Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 4 Vol 8 No 1 2023

Article

Healthcare Monitoring COVID-19 Patients Based on IoT System

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Available from: http://dx.doi.org/10.21931/RB/CSS/2023.08.04.24

ABSTRACT

At the beginning of the Coronavirus disease 2019 (COVID-19) pandemic, the world needed to develop an innovative, accurate system for caring for and following up with patients remotely to reduce the massive influx of patients into hospitals. Therefore, the well-established Internet of Things (IoT) technology was used to build an applied model for health care. The main objective of this study was to create a system connected to an application that allows continuous remote and early detection of clinical deterioration by monitoring different levels of biometrics to reduce the patient's risk of serious complications. Assessments were conducted on four subjects (two males, two females) aged 30-50 years with COVID-19. The system was examined under conditions and medical supervision in the hospital, following a schedule of vital measurements (oxygen saturation rate, heart rate and temperature). An average of 4 examinations was recorded per day over a week. The model has recorded the mean of error of oxygen saturation rate (SpO2), pulse rate, and body temperature as (0.3975%), (0.2625%) and (2.925%) for four patients.
Keywords: Healthcare, COVID-19, IoT System

INTRODUCTION

The World Health Organization (WHO) has classified Coronavirus disease 2019 (COVID-19) as a pandemic because it is a serious and contagious disease.

The Internet of Things (IoT) gathers, processes, and evaluates the data in many systems, such as monitoring healthcare and redefining how its facilities and systems are enhanced. The technologies of IoT are represented by sensors, real-time testing, embedded systems, and machine learning that deal with the concept of the intelligent hospital and wireless-based equipment. In the medical domain, the best technology for monitoring is IoT. The basic devices to Execute the IoT technique are medical instruments, medical sensors, etc. [14,22].

In this paper, The Electronic home monitoring system allows the remote monitoring of COVID-19 patients and reduces the risk of respiratory syndrome. In addition, the system has a medical sensor that provides several vital signs, such as a temperature sensor, pulse rate sensor and Spo2 sensor. These measurements were applied to four people with COVID-19 under the supervision of specialist staff.

Healthcare, according to COVID-19, uses IoT in different techniques that follow literature reviews in 2022, Akpan abd et al. presented medical software for the care of COVID-19 patients by programming to store their data; it helps the healthcare staff to monitor the COVID-19 patients' condition. Therefore, this technique can help the doctor to give the diagnosis and treatment to the patient [23]. In 2022, Ndiaye et al. applied the artificial intelligence technique to check the performance of the acquired information of COVID-19 patients. They had accurate results that helped to reduce the respiratory syndrome risk [24]. In 2019, Haleem et al. researched an intelligent sensor that presents data on the health conditions of COVID-19 patients by checking vital measurements. In addition, the results of this technique are represented by the precision and trust in the medical field [25]. In 2019, Janeh was present in Virtual Reality (VR). This electronic technology Contributes to the preparation of the COVID-19 patients' data in real-time and provides the schedule of the perfect treatment for them [26]. In 2018, Jagadeeswari et al. analyzed big data containing information about COVID-19 patients and stored it in hard copy or digital form. Healthcare has speed solutions with this system [27]. In the same year, Stergiou et al. presented a cloud computing system used to store the information of COVID-19 patients on a computer with the Internet. This technique helps the healthcare staff perform best for monitoring COVID-19 patients [28]. 2015 Lu et al. have been monitoring the responsible system for the needed medical measurements. This technology has an accuracy in the final results [29].

MATERIAL AND METHOD

Proposed Research Methodology

The IoT technology connects medical tools, gadgets, and machines to develop intelligent information systems tailored to the needs of COVID-19 patients. A distinct interdisciplinary strategy is required to improve production, quality, and information about impending diseases. In order to assess relevant data, IoT technology monitors changes in critical patient states. Also, IoT technologies significantly influence high-quality medical equipment, which helps provide a personalized response during the COVID-19 epidemic. These technologies can acquire, store, and analyze data digitally. All healthcare records are stored digitally, and patient data and information may be sent quickly in an emergency, allowing physicians to operate more efficiently [30]. Several recent studies have used smart sensors to achieve a high capacity level for monitoring and managing the significant needs of medical temperature, Spo2 and pulse rate, and information regarding Covid-19 patient health [31,32].

