraging safety compliance, reducing exposure to hazards, and fostering a culture of continuous safety awareness.

By adopting a human-centered design approach and grounding the system in behavioral science principles, this study aims to bridge the gap between static occupational safety protocols and the dynamic, high-risk nature of healthcare work environments, Marcolin, et al (2022). The outcomes of this work contribute to both the technical development of intelligent safety systems and the theoretical understanding of persuasive strategies in occupational health.

2.0 METHODOLOGY AND TOOLS USED

The methodology used for this work is hybrid which combined Agile and Behavior-Driven Development (BDD) Approaches. BDD focuses on understanding the end-user's behavior, essential in persuasive technology to ensure effective and empathetic user interactions. Agile's flexibility, iterative progress, and regular feedback cycles ensure that user needs and requirements are frequently revisited and adjusted. Combining Agile and Behavior-Driven Development (BDD) would enhance clarity by establishing safety-related features and functionality through clear, testable scenarios. The use of BDD-driven tests helps validate that each iteration meets defined safety requirements, supporting a persuasive technology that is user-centered and meets practitioners' needs directly and accurately. In realizing this methodology, the first step was to characterize selected healthcare activities and also safety requirements to develop a new data model. Upon the characterization, a persuasive application software model was developed using the user interface design, monitoring algorithm which measures the adherence of users to the safety requirements and also notify them when not adhered to. In addition, the behavior of the user is recorded and serves as input to a reward and repercussion model which encourages the adherence to the safety requirements and also queries users not following safety requirements. System integration utilized NextJS, server-side rendering, MongDB, RES END, React Mail, to implement the models while the testing and validation of the model will be done to evaluate the performance of the PAS

3.0 ANALYSIS OF THE EXISTING SYSTEM REAL-TIME HAZARD DETECTION SYSTEM BY BOUROU *ET AL.* (2024)

The existing system considered for this work is a real-time hazard detection system by Bourou *et al.* (2024), who applied You Can Only Look Once (YOLOV5) for the detection of hazard in workplace. The methods used are data collection, artificial intelligence model development and real time monitoring. The data collection process was carried out using a synthetic data generation approach which artificially generate 3D version of personal protection equipments. The data samples considered are helmet and vest. Total sample sizes of data used are 11229. The hazard detection systems are presented in figure 3.1.

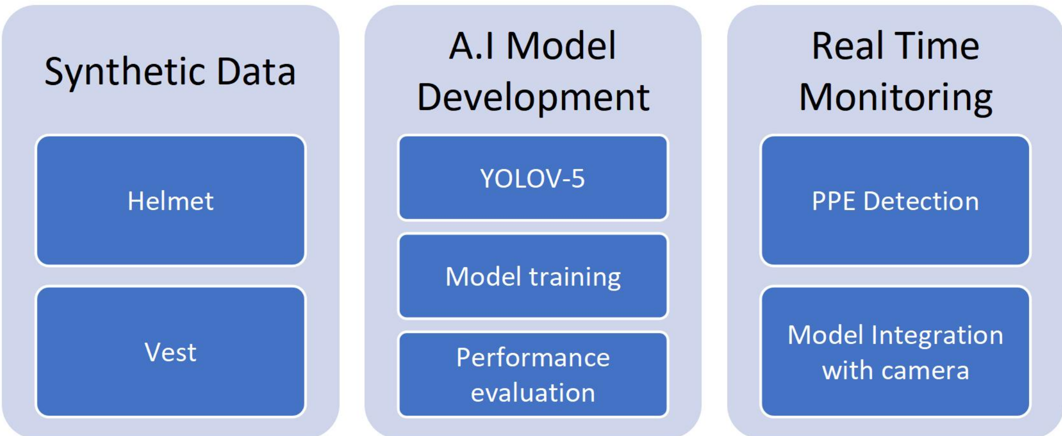

Figure 3.1: The hazard detection systems with YOLOV5 (Bourou *et al*., 2024).

The figure 3.1 presents the component interaction diagram of the existing system. First was data collection of objects which are vest and helmet from the Combined Human and Vehicle (CHV) and Synthetic Human and Vehicle (AHV) were selected and reproduced synthetically using a virtual environment. In the next phase the data were applied to train A.I algorithm for the model deployment. This was achieved using YOLOV5 which is a pre-trained model trained with the data using stochastic optimization algorithm. During the training, the performance was evaluated and upon meeting the stopping criteria, the model for real time monitoring of PPE was generated. This model was integrated with camera for real time supervision of operational hazard detection in industries.

3.0.1 Architecture of the Existing System

The architectural diagram presented in Figure 3.2 illustrates the workflow for an occupational hazard detection system using the YOLOv5 model. The system is designed to detect safety equipment such as helmet and safety vests worn by workers in industrial environments. The system integrates various components to train and deploy the model effectively.

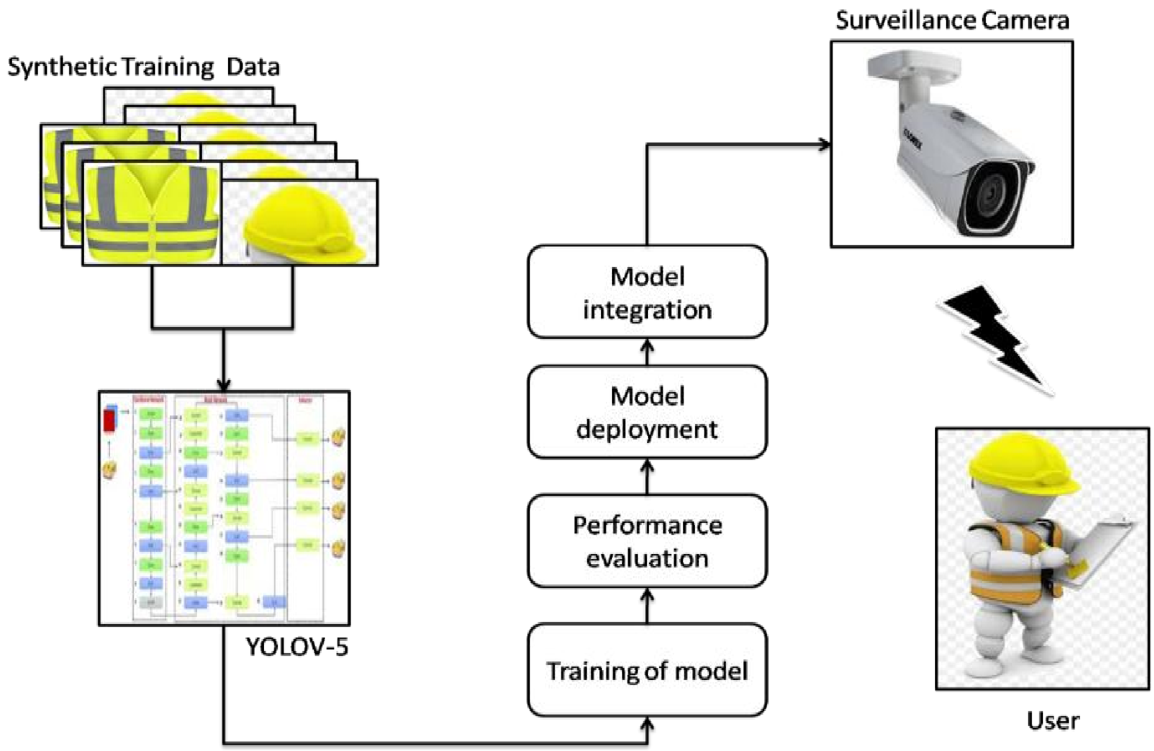

Figure 3.2: Architectural diagram of the hazard detection systems with YOLOV5 (Bourou et al. (2024)

The diagram above figure 3.2 depicts the architectural diagram of an occupational hazard detection system that utilizes the YOLOV5 model. The system is designed to detect safety gear like helmets and safety vests worn by workers, using synthetic training data and a real-time video surveillance setup. The process begins with the generation and collection of synthetic training data, consisting of images of safety vests and helmets, which are used as inputs for the training phase. The YOLOV5 model is trained to recognize and localize these safety items in images. Once trained, the model undergoes performance evaluation, where key metrics such as precision, recall, and Average Precision (AP) for both vests and helmets are assessed. The results of this evaluation show that for the CHV dataset, the model achieved a precision of 89.6%, recall of 84.8%, AP for vests of 86.4%, AP for helmets of 91.4%, and a mean Average Precision (mAP) of 88.9%. In comparison, for the SHV , the model reported a precision of 77.5%, recall of 67.8%, AP for vests of 67.6%, AP for helmets of 75.5%, and a mAP of 71.6%. These results highlight the superior performance of the model trained on real-world data CHV, although the synthetic dataset still provides valuable insights. Finally, after performance validation, the trained model is deployed into a real-world surveillance system, integrating with a surveillance camera to monitor workers. The model integration allows real-time detection of whether workers are wearing safety gear, and any detected violations are reported to the user, ensuring enhanced workplace safety.

3.0.2 Process Block Diagram of the Existing System

The data block diagram in Figure 3.3 illustrates the process of how data moves through the occupational hazard detection system using the YOLOV5 model. It highlights the flow of information from the initial training data input to real-time hazard detection, along with the model's integration into a surveillance system.

