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Research Article

Developing and Implementing an IoT Managed by Electronic Devices for Covid Patient Monitoring via a Secured Communication System

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ABSTRACT

End of 2019 had seen global spread of the deadly coronavirus (SARS-CoV-2) pandemic, which kills people, puts a large portion of the world in danger, and poses a serious threat to all of the world's nations. Leading medical professionals are working extremely hard to identify the virus, develop treatments for it, and create the vaccines that are required to stop and limit its spread. This study intends to develop a low-cost electronic health system to observe patients with covid infections and lessen the work required of clinicians. An enhanced approach for remote health monitoring in hospitals or detention facilities is offered by the internet of things (IoT). The IoT keeps and displays the patient's medical data via a web browser or through specialized apps that offer remote treatment once the sensors collect it. When a patient is in danger, the system offers immediate action to send alarms by email and SMS and to rapidly provide drugs to the patient. Doctors will be updated on each patient's condition thanks to this message.

1. Introduction

More than 213 nations throughout the world were affected by the coronavirus (COVID 19), which spread quickly and became a highly hazardous outbreak. More than 23 million cases have been officially stated to the world health organization (WHO), and over 800,000 individuals have passed away as a result [1, 2]. The global economy, public health, and several other facets of daily life are now at risk due to the emergence of the coronavirus. Frequently, COVID 19 produces lung issues that first manifest as respiratory signs that might turn into pneumonia, which rapidly worsens the patient's clinical condition. Three classifications of COVID 19 infection severity exist: mild infection, high-risk (fatal) infection, and infection without clinical signs [3].

The worldwide threat posed by the coronavirus epidemic to healthcare systems makes it more difficult to treat individuals who are not directly affected by the virus pandemic but who still have health issues that are unrelated to this epidemic. Patients who are admitted to the hospital in critical condition are quarantined from the injured based on the severity of their Coronavirus infection. To relieve the strain on hospitals, patients with minor symptoms were instead sent home to receive care. However, in these circumstances, medical intervention is not necessary until the patient's condition rapidly deteriorates.

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One of the most important things to consider when fighting the virus is how to improve healthcare delivery methods and develop medical platforms to observe patients distantly as well as sustain the health of medical workforce and healthcare service providers. Decreased direct patient contact also helps to stop the epidemic from spreading. The next generation health monitoring and controlling technologies created by current technology makes it necessary to move healthcare from hospitals to homes or detention facilities in order to give medical gadgets to patients who need them most.

Medical technology advancements, including sensors and remote monitoring, provide patients control and offer doctors a viable way to combat the COVID 19 outbreak. Due to the low cost of its component parts, which encourages the development of more innovative technologies, internet-connected devices provide enormous promise for the transition to remote medical care. There are several devices and sensors that make up the Internet of Things (IoT) [4]. Today, health care is seen as a crucial concern due to the possibility of clinical collapse. A patient is remotely monitored via the IoT when they are admitted to a hospital or a place of quarantine, and their anxious family is also kept informed at all times of the patient's status.

Monitoring is done at a minimal cost with Raspberry Pi and IoT using a collection of sensors. The suggested system gauges body movement, heart rate, temperature, blood pressure, and blood oxygenation. The medical staff's burden is reduced, and physicians' lives are also preserved since they can monitor numerous patients at once thanks to the capacity to transmit information instantaneously, particularly when they are at the top of their profession and more susceptible to harm. By communicating with the patient's family, the medical system can work preventing from collapsing.

On the other side, we can accomplish this utilizing the IoT' sensor platform. We have created a health monitoring system to keep tabs on patients and communicate data to the accountable medical professionals via remote monitoring. In order to do this, a microcontroller gathers health data from the sensors, sends it to the cloud, and then displays it on PCs and mobile applications while following a security policy to safeguard patient information. The body area system, which is run by a Raspberry Pi and features a special upgraded communication for low-energy sensors, aims to give comprehensive patient information.

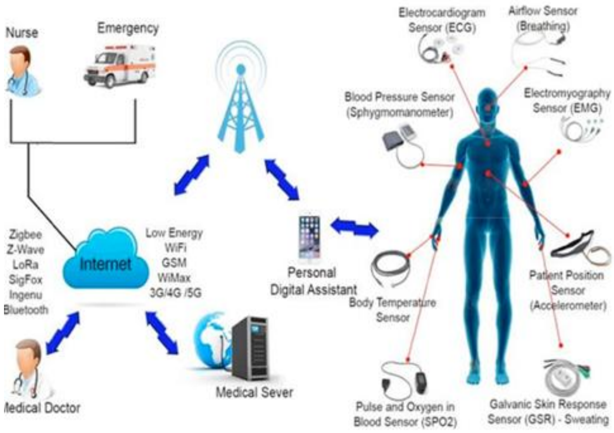

Figure 1. Application scenarios of wearable sensor [5]

Monitoring a variety of accessible physiological parameters such as respiratory parameters, blood oxygen saturation (SpO2), heart rate, blood pressure, and body temperature via wearable devices and unobtrusive sensing can also provide more accurate alerts to anomalous physiological changes, which can potentially identify deteriorating health or the onset of serious medical problems. It has the potential to be used to continuously monitor personal health at home, public places, residential care, or hospitals, with application scenarios including providing screening and real-time triage of patients with suspected infection, monitoring diagnosed patients with mild severity while in isolation, and enabling real-time health surveillance of patients in improvised hospital and established hospital settings. Figure 1 depicts a non-exhaustive list of application possibilities.

