DEVELOPMENT OF IN-PATIENT DIGITAL HEALTHCARE SYSTEM: A HEALTH MONITORING DEVICE FOR PATIENT USING IoT

Christine Marie J. Madrid*, Dominic O. Cagadas
University of Science and Technology of Southern Philippines Cagayan de Oro City, 9000, Philippines
Email: christine.madrid@ustp.edu.ph, dominic.cagadas@ustp.edu.ph

ABSTRACT- *Hospitals in the Philippines are overwhelmed and understaffed. Hence, it is inconvenient and challenging for the nurses to check patients' vital signs on time, and continuous patient monitoring, especially in-patient monitoring, is essential to measure and monitor the critical changes in the patient's status. The advent of technologies like medical sensors improved hospitals' health care and services. This study develops an innovative form of Remote Health Monitoring Device in the healthcare industry that makes use of modern sensor technologies. The developed health monitoring system makes use of an integrated combination of an Arduino Uno and Raspberry Pi 3 Model B microprocessor, connected to three important sensors: a body temperature sensor, a heart/pulse rate sensor, and an oxygen rate sensor. These sensors attached to the glove continuously monitor the patient's vital signs. Through sensor-integrated gloves, the device scans the patient's fingertips to create a connection between the microcontrollers and a data server. These real-time parameters are updated and saved straight to the server, providing a constant flow of the patient's critical data. A healthcare professional's Android mobile device receives this signal right away, enabling prompt response to potential health issues. Any changes to the patient's vital signs are in the meantime continuously uploaded to the data server for additional analysis. By offering thorough, real-time health monitoring outside of conventional healthcare settings, this modern device promises to greatly increase patient care.*

Keywords: Health Monitoring, Medical Sensors, Remote Patient Monitoring, Wearable Body Sensors,

1. INTRODUCTION

Life expectancy has increased worldwide due to significant improvements in medicine and healthcare [1]. However, patients' interactions with their doctors are limited only to visits and it is difficult for them to continuously monitor and give recommendations accordingly.

IoT has an excellent capability to create high-quality results with the help of innovative technologies. In medicine, it becomes a new reality in an innovative concept that provides the best service [2]. IoT is undeniably transforming the healthcare industry. Smart wearable devices such as fitness bands, and other wireless devices like heart rate monitoring cuffs, blood pressure, glucometer, etc. give the patient access to personalized attention.

More recently, the commercial availability and consumer adoption of wearable devices and sensors have greatly increased, with the ability to connect wirelessly for data transmission and storage [3].

The implementation of IoT is streamlining healthcare by helping nurses attend to patients in a timely manner. In addition, IoT supplies nurses, physicians, and other healthcare professionals with critical data that helps them provide appropriate interventions, increase productivity and improve outcomes [4].

Nurses in healthcare centers such as hospitals are in charge of caring for patients, communicating with doctors, administering medicine, and checking vital signs. They play an essential role in a patient's healing and recovery.

However, in the Philippines, about 40% of nurses in private hospitals have resigned due to several factors and that includes the threat of COVID-19 and the low wages [5]. Thus, causing the overwhelmed hospitals to be understaffed. The ideal nurse-to-patient ratio set by the Department of Health as 1:12 seems unattainable, despite the high number of registered nurses [6].

Given the premise stated a device is developed to allow healthcare personnel monitors critical vital signs, which are the Body temperature, Heart or Pulse Rate, and Oxygen Rate of the patients in real-time, to assess health conditions and provide feedback from distant facilities.

This is applicable for the case of critical care applications in hospitals where the care provider can access the information or data at any time and does not need to be physically present in the patient's room to examine/review the results. Some hospitals do not have enough nurses to monitor a patient's vital signs however, in this study, the hospital does not require as many nurses to go rounds in monitoring the patient's vital signs. Patients will be better monitored. This research also may be useful given that we are dealing with an epidemic such as COVID-19 which has become increasingly prevalent, has affected the entire world and every country is facing the challenges. This device will also generate an alarm (mobile notification) to alert the physician rather than requiring the patient to inform his physician of the situation. It will help determine the vital signs of the patient and will be programmed as we are aiming to have wearable remote patient monitoring, that operates automatically or functional on itself to be more proficient.