Required Materials

To execute the system, the following is described in the COVID-19 monitoring diagram as shown in Figure 1:

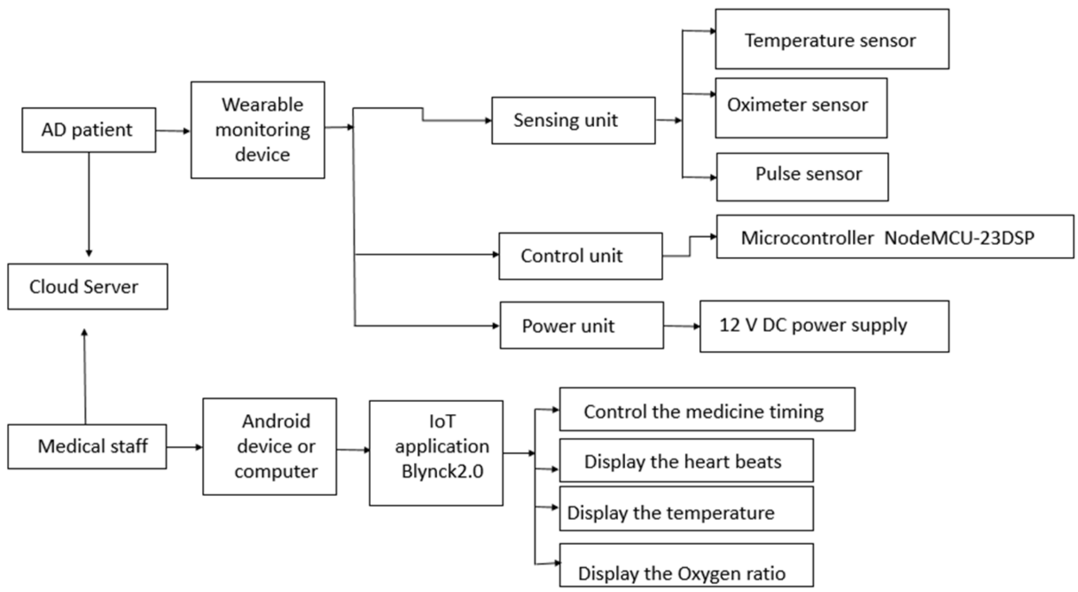

Figure 1. Block diagram for COVID-19 patient monitoring system.

The monitoring system designed in this work focuses on the equipment and sensors (hardware) used for biometrics and the software by use of Blynk. The hardware system included many parts, starting with the power supply, the microcontroller, sensors of vital functions and output devices. The following are the most important parts used to build the system:

An ESP-WROOM-32 module in the breadboard is a Node MCU ESP32 board. At the heart of this module is the ESP32 processor, which is expandable and adaptive. The clock frequency can be varied from 80 to 240 MHz, and two CPU cores can be handled independently. It also works with real-time operating systems (RTOS). The ESP-WROOM-32s module supports traditional Bluetooth, Bluetooth low energy, and Wi-Fi. With various uses: Users can connect to a mobile phone or broadcast a BLE Beacon for signal detection using Wi-Fi. For signal detection, users can connect to a mobile phone or emit a BLE Beacon [33]. The module also supports data rates of up to 150 Mbps for maximum wireless communication and antenna output power of 20 dBm. Consequently, this module meets industry standards for transmission distance, high integration, network connectivity, wireless connectivity and power consumption.

The MAX30100 is a full Spo2 and heart rate sensor system solution designed for highly demanding wearable devices. The MAX30100 has a tiny overall solution size while maintaining excellent optical and electrical performance. Only a few external hardware components are required to incorporate into a wearable. The MAX30100 features software registers for complete customization, and the digital output data is stored in a 16-deep FIFO within the device. The FIFO enables the MAX30100 to communicate with a microcontroller or microprocessor across a shared bus without frequently reading data from the device's Memories [34].

The MAX30205 temperature sensor detects temperature precisely and generates an overheat alert or shutdown signal. This device transfers temperature information to digital form (ADC) using a high-resolution sigma-delta analog-to-digital converter. The accuracy fulfills ASTM E1112 clinical thermometry criteria when placed on the final PCB. An I2C-compatible 2-wire serial interface is used for communication to read temperature data and control the behavior of the open-drain overtemperature shutdown output. The I2C serial interface accepts standard write, read, transmit, and receive byte instructions. The sensor's low 600A supply current, 2.7V to 3.3V supply voltage range, and lockup-protected I2C-compatible interface make it excellent for wearable fitness and medical applications [35].