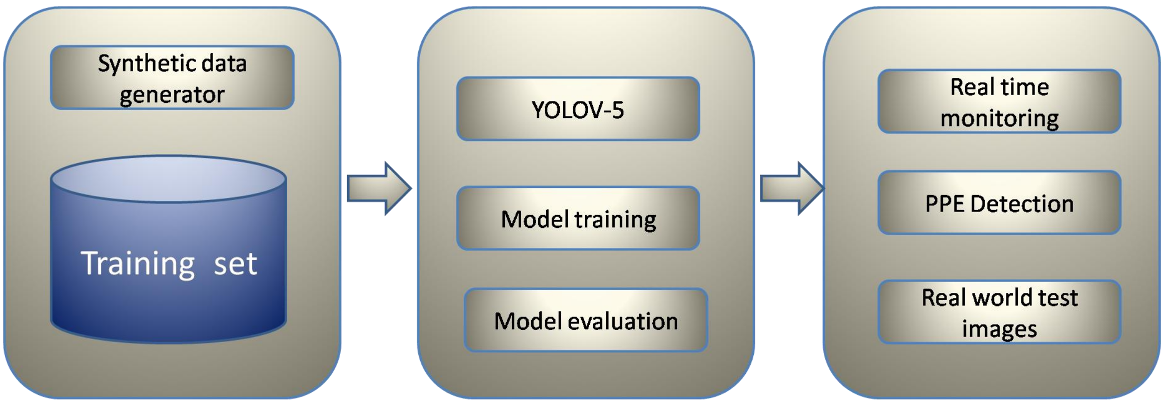

Figure 3.3: Process block diagram of the Existing System (Bourou et al. (2024)

The block diagram in figure 3.3 begins with the collection of synthetic training data, which includes images of safety vests and helmets. These images are fed into the system to train the YOLOv5 model. The synthetic training data is used to train the YOLOv5 architecture. The model learns to detect and classify safety equipment (helmets and vests) by identifying patterns and features in the provided training images. During this stage, various layers of the YOLOV5 network are fine-tuned to enhance object detection accuracy. After the training process, the model is evaluated on metrics such as precision, recall, and Average Precision (AP) for specific classes like vests and helmets. The results from this evaluation help determine whether the model is ready for deployment or requires further adjustments. As shown in the data, the model trained with real-world CHV data outperformed the one trained with synthetic data SHV, achieving higher precision, recall, and mAP. After successful evaluation, the model is deployed into a real-time environment where it integrates with surveillance systems. This deployment allows the model to process video footage captured by surveillance cameras and identify workers wearing (or not wearing) safety equipment. The detected results are then made available for user. If a worker is not wearing the required safety materials, the system provides feedback to alert the user, ensuring prompt action can be taken to enforce workplace safety measures.

4.0 ANALYSIS OF THE PROPOSED PERSUASIVE APPLICATION SYSTEM (PAS)

This section presents the PAS for the management of occupational hazard in health care environment. The major components of the proposed PAS constitute the user authentication platform, the event scheduling platform as the workplan, safety requirements, monitoring algorithm, reward and repercussion, then the system integration. The figure 4.1 presents the proposed PAS block diagram.

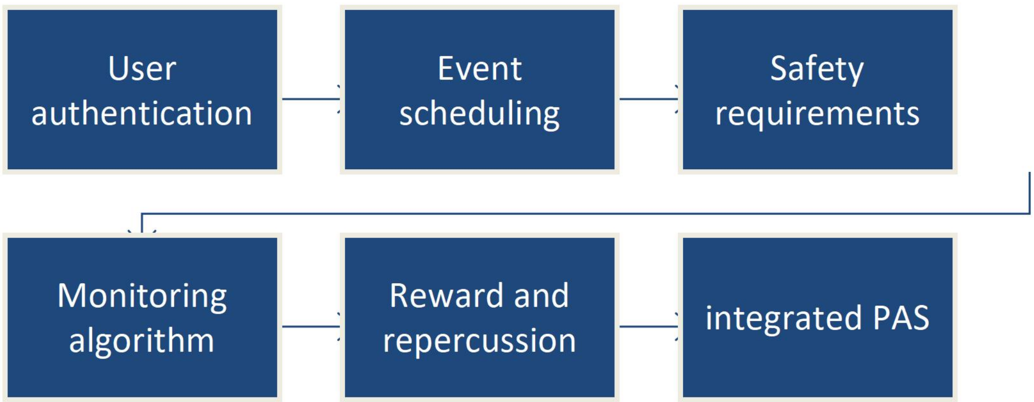

Figure 4.1: The PAS Block Diagram

The block diagram in figure 4.1 showed the essential components of the PAS system created to oversee workplace safety in a medical facility. User Authentication is the first step in ensuring that only people with permission can access the system. Event Scheduling has to do with planning occupational activities by the medical practitioner. The Safety Requirements section lists the procedures that must be adhered to while carrying out the scheduled activities, Mbanusi et al (2025). The Monitoring Algorithm part is in charge of monitoring compliance with these safety guidelines in real-time and continuously reminding the user until adherence to the safety rules. Based on adherence to the safety regulations, a system of rewards and penalties is suggested in the Reward and Repercussion block. Finally, an integrated PAS model which connects all of these components into platform application software to aid occupational safety in health care environment. The flowchart of the proposed system is presented in figure 3.5.

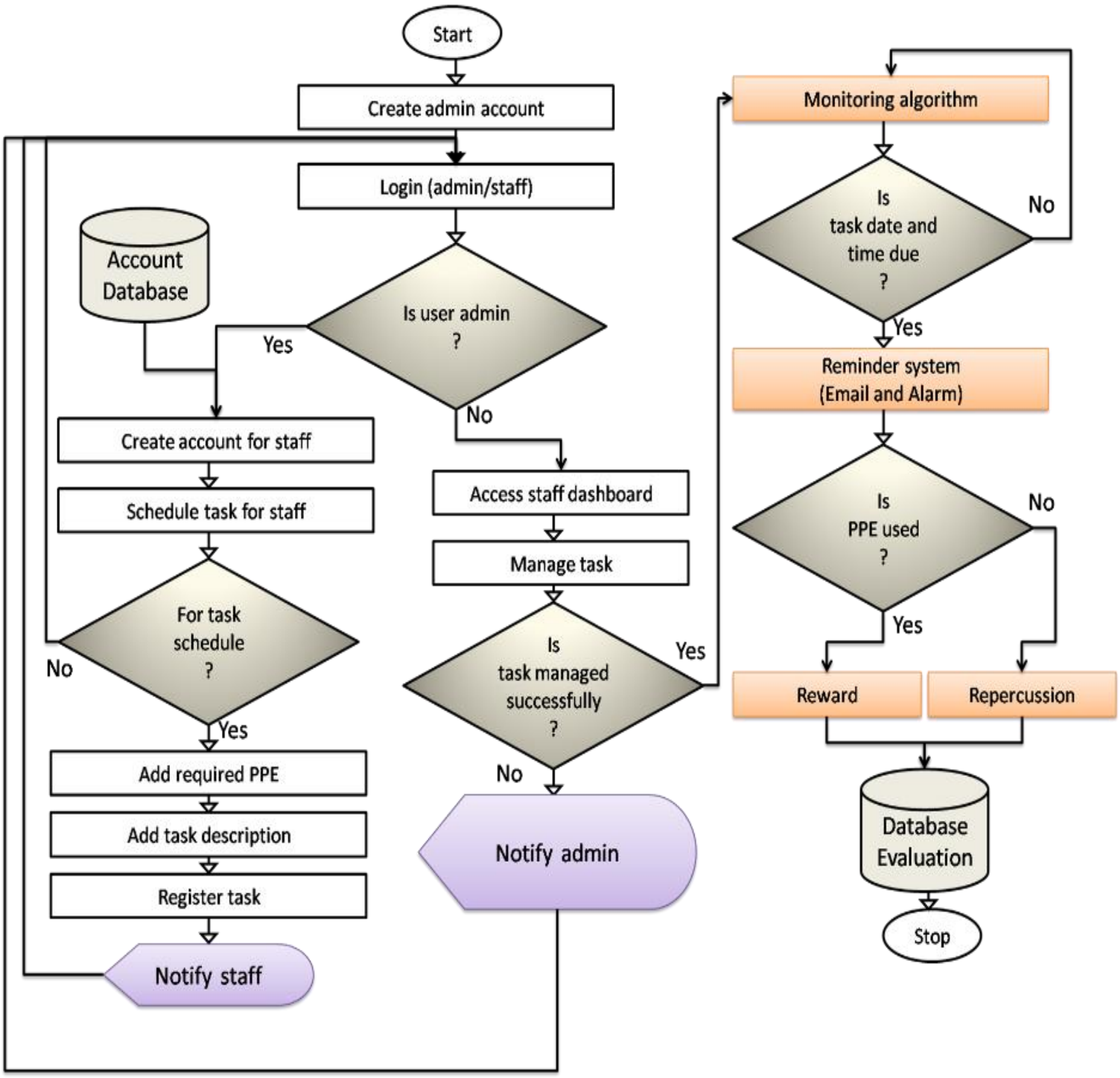

Figure 4.2: Flowchart of the Improved PAS Model

Figure 4.2 illustrates the new PAS with user management and safety compliance features. Users upon logging in or registering are authenticated based on their roles as admin or normal staff which in this context are nurses or doctors. The admin registers activities in the workplace and assign task with their PPE for users. The monitoring algorithm user compliance, issuing reminders through SMS to ensure that before carrying out the task, the necessary safety protocols are adhered to. Depending on compliance levels, the system uses a recommendation feature to categorize users based on their adherence to safety protocols, prompting further actions such as reward, warning, and query if required.

4.0.1 High level Model of the proposed System

This section presents the high-level model of the proposed PAS. This model is made of four major sections which are the user authentication section, event scheduling, monitoring for occupation hazard and management as shown in the figure 4.1.