The research attempts to address the problems in the healthcare industry where hospitals are understaffed, it is inconvenient and challenging for the nurses to check patient's vital signs on time. Moreover, due to the risk of Covid 19, the nurses performing room-to-room assessments of patients' vital signs are vulnerable to the risk of infection from the patient. Through the wearable remote patient monitoring device healthcare workers can save much time by virtually monitoring the patient's condition.

2. METHODOLOGY

Development of the System

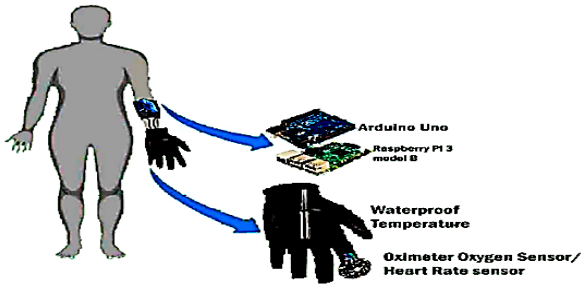

Figure 1. Wearable Remote Health Monitoring Device

The use of sensors for medical purposes is a more realistic approach and for the vital signs is very important and complex. In this project, a Remote patient has done [7]. The remote health monitoring device is composed of two sensors the oximeter oxygen rate sensor/heart rate sensor and body temperature sensor that are attached to the gloves (Figure 1).

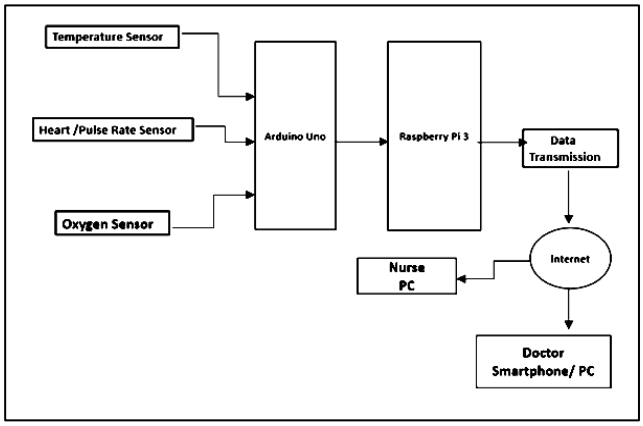

Figure 2. Block Diagram

The transmitter and monitoring sections of wearable remote patient monitoring are distinct. The transmitter section is composed of an Arduino uno, a Raspberry Pi 3 Model B, and several sensors such as a heart rate/pulse sensor, temperature sensor, and oxygen rate. The monitoring section includes a PC or Laptop as well as an Android smartphone (mobile notification). The block diagram of the wearable remote patient monitoring is shown in Figure 2 below. There are three sensors named temperature sensor, heart/pulse rate sensor, and oxygen rate sensor that are connected to the microcontroller (Arduino Uno, Raspberry Pi 3 Model B).

As shown in the flowchart (Figure 3), this is how the device works. It starts with scanning the patient's fingers (gloves) and establishing a connection between Microcontroller, Arduino Uno, and data server. The measured real-time parameters are updated every 1.5 seconds and directly saved to the server. It will continue to read patients' sensor data. If data reaches its set threshold value, it displays the alert through a notification, and the doctor will be notified about the patient's condition on their Android mobile. The data changes will be uploaded to the data server (Laptop).

Extraction of Data

The necessary data stored and sent to the doctor's smartphone or PC are Body temperature, Heart or Pulse Rate, and Oxygen Rate. These are the patient's parameters measured through the gloves. The patient always wears the wearable remote patient monitoring device within the hospital room, which measures their vital signs every 1.5 seconds.

