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Remote Patient Monitoring With Smart Healthcare Support

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Abstract: *Technology is used in remote patient monitoring (RPM) to keep track of patients' health statuses and vital signs away from the usual healthcare settings. Healthcare professionals can remotely gather real-time data on patients' physiological characteristics, medication adherence, and other pertinent health data by using connected devices, such as wearable's, sensors, and mobile applications. Healthcare delivery could change dramatically with the help of remote patient monitoring and smart healthcare support. Utilizing technology, healthcare professionals may proactively monitor patients, personalize care, and enhance health outcomes. In order to fully utilize the potential of this strategy and revolutionize healthcare for the benefit of patients everywhere, it will be essential to overcome the implementation-related hurdles. The aim of this paper is to examine the latest advancements in smart healthcare systems, specifically focusing on wearable and smartphone devices for health monitoring, as well as the application of machine learning for disease diagnosis, and assistive frameworks like social robots developed for the ambient assisted living environment. Furthermore, the study emphasizes software integration designs that are crucial for establishing smart healthcare systems by seamlessly incorporating the advantages of data analytics and other AI tools.*

Keywords: pandemic, IoT, healthcare, LeenaBOT, disease diagnosis

INTRODUCTION

Any human being, regardless of age, gender, location, or health situation, want to be self-sufficient and comfortable. What can be done is limited by age, disease, medication, hospitalization, epidemics, pandemics, and other circumstances. Health monitoring systems have arisen to aid in simple healthy living, more accessible interaction between healthcare practitioners and patients for close monitoring, measurement of important health parameters, routine consultation, and overall healthy living. Furthermore, due of recent developments in information and communication technologies (ICT) with the adoption of Internet of Things (IoT) technology, smart health monitoring and support systems now have a greater edge of development and acceptability for enhanced healthy living [1]. Figure 1 illustrate overall architecture for remote patient monitoring.

A huge transition in technology occurred in the twentieth century, particularly in the sectors of wireless networks and automation, which appeared to be a massive wave in prior decades. The internet has extended around the globe, allowing consumers to access services and smart devices from any location, at any time [2]. The internet of things (IOT) has played a key role in the domains of automation and wireless technologies for nearly a decade. In large-scale situations such as home automation, building automation, intelligent cities, and healthcare, the Internet of Things (IOT) has the power to fully utilize networking's capabilities and modify the device of novel services. While using technology, healthcare monitoring is crucial for saving a patient's life.

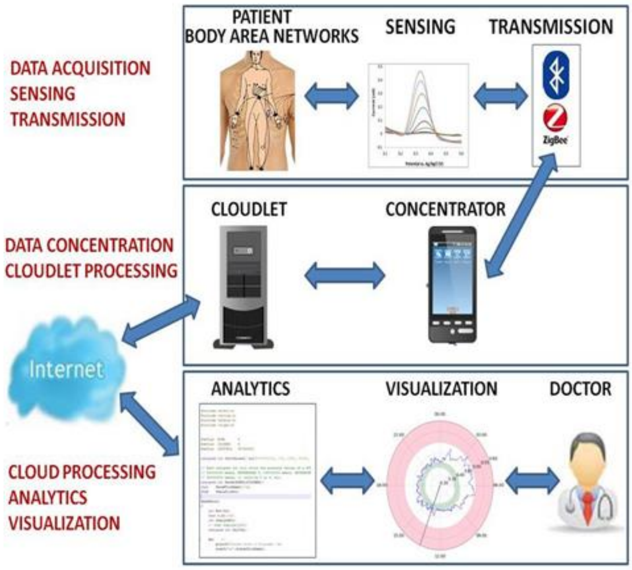

Figure 1. Overall architecture for remote patient monitoring [1].

For this reason, our research is a creative way for monitoring patient health. IoT stands for Internet of Things, which is real-time technology that may be used to monitor any field. On the IOT server, various sensors are used to monitor sensor data in real time. Individual patients will be monitored, and in the event of an emergency, IOT will notify the doctor, and the appropriate therapy will be delivered to that patient [3]. An innovative method of fusing technology and healthcare to improve patient care and healthcare delivery is remote patient monitoring (RPM) with smart healthcare assistance. In this method, patients' health problems and vital signs are tracked outside of conventional healthcare facilities using linked devices including wearables, sensors, and mobile applications. Healthcare professionals can obtain important insights, customize treatment regimens, and conduct remote consultations by gathering real-time data, using cutting-edge analytics, and using artificial intelligence (AI) algorithms. By removing geographical constraints, enhancing patient interaction, and optimizing resource allocation, the introduction of RPM with smart healthcare assistance has the potential to transform healthcare delivery. This strategy offers considerable advantages for both patients and healthcare professionals due to the rising prevalence of chronic diseases, an aging population, and the need for ongoing treatment.