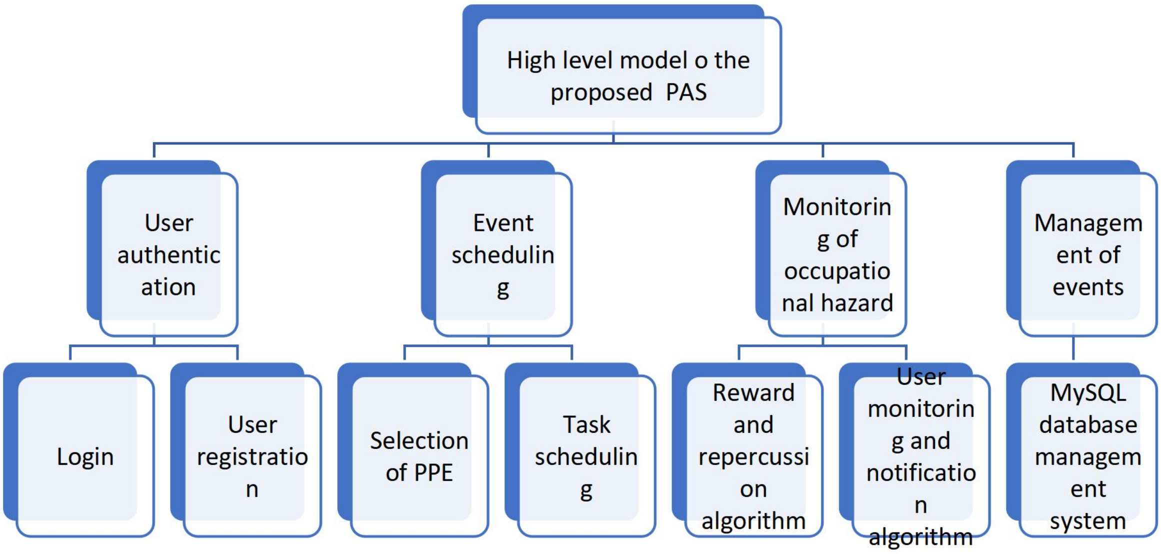

Figure 4.3: High Level Model of the Proposed PAS

The figure 4.3 presents the high-level model of the proposed PAS. The model began with the user authentication section, which allows authorized access for registered users. Upon user registration and login, events are scheduled using date and time, while the PPE for that particular task are also selected and submitted by the admin. The schedules events are made available to the respective staffs expected to carry out the task. When the event is scheduled, the monitoring for occupational hazard section is initiated using the user monitoring algorithm, reward and repercussion algorithm respectively. The user monitoring algorithm ensures that the user accepts utilization of the PPE during the task, while the rewards and repercussion algorithm will ensure that users upon adherence to the PPE during task are recommended for rewards say Ifenyinwa et al, 2025, while those who do not adhere to this PPE application are recommended for repercussion. The recommendation will be based on the overall adherence of users to the PPE.

5.0 TESTING PERSUASIVE APPLICATION SYSTEM (PAS)

This section tested the software at the Memphis hospital, Enugu Nigeria as one of the case studies. In testing the software, two of the staff were used as entities and the results were recorded and discussed here to prove the effectiveness of the system in real world scenario. The testing sequence includes registration of users, login of users, task scheduling by admin, task acceptance by user, reminder to use PPE as email notification and finally the reward and percussion model which evaluates the effectiveness of users in adhering to PPE usage for task. Figure 5.1 reported the login of admin,

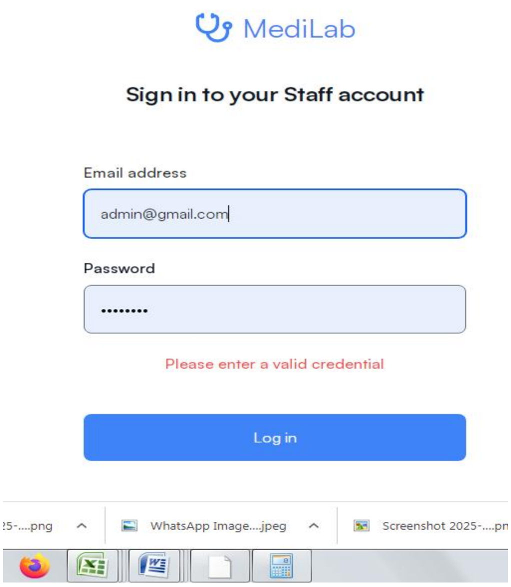

Figure 5.1: Result of admin login

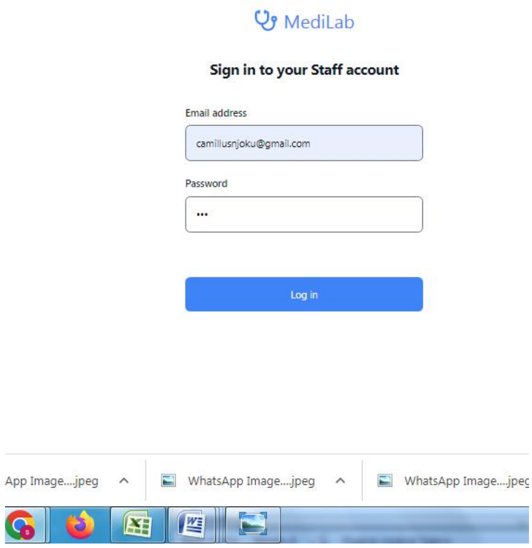

Figure 5.2: Result of staff login

Figure 5.1 and Figure 5.2 showed the result of the system when admin and staff login respectively. The admin login to create account for new staffs, assign task, monitor staff acceptance of task, and adherence to safety. The staff on the other hand, logs into know when staff has been assigned to them and the either accept or reject the task. In Figure 5.2, the admin creates account for the new staff named Dr, Njoku Ekene on the 4th Aril, 2025, while in Figure 28, the new staff was able to login and view task scheduled and to accept or reject the task.

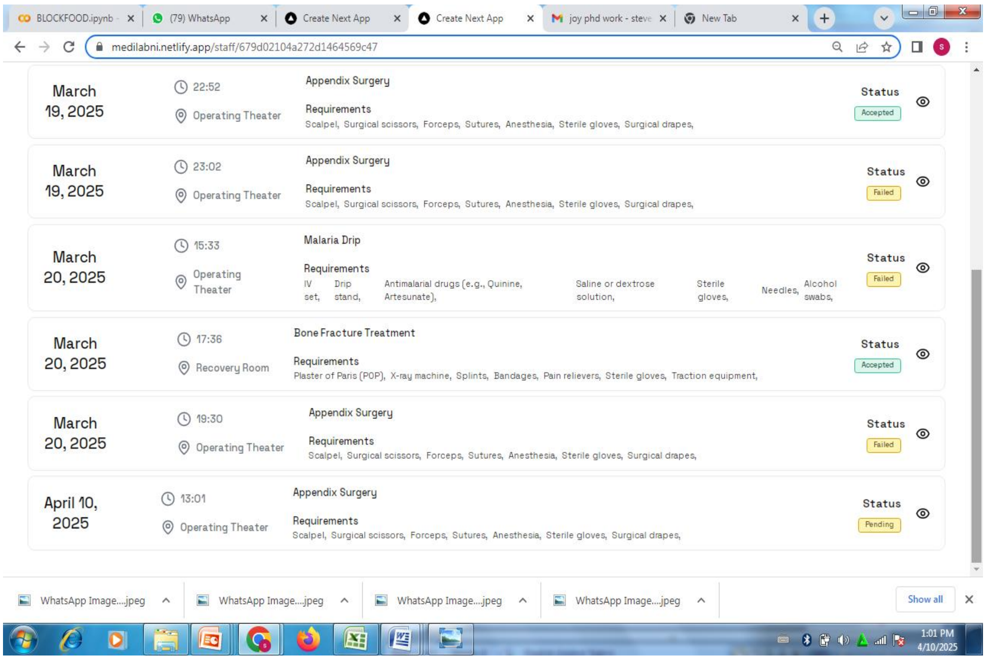

Figure 4.27: Result of admin dashboard (Admin name is Joy Nwankwo)

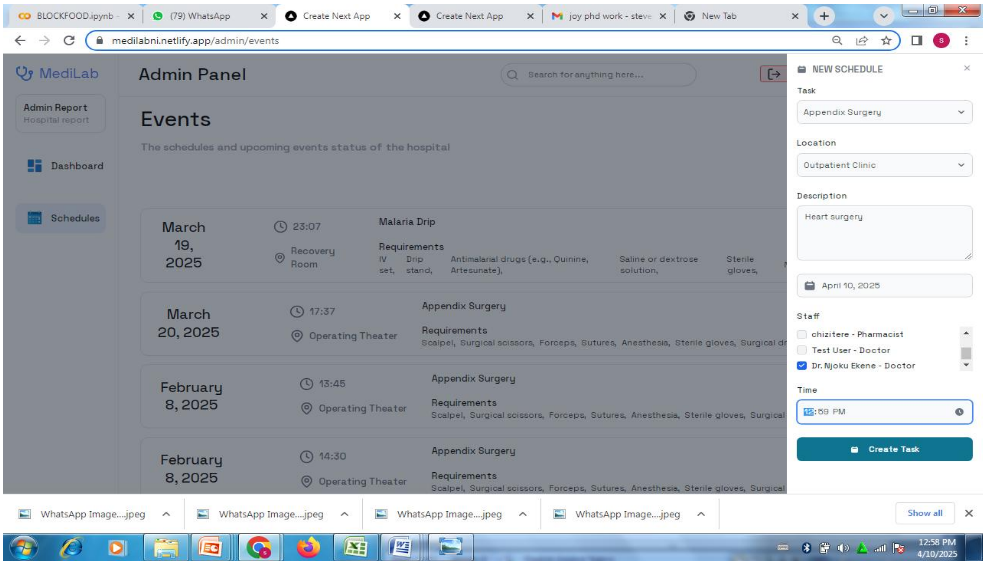

Figure 4.28: Result of Admin Scheduling Task to Dr Nkoju Ekene C.

Figure 4.27 revealed the dashboard of the admin where task can be assigned to users. Figure 4.28, task was assigned to Dr Njoku. The circle part of Figure is where the staff can be selected by the admin and as shown, Steve was the selected Staff. Figure 4.29 showed the email sent to Dr Njoku, notifying of the task schedules, while Figure 4.30 is the dashboard of Dr Njoku to access event scheduled, for either acceptance or rejection.