One of the measured parameters is body temperature. The normal reading of a Human Body Temperature is around 37°C according to [8]. This temperature is quite significant when it comes to health monitoring. The LM35 Human Body Infrared Temperature Sensor is used. Another parameter measured is Heart or Pulse Rate. The pulse sensor is interfaced with the microcontroller to give a digital output of the heartbeat or pulse rate. The normal heartbeat ranges between 60 to 100 BPM for adults [9].

The last parameter is Oxygen Rate. This is used to count the patients' breaths. The

The oxygen rate should be between 95% and 100% [10]. The data that is acquired is stored, analyzed, and visualized on a web server. When the measured parameters will exceed the

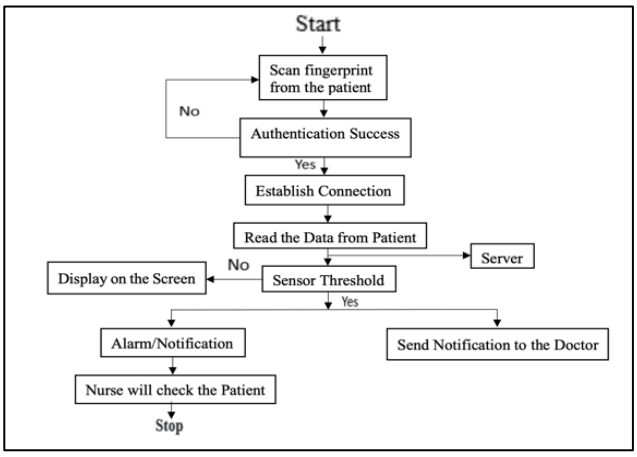

Figure 3. Process Flow of the System

threshold limits, it will alert through a notification. Through this, it will capture the attention of the doctors.

The User Interface

Wearable remote health monitoring display features the patient's basic profile information such, (name, age, sex, and ID number). It also includes essential parameters like Heart Rate, Oxygen rate, and Body Temperature with a real-time line chart showing the vital readings. See Figure 4 below.

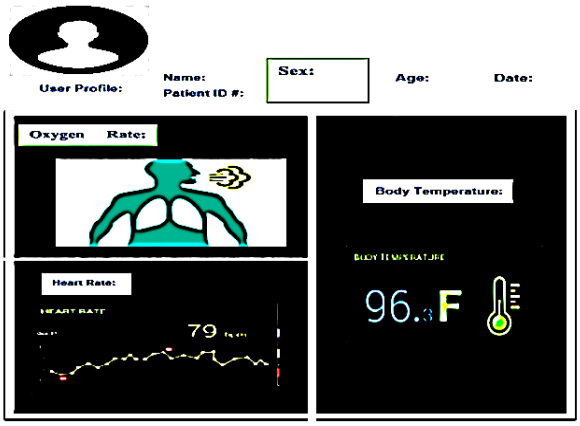

Figure 4. Patient Monitoring Display

3. RESULTS AND DISCUSSION

Data Extraction for the Patient

Healthcare is a field where technology and services are continually evolving. Through the development of this wearable remote patient monitoring device, with numerous benefits in an aging world population with increasing health concerns, it will be more convenient for the healthcare providers like nurses and doctors to monitor the health of the patient remotely.

This device works through this process:

Patients will be registered by the nurses or guardians so that they can easily view and update the patient's health status. Through this, it can provide a good means of data tracking.

The patient must wear gloves - these are to scan the finger of the patient. Instead of a nurse needing to manually check

The patient, the wearable remote patient monitoring will read the patient body temperature, heart or pulse rate, and oxygen rate of the human body in real time. Through these, the nurses and doctors can save valuable time to check the patient.

The Doctor will be notified about the patient's condition. If the patient has an abnormal vital sign the alert will be sent tothe doctor and nurse through mobile notifications and through the user interface.