During the COVID-19 pandemic, wearable technologies and unobtrusive sensing, in conjunction with telemedicine, can monitor COVID-19 symptoms and warning signals, allowing health care clinicians to remotely monitor a patient's health over time. This will enable better management through early diagnosis and monitoring of coronavirus symptoms, reducing the requirement for face-to-face contact even further. If symptoms appear, the data supplied through the secure cloud platform can enable healthcare authorities to implement effective general population triage, such as quarantining patients, transferring them to care home facilities, or managing high-risk people in their own homes.

2. Materials and Methods

2.1. Related works

One of the most crucial variables causing sudden infant death syndrome, a febrile complication, is an unexpected rise in the baby's temperature during sleep. In [6,] an IoT-based infant monitoring mechanism, specifically a smart cradle structure, is offered, which records the baby's real-time temperature, heart rate, wetness, and sound, and the data obtained from the sensors will be uploaded to a web platform over Wi-Fi and verified in real-time. In the event of weeping, the cradle will swing on its own. If the sobbing does not cease or if there is an abnormal increase in the detected body temperature, heart rate, or humidity level, the alert will sound.

It is critical to improve the standards of the data set for efficient big data management, and filtering methods are being developed for a higher quality data set. Using data cleaning procedures, for example, is a preprocessing approach that simplifies data mining processes. By limiting the production of interference, more controllable data is generated, and large data may be managed more successfully. In [7], we look into the effective operation of IoT and massive data generated by the IoT. Furthermore, real-time anomalous data filtering is conducted on IoT edges using a data collection comprised of six separate real-time data sets.

[8] demonstrated wearable sensor and telemedicine technologies for using covid patients. The usage of sensors and remote health caring systems to tackle the coronavirus epidemic was mentioned in the article. Making healthcare systems portable, they also strive to decrease patient-medical staff interaction to halt the transmission of illness and ensure the security of medical personnel. The use of telemedicine in the battle against COVID 19 is extremely promising [8]. In light of COVID 19, researchers and developers have a definite interest in mobile health and the usage of mobile health apps. Its excellent and promising outcomes are starting to be adjusted by medical professionals for wider use. [9] planned COVID-19 Pandemic sensors and new technology.

The development and adoption of technologies that can track patients with the newly emergent covid were reviewed and addressed [9]. Figure 1 presents Application scenarios of wearable sensors. An IoT-based patient monitoring system utilizing electrocardiogram (ECG) sensor has been suggested by [10]. Their study covered an ECG sensor-based remote patient monitoring system. It has been proposed to use a mobile health system that can be remotely operated to monitor the patient using an ECG sensor. These datas are transmitted to the cloud which can be accessed by doctors and can track the patient's health, and notify them of any potential health worsening [11].

A real-time health monitoring system that is IoT based was introduced in [11]. The proposed research uses a collection of sensors using mobile and web applications to control the patient's situation. In order for caregivers and medical experts to access the database, provide guidance, and mitigate any harmful effects, data are collected and created [10]. An IoT-based emergency health monitoring system has been proposed by [10]. In addition to gathering information on the patient's temperature, pulse, and number of heart beats per minute, the article suggests a health system that would enable the doctor to inform and keep tabs on the patient's health state every few seconds [12].

[13] makes the suggestion of a health monitoring system that is based on the IoT. This research describes a cost-effective technology for continuous health monitoring and detection of human body fluctuation. During the study, pulse rate, humidity, and temperature were observed using sensors. The data was saved in the cloud after comparing the sensor results to the predefined value. Then, with the aid of the cloud and Node MCU, sends an alarm message to the user or doctor for health fluctuations when the value goes above the predefined value.
The results of the experiment suggest that a health monitoring device is a more convenient and reliable way to identify changes in the human body in a short period of time [13]. [14] have

proposed an IoT based system for health care tracking and monitoring. An IoT is nothing more than the connection of sensors connected to different things to the internet in order to send data to the internet and to make use of data already accessible on the internet. The link has a lot of potential for improving human health.

Each individual is helped to maintain his or her physical well-being by the various equipment that is available. The primary goal of this study was to provide a complete overview of IoT applications in medical care, as well as to report on the wide variety of gadgets and tools that are already available and planned. We have prioritized both research and commercial devices in our survey article in order to explore and investigate present and future technology [14].