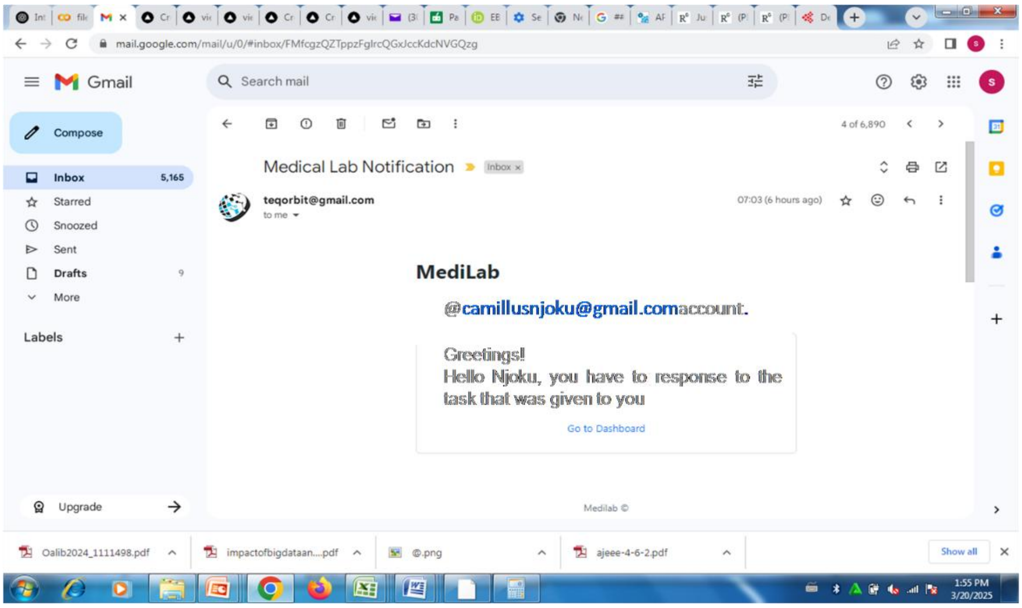

Figure 4.29: Email Notification of Scheduled task.

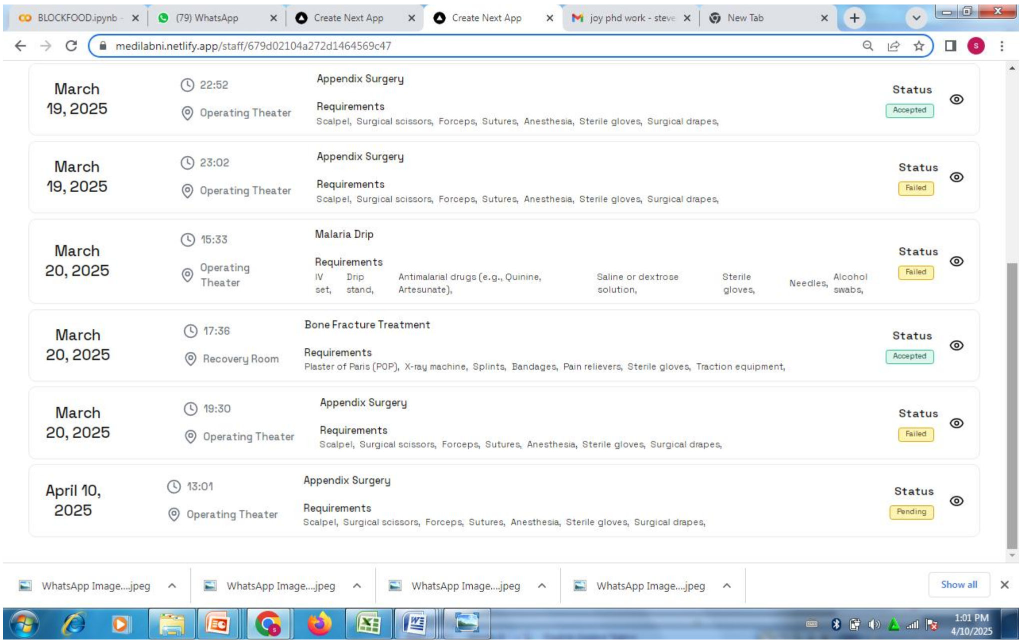

Figure 4.30: Dashboard of Staff to Check Scheduled Event

Figure 4.29 revealed the dashboard of Dr Njoku, showing different task assigned in the past, those accepted, those failed and the recent pending task as shown in the block circle. The Figure 4.30 showed the screen where the task was accepted, while the reflection on the dashboard was reported in Figure 4.31.

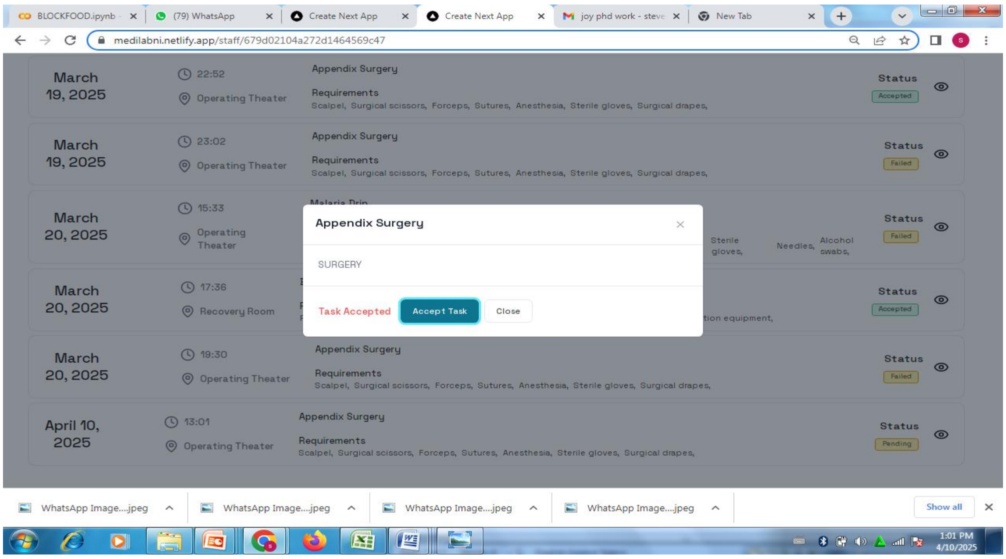

Figure 4.31: Result of Task Acceptance by Dr Njoku

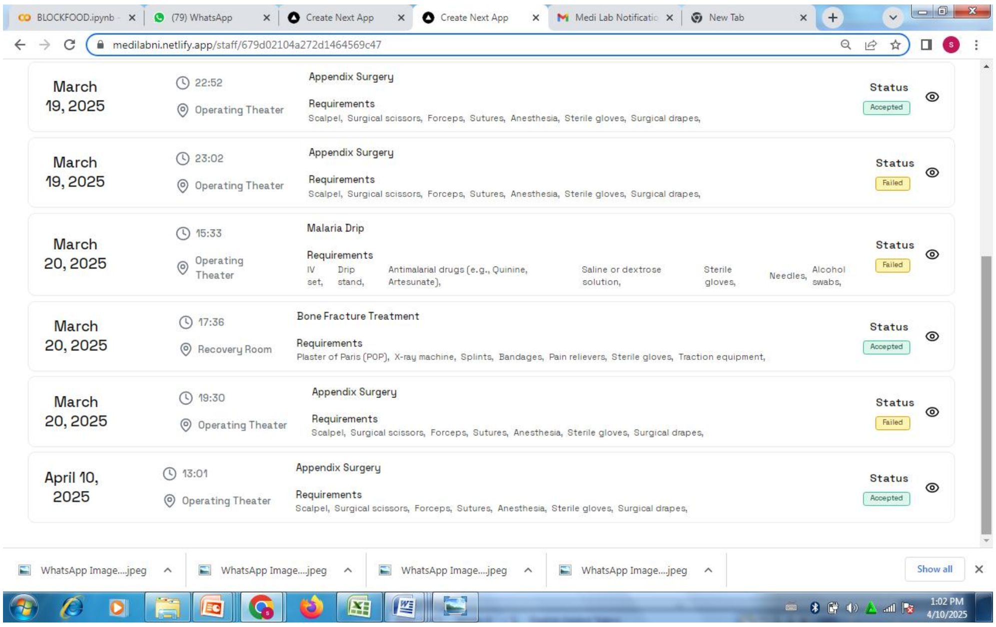

Figure 4.32: Updated Dashboard with Task Accepted

The figure 4.32 showed the accepted task option for the task, while in figure 4.33, the updated dashboard which showed the compliance of Dr Njoku to carry out the task was reported. Through this dashboard, there is transparency on the number of task carryout by every staff, number of pending task and number of those rejected. Upon acceptance of the task, the figure 4.34 showed when the staff is reminded with mail to adhere to the PPE.