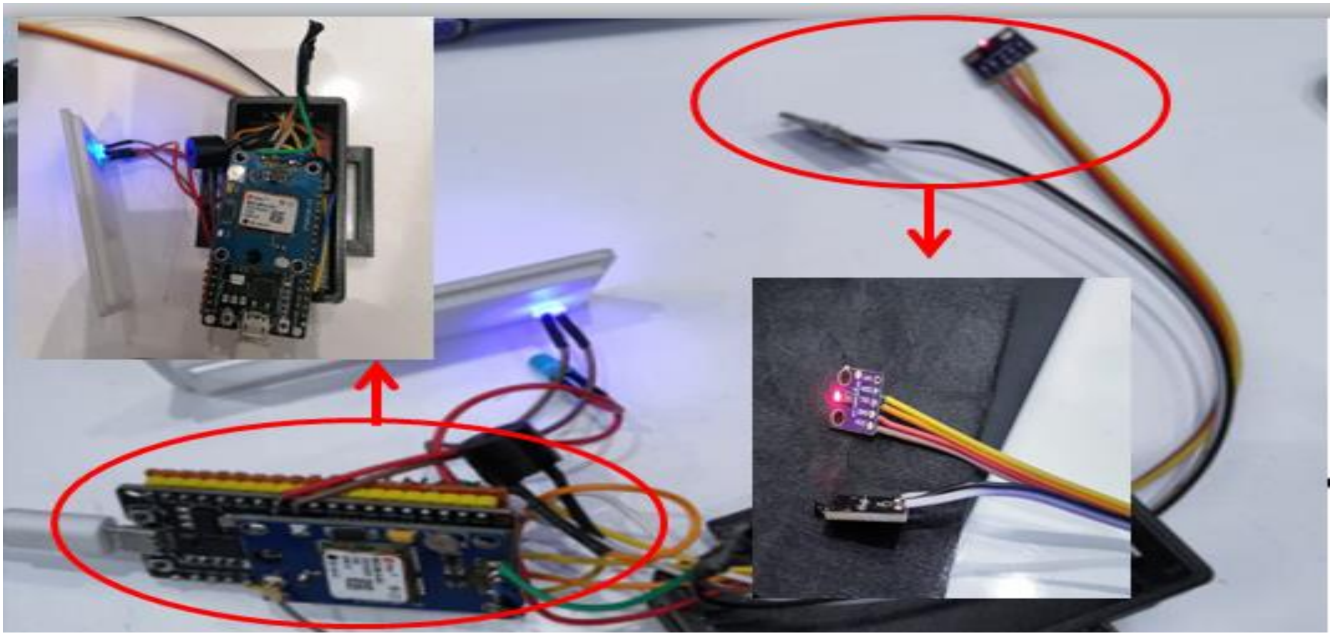

Figure 2. The practical design for the COVID-19 patient monitoring model

Required Software

The second part involved designing a software application based on the Blynk application to provide a remote display of vital readings in real-time. It can consider an IoT application programming interface that enables data collection and storage from devices connected to the Internet, an AP monitoring system connects to the cloud and builds web applications that allow users to scan data in real-time and run it remotely [36]. The Blynk platform was used to design the proposed model for measuring vital signs, including Spo2, heart rate and temperature. The Arabic language for programming the system has been adopted for ease of use and handling in the country where the experiment was applied, as shown in Figure 3, which can be downloaded for Android and iOS. Project objectives have been achieved.

Figure 3. Programming the Blynk application illustrates recording the system in real-time Spo2, pulse rate and body temperature (vital measurements)

RESULTS

Four patients infected with COVID-19 (two males, two females) and their ages ranged from (30-50 years) were studied and monitored in a COVID-19 isolation hospital for one week. The average was taken for four readings per day (every six hours) depending on the variables vital signs and for both Spo2, temperature and pulse rate through direct clinical monitoring of patients in the hospital in cooperation with the medical and nursing staff and after obtaining official approvals. In conjunction with taking clinical readings for the three variables mentioned for the same patients and at the same time using the proposed system IoT by the researchers. The following results were obtained:

Day	Patient 1		Patient 2		Patient 3		Patient 4	
	Average of Hospital Monitoring	Average of Proposed System	Average of Hospital Monitoring	Average of Proposed System	Average of Hospital Monitoring	Average of Proposed System	Average of Hospital Monitoring	Average of Proposed System
Saturday	91	90	89	90.5	87	86.7	89	89.6
Sunday	90	91	88	88.4	88	89	87	86
Monday	90	91.2	89	88.3	86	84.9	90	91
Tuesday	88	89.5	88	87	86	88.1	89	90.5
Wednesday	87	86.8	87	89	84	85	87	86
Thursday	86	86.7	85	83.9	85	84.4	86	85.9
Friday	85	84	87	87.4	84	86	84	85
Percentage of Error (%)	0.35 %		0.23 %		0.68 %		0.33 %	
Mean of Percentage of Error for 4 Patients					**0.3975 %**			

Table 1. Reading of Oximeter (%)

Day	Patient 1		Patient 2		Patient 3		Patient 4	
	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading
Saturday	90	92	95	94. 2	97	96	91	92
Sunday	91	90.7	96	97	98	99.3	90	89
Monday	93	92	98	98.8	100	102	92	93.2
Tuesday	95	96.2	100	99	108	106.8	97	98
Wednesday	97	97.8	99	100.5	102	103	95	94.8
Thursday	100	99	105	103.5	114	110.7	100	103
Friday	105	102	107	108	101	100.5	104	102.4
Percentage of Error (%)	0.18 %		0.14 %		0.23 %		0.5 %	
Mean of Percentage of Error for 4 Patients					**0.2625 %**			

Table 2. Reading of Pulsimeter (beat/min)

Day	Patient 1		Patient 2		Patient 3		Patient 4	
	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading	Average of Hospital Monitoring	Average of Proposed System Reading
Saturday	37	36	37.6	36.8	39.9	38	37.2	36
Sunday	37.3	37	38.4	37	38.3	37.4	37.8	37
Monday	38	37	38.6	37.4	39.5	38.6	38.6	37.1
Tuesday	38.9	37.4	39.5	38	39.5	38	39	38.2
Wednesday	39	38	39.7	38.2	39.7	38.2	39.6	38.9
Thursday	39.5	37.9	39.4	38	40	38.9	39.9	39
Friday	39.5	38.2	40.4	39	40.5	39	40.1	39.6
Percentage of Error (%)	2.8 %		3.3 %		3.3 %		2.3 %	
Mean of Percentage of Error for 4 Patients					**2.925 %**			

Table 3. Reading of Temperature (°C)