A health monitoring system for remote patient has been proposed by [15] which is also IoT-based. With the use of sensors, the proposed system can keep tabs on patients' basic vitals such their body temperature, blood pressure, pulse rate, and ECG data at home or at other places. The user may remotely monitor the patient's current state from any location, with the caveat that the user must have internet access to get real-time information about the patient. The suggested concept would be tremendously beneficial to society and would complement current health monitoring technologies [15].

[16] has proposed a wearable health monitoring device. A wearable health monitoring gadget was presented in this proposal, which would be especially helpful for those with Parkinson's disease. This system offers a thorough way for heart rate monitoring, real-time showing, collecting historical data, and sending crucial data to a mobile phone, in contrast to other options that are now accessible. Other capabilities include step counting, aberrant gesture detection, and falling detection, as well as the ability for users to design their own anomalous gestures and be taught off-line [16]. Figure 2 depicts wearable pulse oximeters.

Figure 2. Wearable pulse oximeters [8]

2.2. Physiological measurements

In this section, different measurements systems will be described. Vital indicators such as oxygen saturation, respiratory rate, heart rate, blood pressure, temperature, glucose, ECG, galvanic skin response (GSR), and body posture are utilized to evaluate the health state of COVID 19 patients.

2.2.1. Oxygen saturations (SPO2)

One of the fundamental elements for maintaining life is oxygen. A significant sign of the newly developing covid illness is an oxygen deficiency. It refers to how much saturated hemoglobin is present in the blood. Inflammation of the lung's air sacs brought on by COVID 19 impairs oxygen delivery to the blood and harms the lungs [17]. When a patient has respiratory issues, their proportion of Spo2 falls from 95% to 99%, which is the range for a healthy individual. A key indicator for identifying people with coronaviruses is oxygen saturations.

People with spo2 levels of over 94% may be able to get home health care, according to the WHO [3]. According to this study, a COVID patient who have a percentage of less than 93% should be hospitalized [18]. Less than 90% of patients had a higher mortality rate [19]. To preserve patients' health and prevent any potential health deterioration, continuous monitoring of oxygen saturation hemoglobin is crucial. It can save a lot of lives, principally as it is portable and available in any home, mainly in underdeveloped nations [20, 21].

The basis for how pulse oximetry devices operate is optical imaging, or the degree to which arterial blood volume alters light absorption. The oxygen gadget, which is often worn on the finger, has an LED and an infrared beam. The ratio is estimated once the wavelengths are identified based on how much oxygenated and non-oxygenated hemoglobin absorbs each of the two light wavelengths. De-oxy and oxyhemoglobin (HBO2) are the two kinds of hemoglobin found in red blood cells [22].

2.2.2. Respiratory rate

The respiratory rate (RR) is a crucial marker for managing COVID-19 patients because it may accurately and quickly anticipate conditions like hypoxia (low oxygen levels) and elevated blood carbon dioxide levels. The main determinant of respiratory illness is RR. Additionally, a characteristic of a COVID patient is respiratory rate. Studies on sars-cov-2 patients in Wuhan, China, revealed that 63% of those who passed away from the covid had a greater RR (54) per minute [22]. Therefore, monitoring the evolution of covid and identifying any potential worsening to mediate in a timely way to deliver therapeutic therapy is made feasible by utilizing the IoT to measure the respiratory rate.

There are three techniques to monitor respiratory rate using the IoT:

• By sensing factors such as temperature and carbon dioxide, and then calculating the quantity of respiratory airflow.

• Breathing is accompanied by a sonic and bodily experience of mechanical stress, in the form of respiration and concomitant chest and abdominal motions.

• Based on the modifying impact of breathing on respiratory arrhythmia (RSA) signals, as well as other cardiovascular signals such as the ECG and Photoplethysmography (PPG). Thermal, acoustic, humidity, pressure, resistance, acceleration, inductance, resistance, and electromyography are examples of technologies. These sensors can be found in wearable devices that can be strapped to the chest [23-26], or put on the skin [18, 27].

2.2.3. Airflow

The basis for the airflow approach is Exhaled air is hotter, more humid, and contains more carbon dioxide than inhaled air. According to it, the amount of carbon dioxide and temperature change are used to calculate the respiratory rate. The nose's airways serve as a sensor for the airflow sensor's basic design. The sensor, which is a thermostat in the mouth or nose, determines the quantity of carbon dioxide and humidity present during inhalation and exhalation. It has been stated that a high-sensitivity respiratory sensor is capable of detecting various breathing patterns [18]. According to reports, a multi-air flow sensor electrolyte that can be utilized with a face mask in a COVID -19 scenario has also been created [28]. Figure 3 shows an airflow sensor.

The average healthy adult breathes between 12 and 20 times each minute. This percentage varies based on the patient's health, with low or high respiratory rates indicating a larger or lesser requirement for oxygen, respectively. A serious decline in the patient's health is also indicated by a drop in RR to 9 per minute or less.