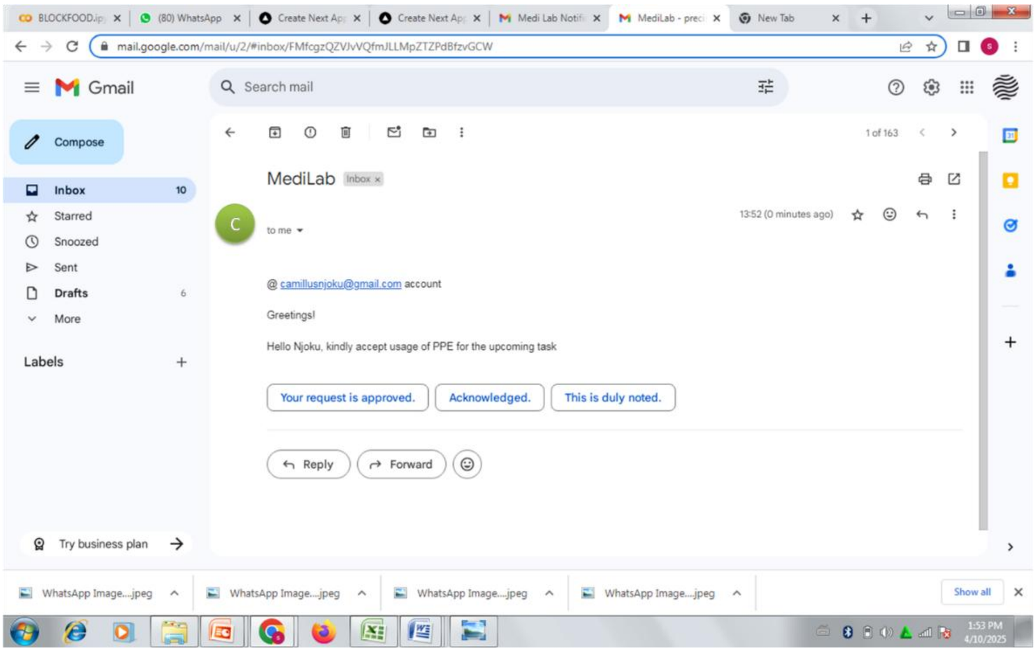

Figure 4.34 Result of Notification to Use PPE

The figure 4.34 presented the email sent by the system to notify user to use PPE before carrying out the task. This email was sent sequentially according to the monitoring algorithm developed which tracks the adherence of staff to PPE before carrying out a particular task. Figure 4.35 presents the final notification message sent to remind Dr Njoku to use PPE for the task.

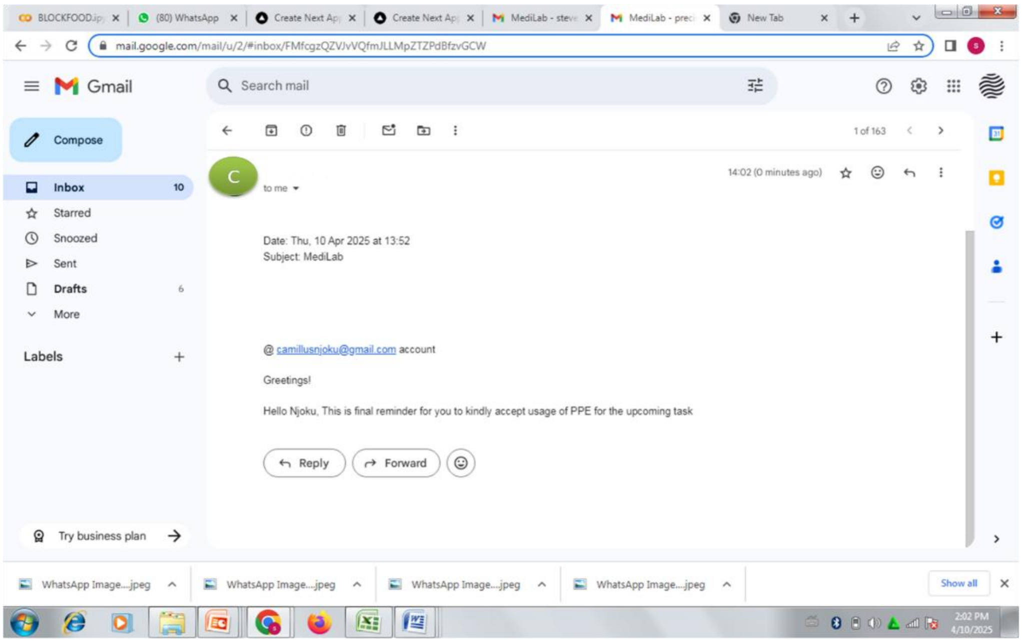

Figure 4.35: Final notification for PPE Usage

The figure 4.35, reported the final notification message sent to Dr Njoku to confirm usage of PPE for the task. After the message was sent and Dr Njoku did not use the PPE , it was then uploaded to the admin dashboard that his adherence factor is 0% (meaning no adherence to PPE while carrying out task).

In another event, Dr Emeka Kinsley of Memphis Hospital was used to test the work. The event scheduling result by admin was reported in figure 4.36.

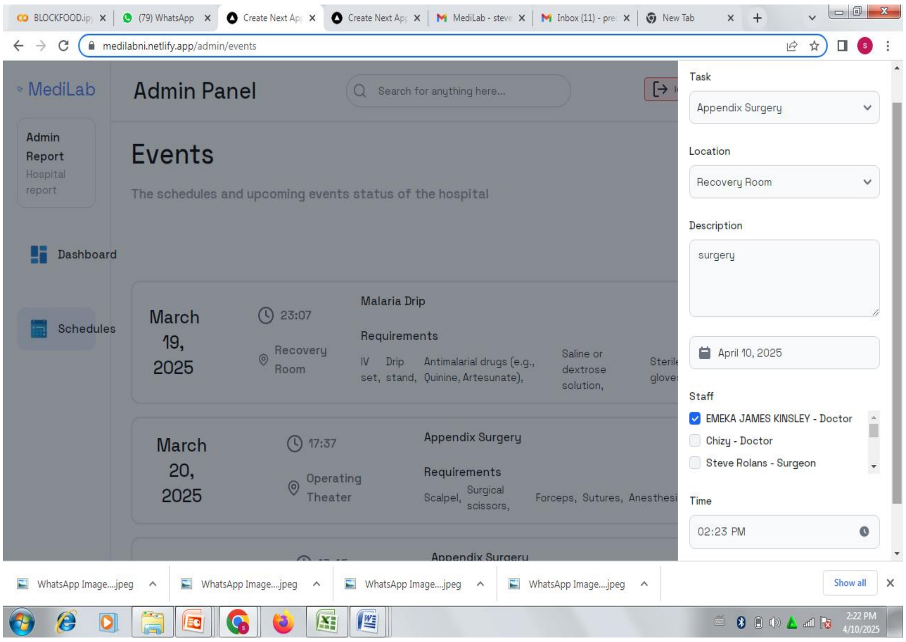

Figure 4.36: Result of admin scheduling Dr Emeka Kinsley for task

Figure 4.36 reported the result of the even scheduling for Dr Kinsley by the admin. The scheduled task upon success, notified the staff Dr Emeka of the event through email as shown in the figure 4.37. While the figure 4.38 showed when the staff logged into dashboard to confirm and accept the task.

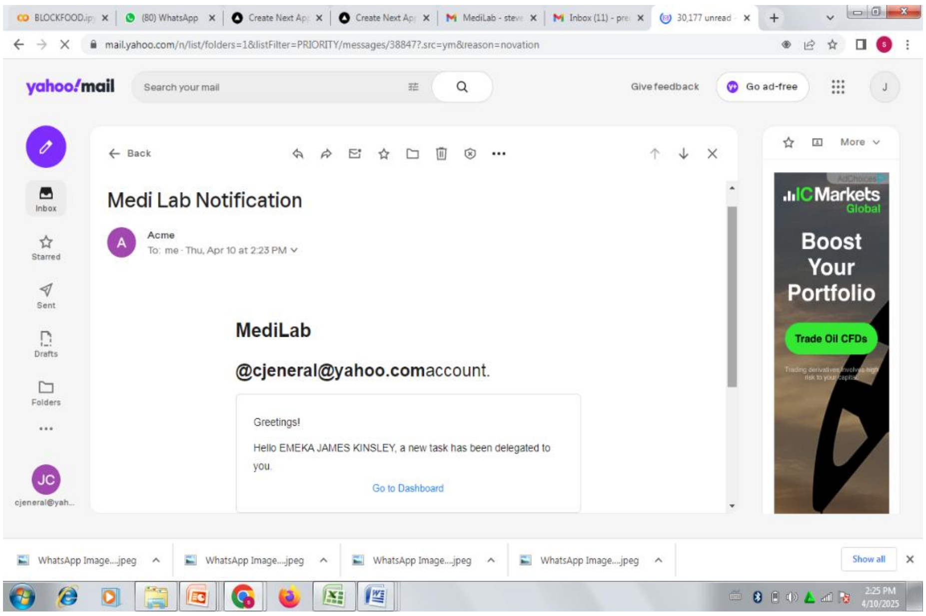

Figure 4.37: Result of staff notified of the task by email

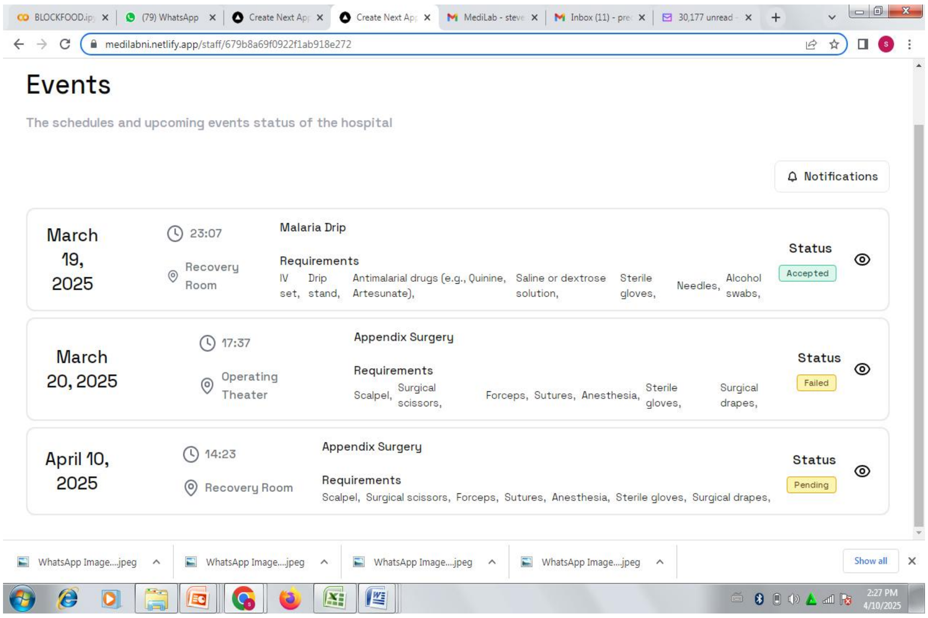

Figure 4.38: Result of staff login to dashboard when task was assigned

The figure 4.37 reported the notification of staff when task has been scheduled, while figure 4.38 reported the staff dashboard of Dr Kinsley to view the assign task, and description. Upon login to the dashboard, the user has the option to either accept of decline the task. In figure 4.39, it was seen that the task status has changed to accepted, which is an indication that Dr Kinsley has accepted to accomplish the task.