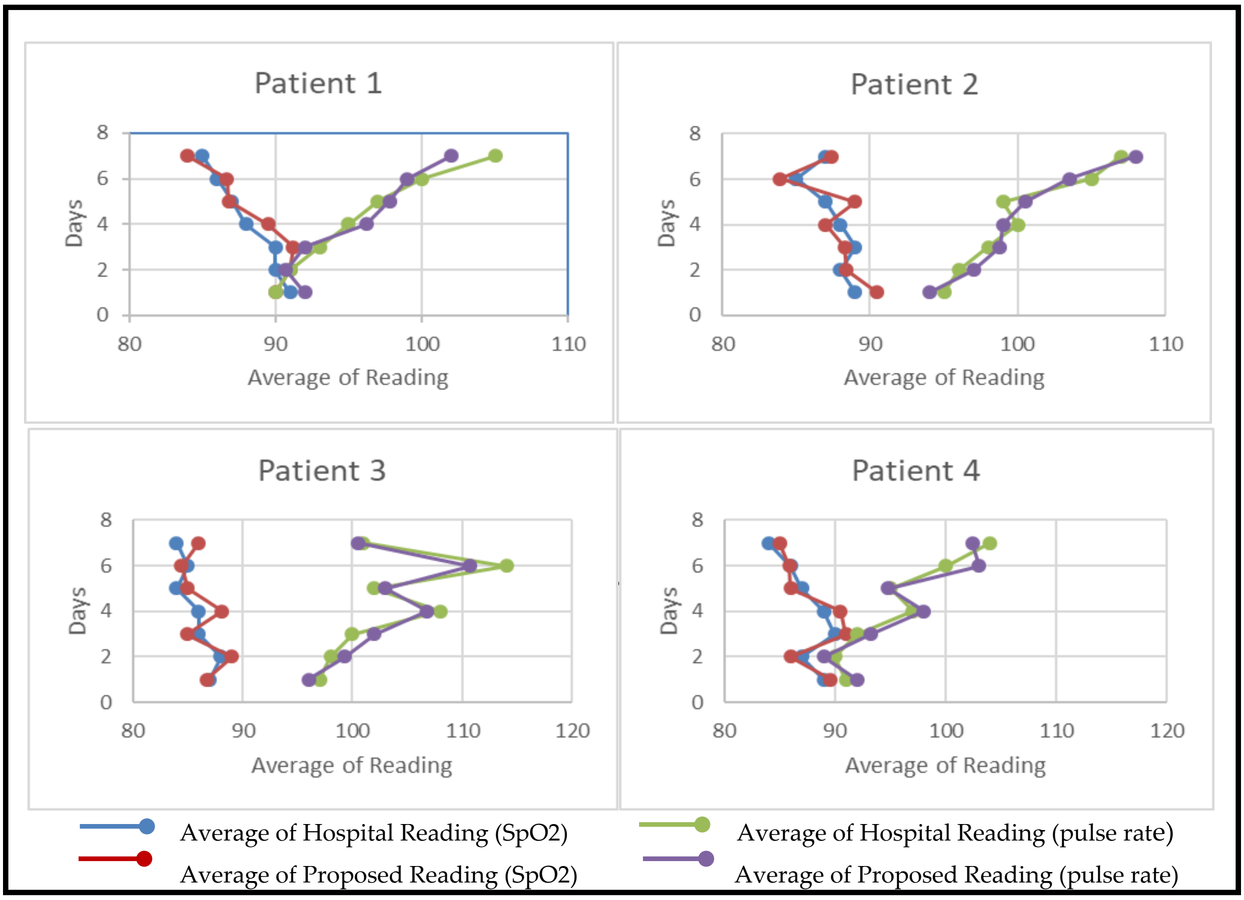

Figure 4. Relationship between oxygen saturation and pulse rate readings

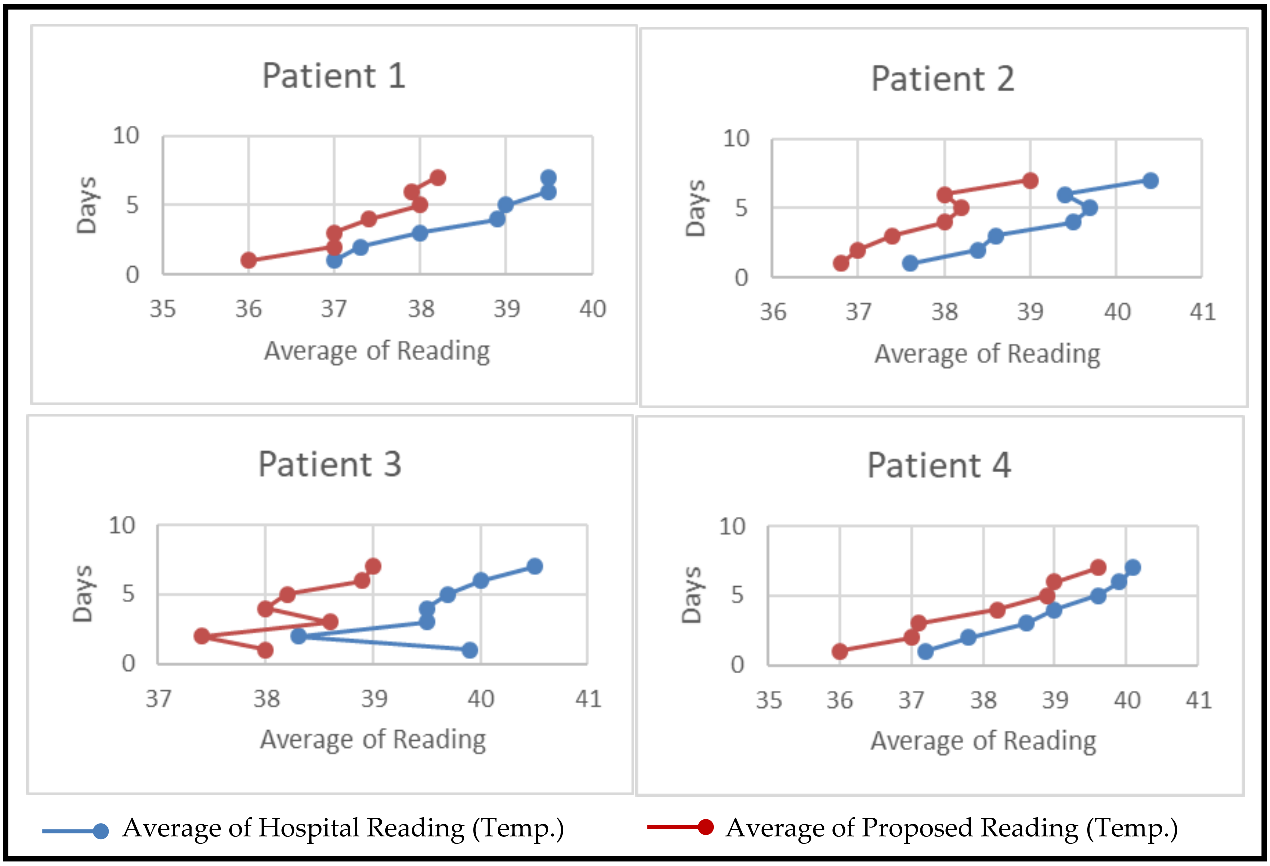

Figure 5. Relationship between temperature readings

For the first patient:

The percentage of error of SpO_2 between the hospital reading and the proposed system reading is (0.35%) as shown in Table 1. The percentage of pulse rate error between the hospital reading and the proposed system reading is (0.18%) as shown in Table 2. The percentage of temperature error between the hospital reading and the proposed system reading is (2.8%) as shown in Table 3.

For the second patient:

The percentage of error of SpO_2 between the hospital reading and the proposed system reading is (0.23%) as shown in Table 1. The percentage of pulse rate between the hospital reading and the proposed system reading is (0.14%) Table 2, and the percentage of temperature error between the hospital reading and the proposed system reading is (3.3%) Table 3.

For the third patient:

The percentage of error of SpO_2 between the hospital reading and the proposed system reading is (0.68%) Table 1, the percentage of error of pulse rate between the hospital reading and the proposed system is (0.23%) Table 2, and the percentage of error of temperature between the hospital reading and the proposed system reading is (3.3%) Table 3.

For the fourth patient:

The percentage of error of SpO_2 between the hospital reading and the proposed system reading is (0.33%) in Table 1, the percentage of error of pulse rate between the hospital reading and the proposed system reading is (0.5%) in Table 2, and the percentage of error of temperature between the hospital reading and the proposed system reading is (2.3%) Table 3.

Through the results obtained, we noticed that the mean error of SpO_2 and pulse rate for four patients are (0.3975%) and (0.2625%) as shown in Table 1,2, which means there is a small percentage of error between oxygen saturation rate and pulse rate as shown in Figure 4,

DISCUSSION