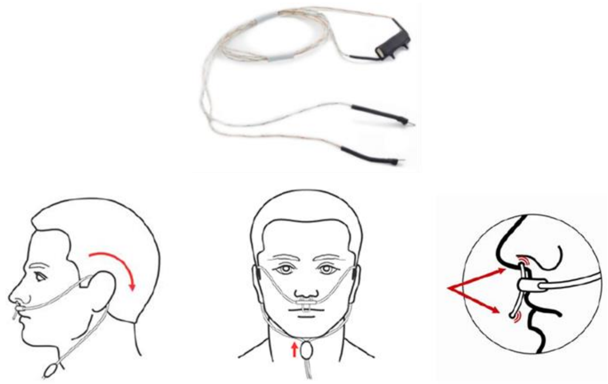

Figure 3. Airflow sensor [29]

2.2.4. ECG for monitoring COVID patients

By observing the heart's actions, the ECG equipment carries out the process of assessing the muscular and electrical function of heart. One of a person's vital signs, it is. Monitoring heart activity has become essential for individuals with cardiovascular issues, particularly with COVID 19 patients. Patients with COVID 19 have reportedly had a considerable alteration in their ECG signals and an increased heart rate [30]. Cardiac functions must be regularly checked in order to avoid any worsening in the patient's health [31]. The IoT-based ECG sensor also lessens direct patient-doctor contact and guards against dangerous infections. The portable ECG gadget has three ends, each attached to the patient's chest with a circular adhesive and connecting cables. The proposed sensor is quite convenient and cozy to use. The ECG is one of several items that the Food and Drug Administration has approved for use in COVID 19 patient monitoring [32]. Figure 4 presents an ECG sensor.

Figure 4. ECG sensors

2.2.5. Body temperature

It is an essential sign of a healthy physique. By keeping an eye on the temperature, we can determine whether a patient has a fever with precision. In heavily packed public spaces like airports and subway stations, thermal scanning devices such as infrared scanning were utilized during the COV-SARS-2 virus epidemic. As a result, the suggested temperature monitoring device can track changes in body temperature since it can quickly identify individuals with high temperatures who may be infected with the virus [32], particularly those without symptoms who may be treated remotely. In Figure 5, a temperature sensor is shown.

Figure 5. Temperature sensor [31]

2.2.6. Blood pressure monitoring

Blood pressure is a warning sign for heart patients and is thought to be the cause of 10 million deaths globally [33]. It is a reflection of the condition of the heart and blood arteries. According to studies and research done on 5800 Corona epidemic patients, high blood pressure is also a disorder that affects the patient (3090 out of 5800, with a rate of more than 57%) [34]. Recent studies that involved 44,900 patients found that persons with high blood pressure (6.1%) and heart disease (11%) had higher death rates than patients without heart issues (1%) [35].

Blood pressure has been monitored during the previous century using the traditional method, which necessitates the face-to-face presence of medical personnel. However, as the coronavirus outbreak expanded, more patients asked for blood pressure monitors. This put a great deal of strain on medical personnel and raised the danger that they would become infected with the COVID 19 virus, which is extremely infectious. Therefore, we can monitor and supply the medical personnel with the most recent information by using IoT technology and certain wearable sensors. This will result in better blood pressure management related to the coronavirus. A blood pressure sensor is presented in Figure 6.

Figure 6. Blood pressure sensor

2.2.7. GSR

Galvanic skin reaction is what it is. Strong emotions activate the sympathetic nervous system, which causes the sweat glands to release perspiration and allows for the measurement of the skin's electrical conductivity. As seen in Figure 7, linking the polarity of the fingers allows for the monitoring of emotions.

Figure 7. GSR sensor

2.2.8. Glucose

It is a tool for measuring and keeping track of blood glucose levels. A single-use test strip is used to collect a sample of the patient's blood, and after some time, the result is shown, as shown in Figure 8.

Figure 8. Glucose sensors [36]

2.2.9. Body position

The patient is continually monitored, as shown in Figure 9, and the body position sensor is put around the chest to detect the form of the body, for instance (standing, lying down, laying left, right, down). A body position sensor is shown in Figure 10.

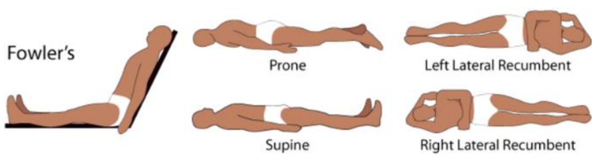

Figure 9. body position

Figure 10. Body position sensor

2.3. Design and working methodology

Before attaching the sensors to the microcontroller device, we'll need a health sensor shield to connect them all together, including the blood pressure sensor, pulse sensor, temperature sensor, oxygen sensor, sugar sensor, and motion sensor (Raspberry Pi or Arduino). After being gathered from the patient by sensors, data is transferred by Wi-Fi or GSM to the database where it is stored. The doctor may obtain the information remotely using a smartphone or computer device. System work flow is presented in Figure 11.