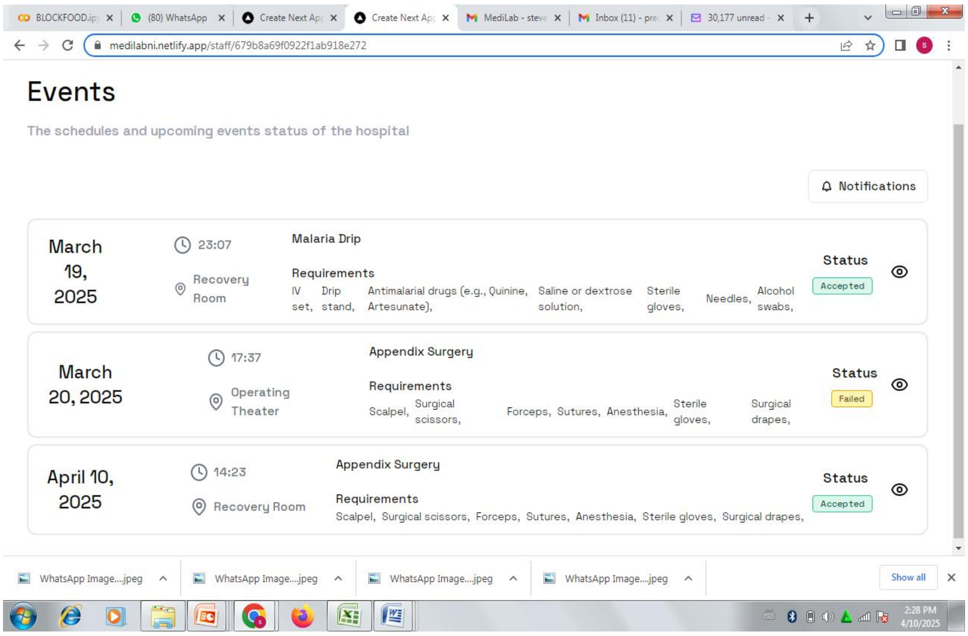

Figure 4.39: Result of staff dashboard when task was accepted

Figure 4.39 showed the changes task status to accepted, when then initiated the monitoring algorithm which check for PPE when is time for the task to carried out. 60min to the task, the figure 4.40 showed the first email sent to the user (Dr Kinsley) to accept use of PPE for the task. While the user did not confirm the usage of PPE, the notification was then sent again after 30min to the task as shown in the figure 4.41.

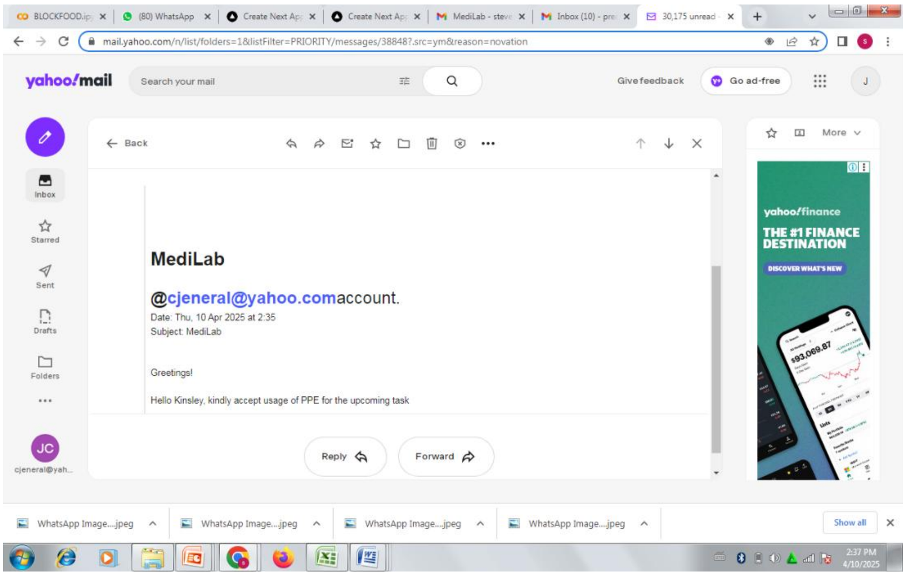

Figure 4.41: Result when notification to use PPE was sent for the task

Figure 4.41 showed the final notification sent to the user, prompting the person to adhere to use PPE for the task and accept it. Finally, 30min to the task, figure 4.42 showed the message sent to the user again to remind him or her to use PPE. When the message was not attended to through confirmation, then the PPE utilization factor is updated at the admin end.

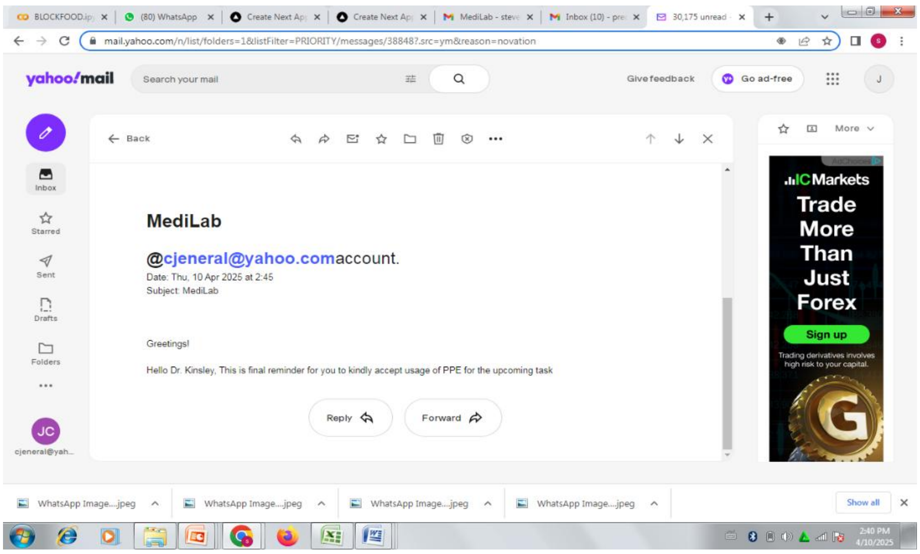

Figure 4.41: Result when final notification was sent for user

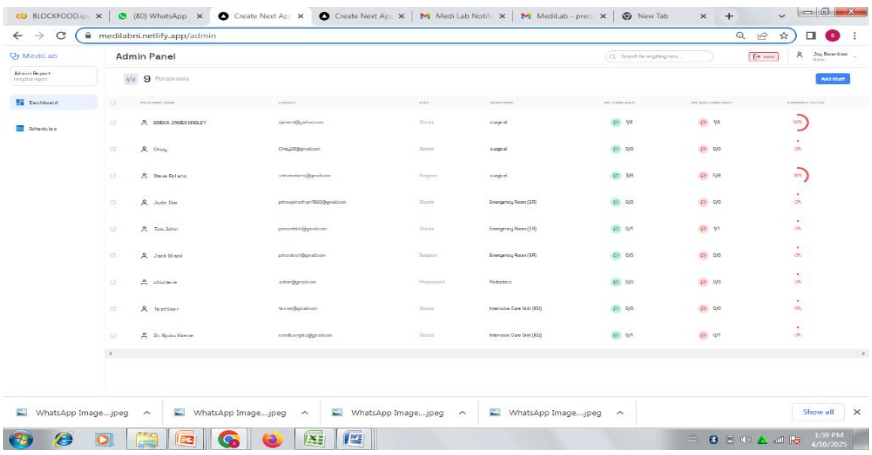

Figure 4.42: Result of PPE Adherence Analysis for Staff

The figure 4.42 showed the rage at which staffs adhere to PPE application while carrying out task assignment. From the results, the reward and repercussion algorithm was used to compute the rate of adherence for each user to PPE and then report the outcome in percentage as shown. For instance Dr Njoku 0%, which implied no adherence to safety requirements for task, while, Dr Steve recorded 25% adherence, which mean that so far the doctor utilized PPE one out of every four task carried out. Dr Kinsley reported 50% which implied that out of every two task carried out in the hospital, PPE was used for one, which an average performance. Other doctors such as John and Chizzy also recorded low adherence factor, which implied that the adherence to PPE by staff was poor. The result recorded by Emeka is 100% adherence factor, which implied that the user always applies PPE before carrying out task. Overall these staffs adherence factor influences the recommendations at the end of the year. For instance, the staff with 100% adherence factor will receive award, while those less than 50% adherence factor like our beloved Dr Steve will receive query. Overall this system serves as a persuasive model which ensure strict adherence to PPE without force, and ensure that staff are kept safe while trying to save lives of others.

4.8.4 Testing the model with nurse assistance at Memphis Hospital

Another expert consulted and used to validate the work is Nurse Mary Kenechukwu Agbo at Memphis hospital who was scheduled by the admin for infusion of drip on a malaria patient. Figure 4.43 reported the creation of account for the staff, while figure 4.44 showed the scheduling of task by the admin for the staff.