Each scanned vital signs are automatically saved into the database. Through these data, the nurses and doctors may be able to know the record of each patient. Results can be printed as well.

The Mobile Application

The wearable remote patient monitoring also has a mobile application that is downloadable from the PlayStore (Figure 5).

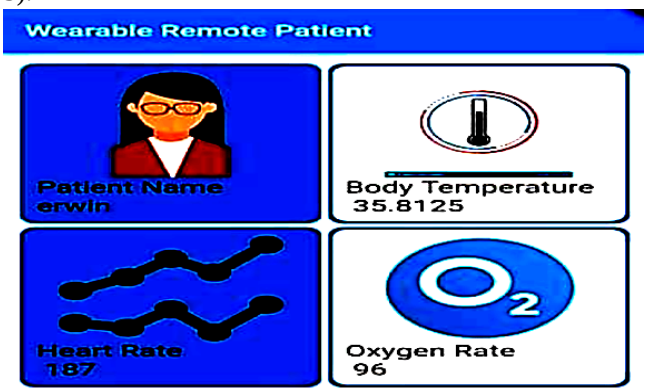

Figure 5. Patient Monitoring Mobile Application

Mobile Notification is one of the important features of this device. It notifies the healthcare provider of the activities of the patient like wearing and removing the gloves (Figure 6). As well as alerts if readings reach the threshold values.

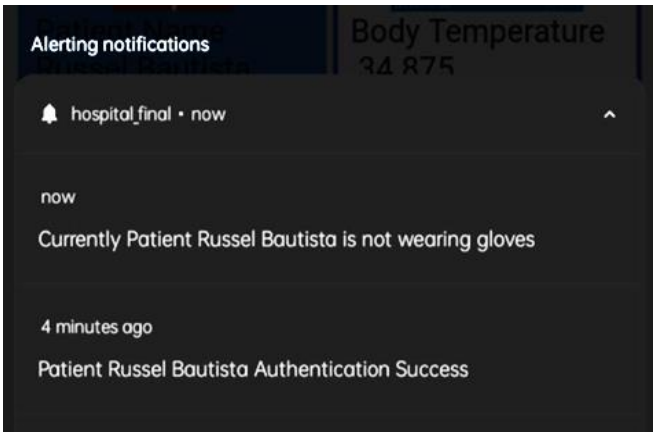

Figure 6. Notifications

The Web Application

As seen in the figure below (Figure 7). Patients are registered personal information about the patients are entered such as their names, birthday, sex, and age.

Registration is a process by which a patient's name and identity are enrolled into the records of the hospital. This is required in order to provide services of the hospital to the patient and to keep track of various services that are availed by each patient.

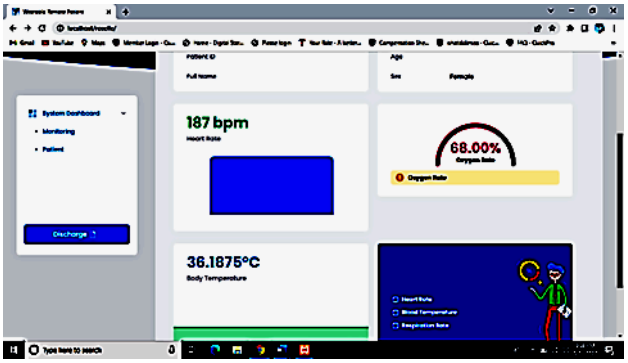

Figure 7. Patient Registration

Every time the patient wears the gloves, it will directly record in the database. The figure (Figure 8) below shows