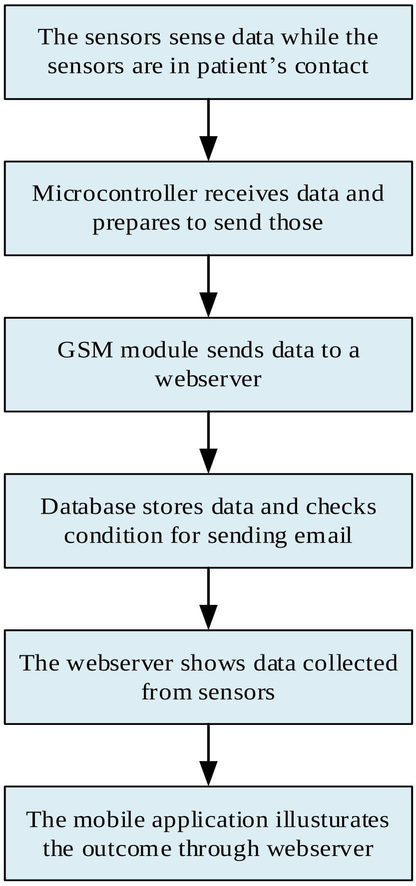

Figure 11. System work flow

2.3.1. System model

The proposal suggests a system in which information is gathered from sensors and delivered to the microcontroller, which then transmits vital signs to the cloud through Wi-Fi or GSM, where a database is produced and saved for use by smartphone and computer devices. System model is presented in Figure 12. Table 1 presents measurement levels of monitoring patients with COVID 19 using wearable technologies.

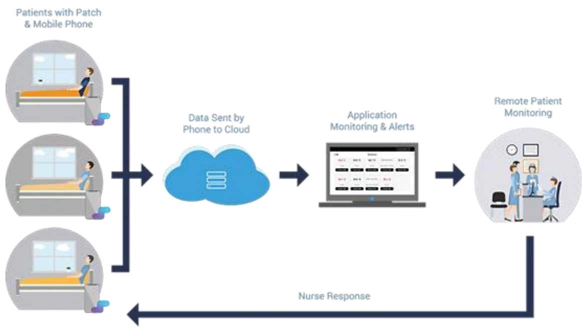

Figure 12. System model

Table 1. Monitoring patients with covid-19 using wearable technologies [8]

Measurements	Warning levels for COVID 19	Normal levels
Oxygen Saturation (SPO2)	< 90 %	95-98 %
Respiratory Rate (RR)	< 25 ppm	12 – 25 ppm
Body temperature	> 100 °F	97.7 – 99.5 °F
Heart Rate (HR)	> 120 < 60	60 – 120 bpm
Blood Pressure	> 120 mmHg systolic > 80 mmHg diastolic	<80 / <120 mmHg
Glucose	> 144 mg/dl < 72 mg/dl	72 – 144 mg/dl
GSR	> 7.0 μs < 2.0 μs	2.0 – 7.00 μs

2.3.1.1. E-health sensor platform shield

As seen in Figure 13, an electronic circuit was created that can control all the sensors at once. The Raspberry Pi is used to collect data from the sensors, which include the glucometer, ECG, body temperature, GSR, airflow (breathing), pulse, SPO2, and patient position (accelerometer).

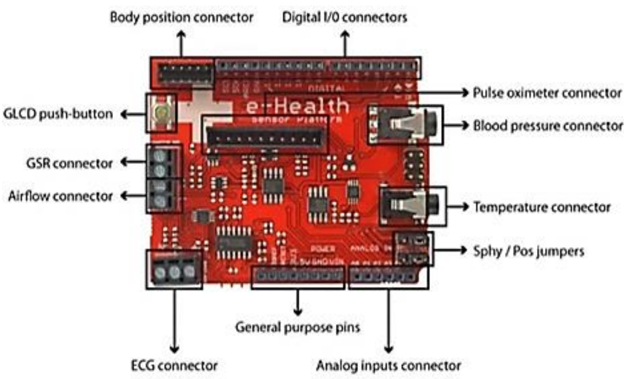

Figure 13. e-health sensors

2.4. Telemedicine technology

Even if e-health and telemedicine are not still in their infancy, they are crucial initiatives in the war against SARS-CoV-2 [37]. Many healthcare systems throughout the world, particularly those in nations with highly developed medical infrastructure like the United States, have declined as a result of Covid-19's fast proliferation [37]. It is now crucial to design and implement a health system which embrace telemedicine technology and implement the mobile digital system [38].

Through the use of video medical care (videoconferencing services), telemedicine, mobile health, and wearable medical sensors outfitted with IoT and neural networks (NN) technology and big data analysis, can advance dramatically [39]. Additionally, by following up, keeping tabs on patients' health, and delivering the right care remotely.

Reducing the danger of direct patient contact, slowing the transmission of viruses, and preventing the collapse of the medical system due to high infection rates are significant advantages of telemedicine and mobile digital system. The United States of America is one of the nations that has shifted its medical practices to telemedicine [37]. It advised performing remote medical examinations, minimizing direct patient interaction, cutting back on the amount of time needed, and hiring fewer physicians.