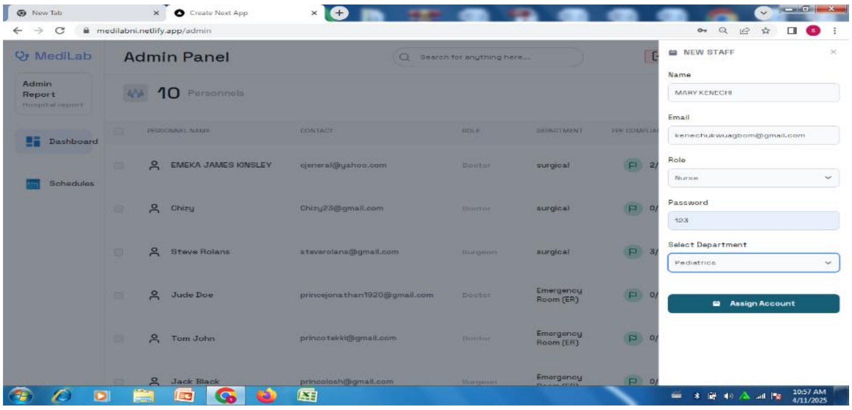

Figure 4.43: Creation of account by admin for Nurse Mary Kene Agbo

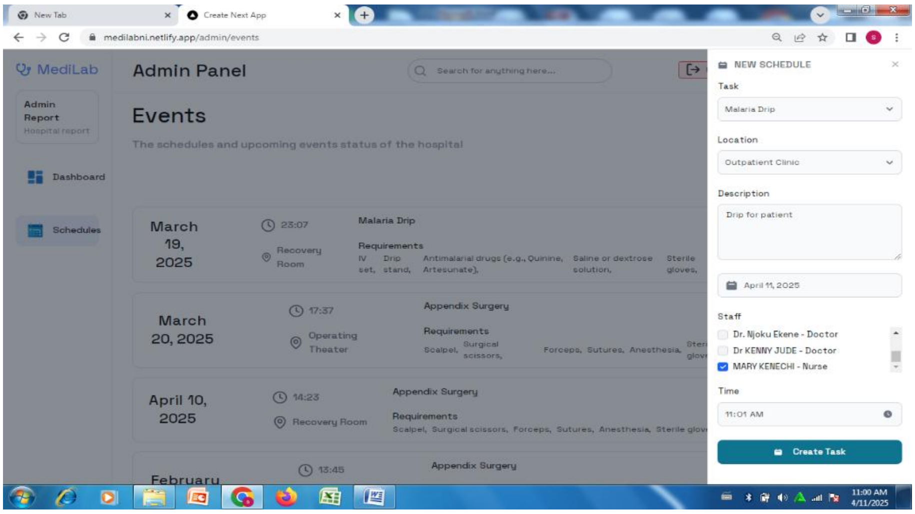

Figure 4.44: Scheduling of task by admin for Nurse Mary Kene Agbo

Figure 4.43 and figure 4.44 showed the initial staff account creation process for a new Nurse consulted at Memphis to test the software. Upon registration, the Nurse received notification as shown in figure 4.45, while upon task assignment; figure 4.46 reported the notification received by the staff via email.

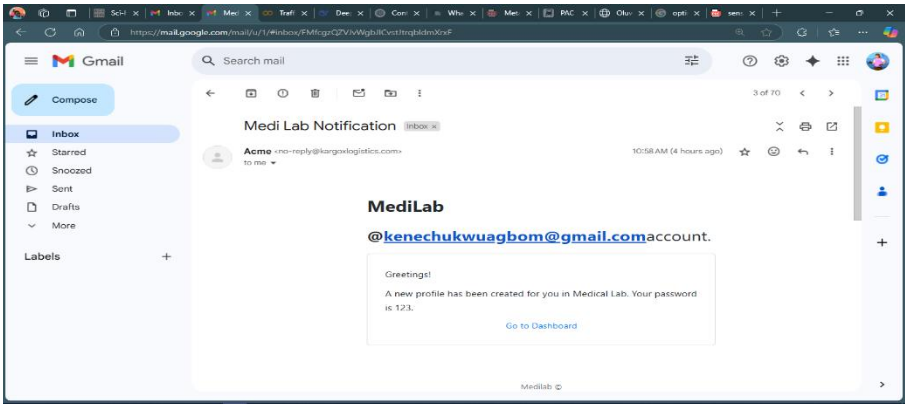

Figure 4.45: Email received by Nurse Mary Kene upon account creation

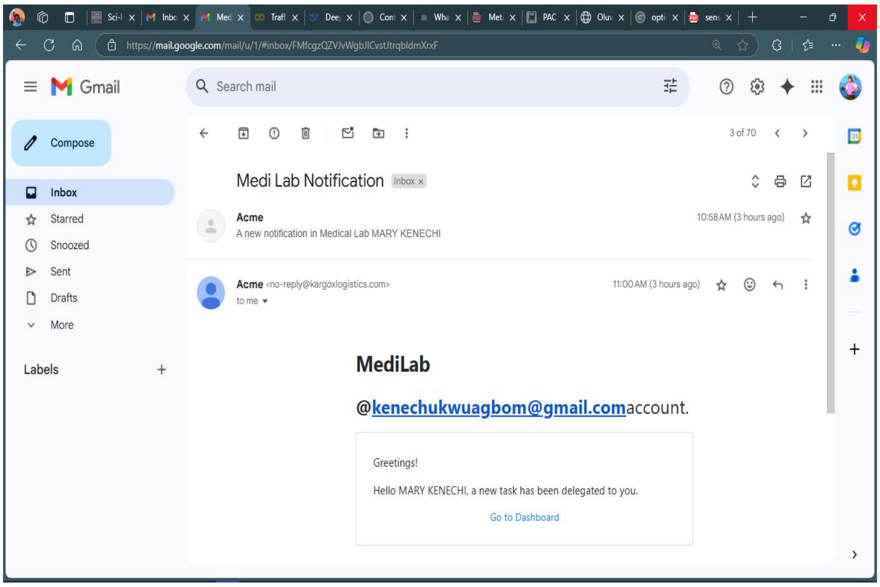

Figure 4.46: Email received by Nurse Mary Kene when task was scheduled

Figure 4.46 showed the email received by Mary K, which is the nurse scheduled to administer drip on malaria. Figure 4.47 showed when the staff logged into dashboard to view the task assigned and then accept or reject it.

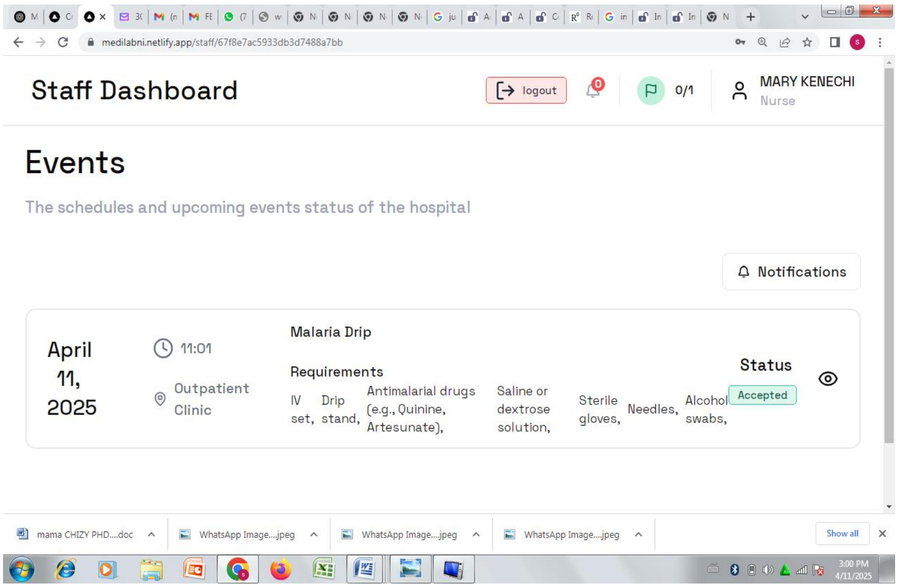

Figure 4.47: Result of Nurse Mary dashboard after task was accepted

Figure 4.47 showed the dashboard of Nurse Mary after she logged in and then task was accepted. Figure 4.48 reported the message received by the nurse on the day of the task. The message was sent 60mins to the task for the nurse to accept usage of PPE. This message serves as the first persuasive approach to ensure user used PPE while carrying out a particular task. Figure 4.49 also showed the results of notification sent as final alert to use PPE for the task before its then automatically updated the PPE adherence factor in the admin dashboard.