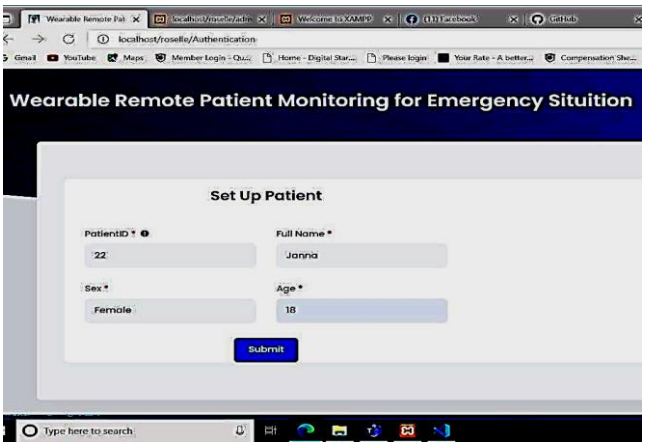

Figure 8. Patient Monitoring

the information that is displayed on the monitor system of the Doctors/Nurses. In this figure, you will see the patient's personal information such as Patient ID, Full name, Age, and Sex. On the left side, it shows the dashboard with the links to the Patient's Information, Monitoring, and Discharge button. Once the patient wears the gloves, it will directly read their vital signs and displayed them to the Doctor/Nurse

monitor containing the patient's Heart Rate (bpm), Body Temperature (°C), and Oxygen Rate (%) (Figure 8).

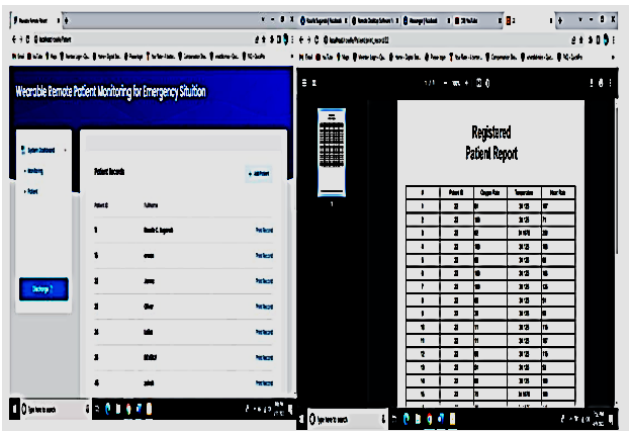

Figure 9. Printing of Patient Report

Showing the Vital Readings Patient's record can also be generated and printed by Nurses or Doctors (Figure 9).

4. CONCLUSION

The main objective of the development of this device is to help manage patient care, especially for understaffed hospitals. One of the most important features of this device is to measure different important physiological parameters of the human body such as body temperature, heart or pulse rate, and oxygen rate. Various sensors such as pulse rate, body temperature, and oxygen rate, are interfaced with the microcontroller for measuring the important physical parameters of the patient. It uses wireless sensor networks and information communication technologies to provide remote monitoring. The measured real-time physiological parameters are updated every 1.5 seconds. The data acquired is first stored, analyzed, and visualized on a web server. The system has been designed to notify the doctor in such a way that, when the measured physiological data exceeds certain threshold values, the doctor will be notified through mobile notification. This device improves the management of the patient in understaffed hospitals since the regular visitation of nurses to check the vital signs of the patient is reduced.

However, several improvements for the system are being recommended like the addition of sensors for blood pressure and sugar level in order to optimize the use of the health monitoring system. Moreover, since the system captures these vital health parameters, future research should focus on applying advanced analytical algorithms to interpret data to help the system predict potential health crises.

Another improvement should focus on data privacy and security. Future research should incorporate advanced data encryption methods to protect the patient's data during transmission to maintain the patient's privacy and confidentiality. Future researchers should take advantage of the next-generation way of wireless communication, the 6G network. In a study conducted by Saad, [11], he enumerated the advantages of 6G in terms of its contribution to communication, automation, creation of smart cities, smart homes, its contribution to weather forecasting, and significantly more. Research concerning health monitoring can take advantage of this emerging technology in communication. Lastly, since the system uses Raspberry Pi 3 and Arduino Uno, it is recommended to conduct a study on power optimization to ensure the remote patient monitoring device can operate for longer periods.

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