This section will highlight cutting-edge telemedicine and mobile health technologies that can treat the newly developing Coronavirus. The focus will be on treating individuals suspected of having the Corona Virus, providing treatment, and utilizing telehealth technologies. Finally, we'll offer an exemplary medical sensor platform that can handle a variety of data.

i. E-Health Monitoring of SARS-CoV-2

Smart devices and wearable sensors are supported by the health platform known as Mobile Health [40]. The suggested system is divided into 3 primary components:

1- Wearable sensors for the purpose of gathering the needed data.

2- A network with the purpose of sending the gathered data to the main station monitoring, which functions as a central computer.

3- A cloud whose job it is to evaluate the sensor-generated data and make use of the valuable information.

The technology can trace infected individuals' interactions and deliver essential medical treatment.

ii. Contact tracking technology

The most crucial tactic for limiting the transmission of the virus is contact tracking [40]. Quarantine, isolation of people infected, and social estrangement will continue to be the most crucial elements in curbing the epidemic's spread in the absence of effective treatment and a vaccine [41]. To stop the spread of the illness, remote surveillance and infection tracking are helpful [42].

To stop the disease from spreading, a contact tracking tool that compiles a list of contacts can inform those individuals. Security issues pertaining to user privacy are brought up by the practice of gathering data from mobile devices from individuals on a broad scale. A peer-to-peer contact tracing normalization has been created to address this issue, employing Ysak's encryption of user identification to protect user privacy in the event of a pandemic [43].

Using bluetooth technology, Google. and Apple have created a contact tracing application that exchanges signals without disclosing the user's identify or sharing data. Users who were in contact with a suspected and diagnosed case can receive notifications from the system [44].

iii. Remote monitoring physiological

It is feasible to transfer treatment from the hospital to the home using the COVID19 mobile health platform, particularly for patients with minor wounds and those with various illnesses who run the risk of contracting an infection from interacting with other patients. Medical instruments like those connected with a temperature sensor platform, blood pressure sensor, and the percentage of oxygen are needed to monitor the patient's health in addition to the very necessary portable ECG equipment to check the patient's tachycardia difficulties.

The mobile medical platform, which depends on a collection of remotely collected sensors, cannot take the role of specialist medical professionals, but it may be a helpful tool in making judgments about treatment that enable the medical unit to act quickly.

iv. Remote imaging

One of the major clinical indicators of COVID 19 illness is acute pneumonia connected with SARS-CoV-2, where medical imaging plays a crucial role in observing and identifying the condition. COVID 19 disease has the potential to harm the organs and tissues of patients. The medical unit receives the findings of the MRI and CT scans for remote diagnosis. Figure 14 shows portable medical imaging devices.

Figure 14. Portable medical imaging devices [45-46]

There are several medical imaging systems, such as remote x-ray, remote ultrasound, and tomography, that process pictures utilizing neural network methods (artificial intelligence). People who are infected by the virus may be able to receive a CT picture by using a mobile medical imaging center, provided that remote clinicians make the diagnosis and the outcomes and images are preserved in the cloud [45–47].

2.5. Data encryption

The IoT is widely used in telemedicine and medical care. As a result, the IoT came into focus. This provided a significant possibility for growth and higher productivity, which in turn boosted quality as it applied to the delivery of medical treatment for Corona virus patients.

Remote medical treatment is becoming one of the most important components of life, not only for COVID affected people but also for everyone with a chronic condition and the elderly. This is due to the fact that managing, diagnosing, and treating patients remotely is now feasible, saving time and effort while also safeguarding the staff's health.

One of the primary obstacles preventing the IoT and mobile health platforms is the growing user concern over privacy and security due to the worry of harmful attacks and privacy violations [45]. Therefore, there is a pressing need for greater study in the area of user protection and information security.

Data encryption and app security are required to protect patient data. One of the biggest issues for mobile health apps and cloud services is dealing with security concerns such as patient privacy violations, illegal access, and the manipulation of critical cloud data. We'll go through the two most crucial mobile health safety standards: [48, 23].

i. Authentication: Using one of the encryption techniques, proving the user's identity and confirming it with the medical professionals if the user is ill.
ii. Authorization: Following the user's identification has been confirmed, this is the next stage. Depending on the privileges granted to each party, access rights are dispersed.
iii. Non-repudiation: By employing a unique encryption platform and maybe distinctive symbols or signatures, it confirms that the sender of the communication actually transmitted it.
iv. Integrity and confidentiality make sure that the message is only viewed by the intended recipient and that the transmission is private.

For a cloud-based mobile health system, a four-layer structure is suggested, each of which is interconnected.

- First layer: It inclusea users in general, such as patients, technicians, doctors, and hospital administrators.
- Second Layer: The computers, smart gadgets, and office equipment found in this layer are used to receive, transmit, and display data for the first layer.
- Third layer: Between the first layer and the fourth layer, communication and data transmission are handled by this layer.
- Fourth layer: In this layer, which is used to monitor patients, direct orders, and provide instructions, are hospitals, health centers, and decision-making centers.