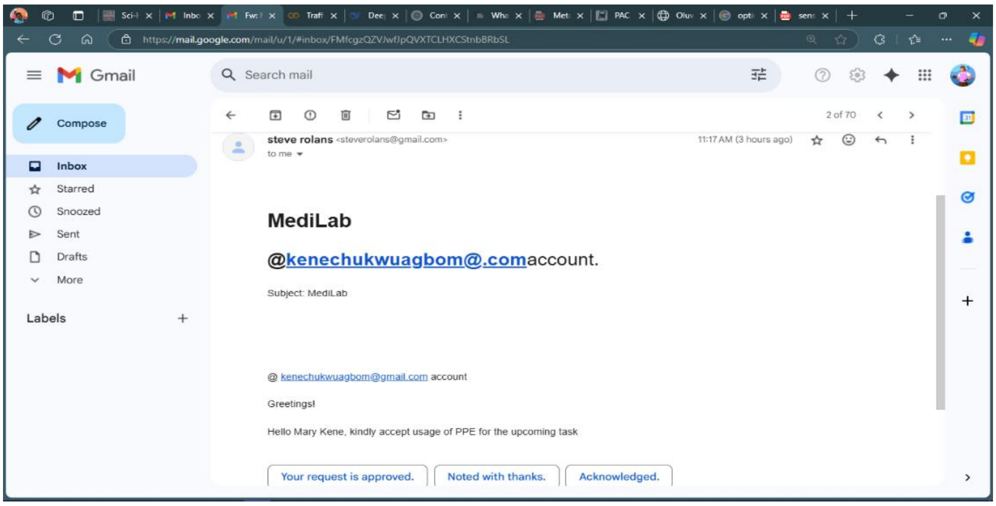

Figure 4.48: Notification email to use PPE for task

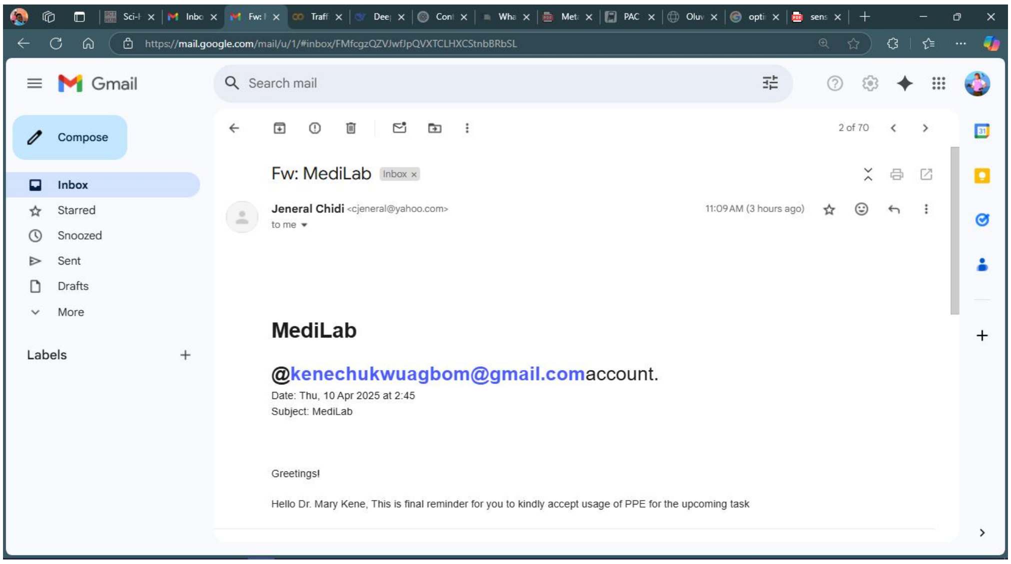

Figure 4.49: Final notofication email to use PPE for task

Figure 4.49 reported the final email sent to the staff (Nurse Mary) to use PPE for the task, before it was updated at the central dashboard of the admin as shown in Figure 4.49.

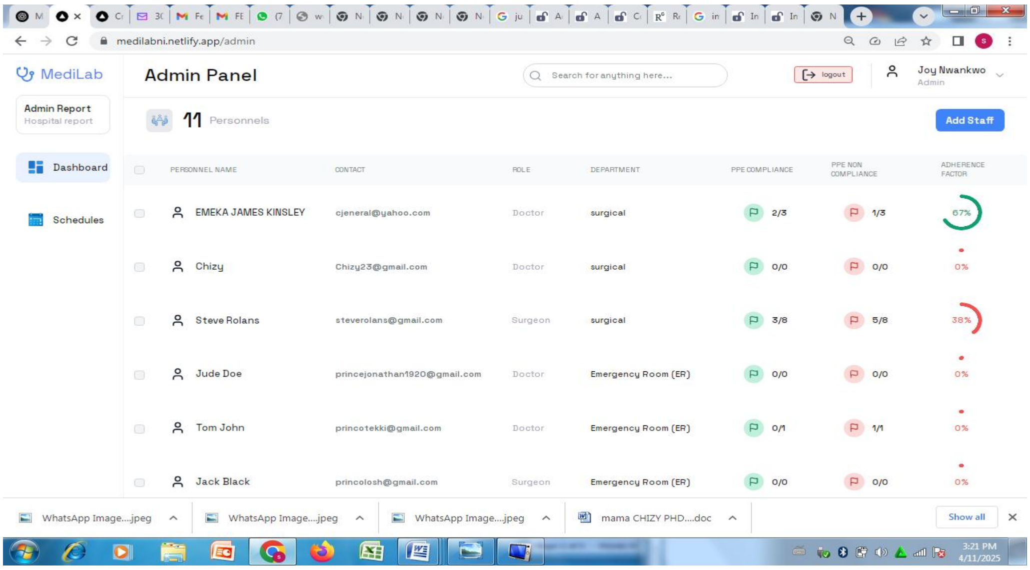

Figure 4.49: Updated dashboard on the admin end

Figure 4.49 showed the updated dashboard of the admin end. These results showed the PPE utilization factor for each staff using the developed algorithm and rank staffs according to their performance in using PPE. From the score recorded, those who adhere to PPE while carrying out their task are rewarded while does who do not use PPE are queried. The transparency of this dashboard also helps address issues of favoritism or bias in selecting staffs for reward or query, making this system reliable as an effective health care system for patient and staff administration.

4.8.5 Feedback from domain experts and findings

This section presents the different feedback of domain experts who evaluated the software after testing its functionalities and relevance to healthcare settings. The experts, comprising nurse, and several doctors who after testing he software, provided valuable insights regarding the usability, effectiveness, and areas for improvement in the system. Figure 4.50 reported the feedback from Nurse Mary.

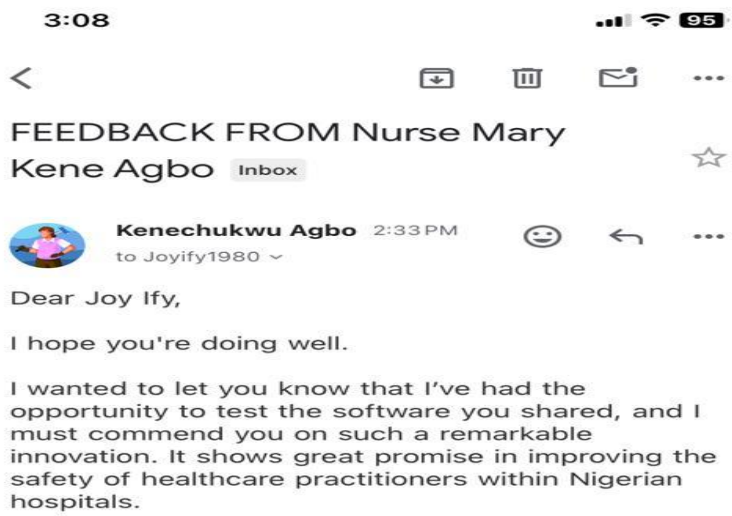

Figure 4.50: Feedback result from Nurse Mary

Figure 4.50 showed the feedback received from Nurse Mary, which is very positive and justified the work effectiveness in health environment with occupational hazards. Figure 4.51 reported the feedback from Dr Kenny ude of Memphis hospital.

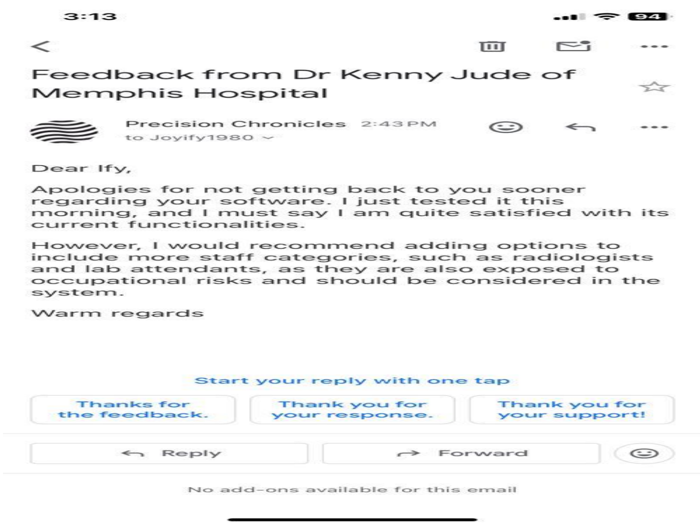

Figure 4.51: Feedback from Dr Jude

Figure 4.51 reported the feedback received from Dr Jude of Memphis hospital after using the software. The response was also positive as it acknowledged the functionalities on the software and potential to help save lives of health care workers, and then made recommendations to include other domain experts like radiologist and lab attendants to make the software more user diversive. Feedback received by Dr Steve of UNTH was reported in figure 4.52.

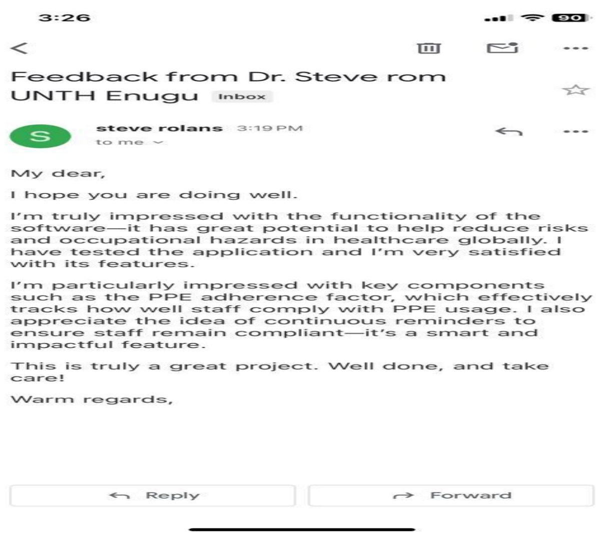

Figure 4.52: Feedback from Dr Steve of UNTH

Overall, the feedbacks from the domain experts were positive, with particular praise for features that promote safety, such as the PPE adherence tracking and automated reminders. Some experts recommended expanding the system to include more healthcare roles like radiologists and lab technicians, who are also at high risk of occupational exposure. The findings from this feedback have been instrumental in refining the software to better meet real-world needs and improve adoption in healthcare institutions.

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