The visual similarity between Coronavirus's first and second sequence is considered a severe respiratory syndrome [1,2,3]. Covid -19 led to clinical, economic, and social crises. Otherwise, respiratory syndrome is a big risk of death for patients who suffer from high blood pressure, diabetes, low immunity, chronic diseases, and seniors [4,5]. The high number of COVID-19 patients and massive flow to hospitals confused health care staff service. Moreover, the contact between patients and the staff caused increased injury with COVID-19. Therefore, remote patient monitoring is the best mechanism for following up on the sick and presenting appropriate treatment for his state [6,7].

Healthcare offers how to deal with COVID-19 patients, social distancing, and quarantine measures, so electronic home monitoring can be considered great attention for patients suffering from coronavirus [8,9,10]. Electronic home monitoring helps the healthcare staff monitor COVID-19 patients and rate their health condition at home using several sensors. Wearable sensors give vital signs for the human body's health and physical performance, such as temperature, oxygen saturation rate (Spo2), breathing, A ratio of beats per minute (BPM), and others [11,12,13].

CONCLUSIONS

This leads us to conclude that the proposed system can be relied upon in the daily monitoring of the condition of Covid-19 patients. The mean temperature error for four patients is (2.925%) as shown in Table 3, which is relatively large, as shown in Figure 5 because the proposed system relied on taking the temperature through the end of the finger. It is considered the weakest method of measuring temperature and can be treated by adding (0.5) degrees to the reading recorded by the proposed system.

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Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023
Citation: Al-Hatab, M., M. Ebrahem A., T. Al-Jader A., R. Qaism, M., A.; Al-Jabbar, E.Y. Healthcare Monitoring COVID-19 Patients Based on IoT System. Revista Bionatura 2023;8 (2) 63. http://dx.doi.org/10.21931/RB/CSS/2023.08.04.24