An encryption technique with three stages—authentication, data encryption, and decryption—has been developed to secure data and create a secure link between the user layer (first layer) and the communication layer (third layer). Figure 15 depicts secure framework for IoT-based medical data.

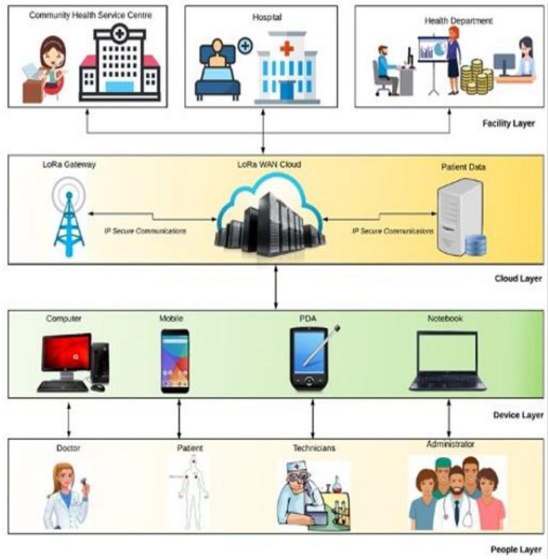

Figure 15. Proposed secure framework for IoT-based medical data [48]

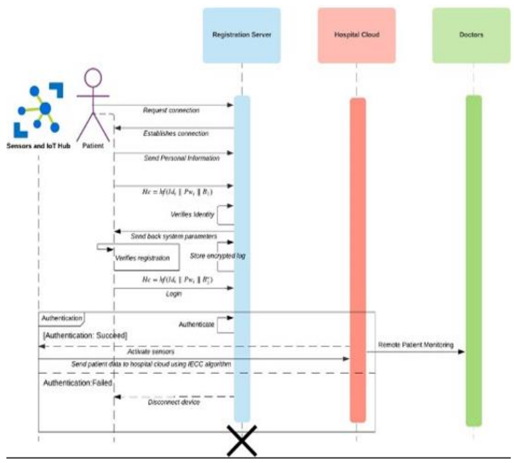

Figure 16. Encryption Scheme [48]

Three processes are involved: data recording, logging in using the entered information, and verification. A user name and password are provided to the user, and all login information is maintained in the cloud. Hash codes are produced using the SHA-512 encryption technique to confirm the patient's identification, and after verification, the sensors are turned on, the e-health platform is engaged, and the data and results are encrypted using Caesar encryption. The text is replaced with the encrypted text as part of the encryption process. Then, an elliptic encryption method is used to further encrypt the data. Figure 16 shows how the cloud sequentially receives encrypted data and starts to decrypt it before assembling it and sending it to the hospital's private layer.

3. Results and Discussion

This study established the use of IoT-driven electronic devices and their integration with secure communication systems for COVID-19 patient monitoring. There are, however, several critical considerations to consider when comparing comparable research. For starters, if IoT devices are unsafe or have flaws, the chance of patients' confidential health data being disclosed increases.

As a result, future research should place a greater emphasis on the security of IoT devices. Furthermore, widespread usage of this technology may result in data management and communication issues between healthcare personnel and patients. As a result of the findings of previous research, appropriate management and user training procedures for IoT-based COVID-19 patient monitoring systems must be established. In conclusion, while this study indicates the promise of IoT technology for monitoring COVID-19 patients, it also underlines the importance of future research on security and data management. Moreover, after the implementation of 5G, a lot of IoT based applications will be available [49].

3.1. Analysis of the results for body temperature

The average body temperature for adults is 98.6 degrees Fahrenheit, with a 24-hour range of 0.5 degrees Celsius (0.9 degrees Fahrenheit). Table 2 and Figure 17 show the body temperature rates and outcomes, respectively.

Table 2. Body temperature rates

Normal	36.5–37.5 °C (97.7–99.5 °F)
Hypothermia	<35.0 °C (95.0 °F)
Fever	>37.5–38.3 °C (99.5–100.9 °F
Hyperpyrexia	>40.0–41.5 °C (104–106.7 °F)

Figure 17. Body temperature results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

3.2. Analysis of the blood oxygen and pulse test results (SPO2)

Normal rates are between 94% and 99% for healthy individuals, but they fall to 85% or less for COVID 19 patients and patients who are oxygen deficient because the virus targets the patient's respiratory system, which lowers the oxygen level. Figure 18 shows Spo2 results.

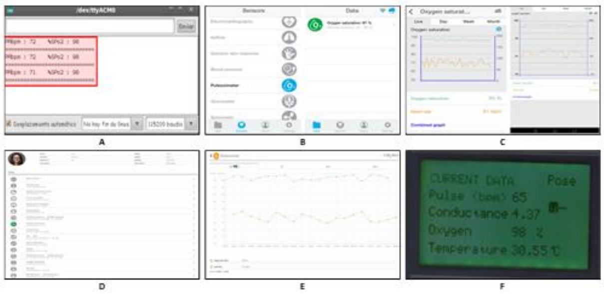

Figure 18. Spo2 results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

3.3. Analysis for electrocardiogram (ECG)

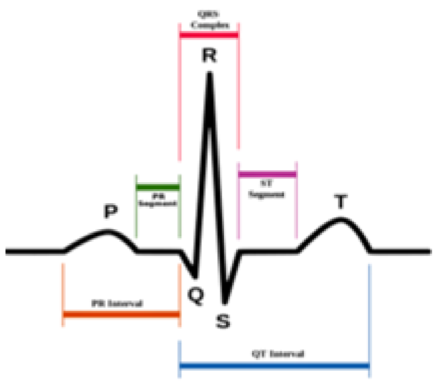

Figure 19. ECG Schematic

One of the most vital medical devices for diagnosing and determining the functionality of the heart is the ECG machine. ECG system and results can be depicted in Figure 19 and 20, respectively.

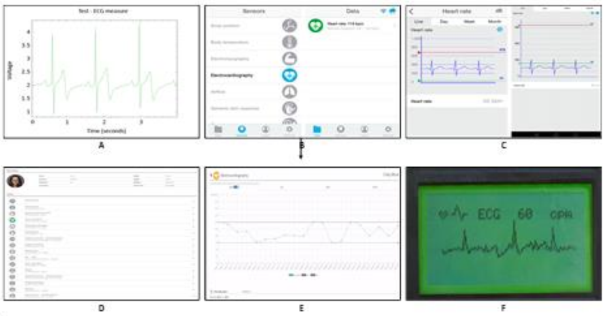

Figure 20. ECG results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

3.4. Analysis for airflow: Breathing sensor

The newest findings on COVID 19 sickness reveal a shift in respiratory rates as a result of the harm the virus does to the human body, making the respiratory index one of the key indicators of a person's overall health. Airflow results are shown in Figure 21.

Figure 21. Airflow results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

3.5. Analysis for blood pressure

One of the most important markers of a patient's health is their blood pressure, which is not always steady due to changes in patient's posture, stress levels, and psychological state due to COVID 19 pandemic, especially in patients who have chronic illnesses. Table 3 and Figure 22 show a system for classifying blood pressure and blood pressure results, respectively.

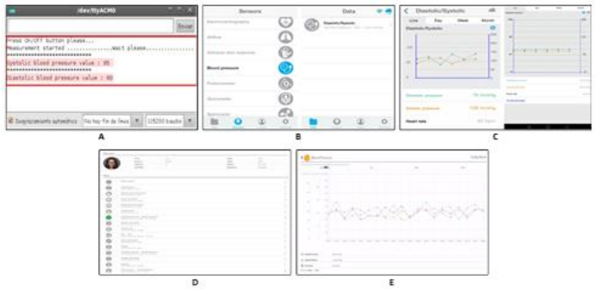

Figure 22. Blood pressure results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in webserver

Table 3. A system for classifying blood pressure

Bp	Systolic	Diastolic
Ordinary	<120	and <80
High blood pressure	>119 – <140	81–90
Step 1: Hypertension	>141 – <160	91 –98
Step 2: Hypertension	>161	>100

3.6. Analysis for glucometer

It is the level of blood glucose concentration. On the single-use test strip, we place a drop of blood, and then we insert the strip into device. Figure 23 shows glucometer results.

Figure 23. Glucometer results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in the web server

3.7. Analysis for galvanic skin response (GSR)

The quantity of moisture affects measurement of the skin's electrical conductivity sensor. When skin's electrical resistance varies, the sweat gland regulates the sympathetic nervous system to keep track of the stress. Figure 24 shows GSR results.

Figure 24. GSR results: (a) in serial monitor; (b) in mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

3.8. Analysis for body position

The location of the item is determined using a 3-axis accelerometer (sitting, standing, lying down, prone). Figure 25 shows body position results.

Figure 25. Body position results: (a) in serial monitor; (b) in the mobile application; (c) waves in the mobile application; (d) in web server; (e) waves in web server; (f) in GLCD

4. Conclusion

We provided a thorough real-world picture of wearable sensors and remote medical treatment during the Corona Epidemic in this study. By moving direct care to far-flung locales, it helps ease the strain on medical facilities (i.e., transferring care from the hospital to the home). With the help of the telehealth center, it is possible to keep an eye on patients, make quick diagnoses, and take action to stop any potential worsening and minimize contact between medical professionals and patients. As a result, it will be used to treat epidemics in the future, particularly COVID 19. While wearable devices and telehealth offer tremendous potential to help improve the management of infectious diseases such as COVID-19, overcoming some of the challenges to enable more widespread adoption remains a key concern. Some promising aspects of the development and introduction of wearable devices, unobtrusive sensing, and telehealth will be studied for future research and applications. Moreover, artificial intelligence-based software will be developed as future work.

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Authors' Contribution

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The Declaration of Conflict of Interest/ Common Interest

The authors have not disclosed any conflicts of interest or common interests.

The Declaration of Ethics Committee Approval

This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics

The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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