RPM's main goal is to make it possible to monitor patients' health conditions pro-actively and continuously. Connected devices can gather information on vital indicators like heart rate, blood pressure, glucose levels, and oxygen saturation. Examples include wearable activity trackers, smartwatches, and medical sensors. Healthcare professionals can monitor patients' conditions remotely and take immediate action if any irregularities are found thanks to the secure transmission of this real-time data to them. RPM lowers the incidence of problems and hospitalizations by continually monitoring patients' health and enabling early detection of potential health issues, prompt intervention, and revision of treatment programs. RPM is complemented by smart healthcare support that makes use of cutting-edge technology like AI and machine learning. These tools evaluate the data gathered, spot patterns and trends, and give healthcare practitioners useful information. Based on the unique health profiles of individuals, AI systems are able to identify anomalies, anticipate unfavorable outcomes, and provide individualized advice. This data-driven strategy optimizes treatment outcomes, facilitates preventative care, and improves clinical decision-making. The capacity to expand healthcare access outside of conventional healthcare settings is one of the main benefits of RPM with smart healthcare assistance. Continuous monitoring and virtual consultations can help patients in remote or underserved locations, reducing the need for frequent hospital visits. Additionally, this method gives patients the freedom to take an active role in their own care. They have access to their health information, get educational materials, and get feedback on their development, encouraging self-management and good habits.

However, there are difficulties in implementing RPM with smart healthcare assistance. Since sensitive health data is transmitted and stored electronically, ensuring data privacy and security is crucial. For successful care coordination and continuity, interoperability—the seamless integration of RPM data with current health IT systems—is essential. Additionally, for widespread use and sustainability, it's crucial to create effective reimbursement models and get through regulatory barriers.

LITERATURE REVIEW

The authors of Ref. [4] envisioned an e-health care system that would allow doctors to monitor patients' vital physiological markers remotely. The proposed system can collect the required patient data and make it available and visible to the doctor for action. The online application is a function of the system that allows the doctor to record the patient's information, provide comments for guidance, prescribe, and administer drugs, as well as allow the patient to enter measured psychological parameter values and read information from the doctor. A smart TV application was used to remind patients of their activities, medicines, and other events on a daily basis. Finally, the system includes a mobile app that performs the same functions as the internet app, with the added benefit of being accessible from anywhere and at any time.

Sparsh and Agarwal [5] presented a remote health monitoring system that collects blood pressure measurements from patients using mobile phones. Doctors or caregivers can access and view values captured on mobile phones via the system's internet interface. Doctors can utilize the technology to monitor and manage a patient's condition while also providing feedback to the patient.

BSN-Care, a secure IoT-based modern healthcare system based on the Body Sensor Network, was proposed by the authors of Ref. [6]. The proposed system uses wearable sensors to measure and monitor physiological parameters such as blood pressure, electrocardiogram (ECG), and electroencephalography (EEG) conditions in the body. The Local Processing Unit, the system's coordinator, receives the measured parameter values and forwards them to the system's coordinator. The BSN-Care server analyses data from the patient's body and enters it into the database. Depending on the analysis and degree of anomaly in the values, the system notifies the patient's family member, local physician, or emergency unit contact. A lightweight anonymous authentication system protects the BSN-Care server, ensuring that everyone who accesses it is who they say they are. To ensure data privacy, integrity, and freshness, the Offset Codebook (OCB) authentication encryption mechanism was used.

The CoSHE smart home environment, which incorporates a home healthcare wearable unit, a private cloud, and a robot assistant, was shown by Minh Pham et al. [7]. The CoSHE system captures physiological, motion, and audio signals from residents using non-invasive wearable sensors, providing information on their daily activities and position in the home. Caregivers and caregivers can access detailed health data via a web application established on the system's cloud server. The device also includes a hydration monitoring application that enables for continuous monitoring of the patient's water consumption and daily fluid requirements. To evaluate hydration, the technology integrates sound data from microphones and bodily activity context from a wristband accelerometer.

A second-generation RFID-based E-healthcare management system was proposed by Min Chen et al. [8]. Video conferencing chats over the internet are used to monitor the patient's medical condition and communicate with the doctor or health care provider, as the case may be. In order to respond to medical situations, the system may also gather and process data. A body sensor placed to a specific part of the patient's body is used to collect physiological signals such as temperature, blood pressure, and heart rate. In a healthcare database, the system also keeps track of the user's profile and medical history.

This article gives a thorough overview of remote patient monitoring (RPM) technologies and how they are used in different healthcare settings. It covers the use of mobile applications, sensors, and wearable technology for data gathering, transmission, and analysis. Additionally, the review looks at how RPM affects patient outcomes, such as better disease management and fewer hospital readmissions.

This systematic review and meta-analysis explicitly examine the role of remote patient monitoring in the treatment of chronic heart failure. A remote monitoring of vital signs, medication adherence, and symptom reporting are just a few of the home-based telemanagement interventions that are evaluated in this study for their efficacy. The results show that patients with heart failure enrolled in remote monitoring programs experienced notable improvements in clinical outcomes and decreased hospitalizations.

This in-depth analysis examines how wearable biosensors, a crucial part of remote patient monitoring, are used in healthcare. The study examines how physiological parameters, activity levels, sleep patterns, and other health-related information are monitored using biosensors. Additionally, the article looks at how biosensors can be used with mobile applications and talks about the advantages and disadvantages of doing so in healthcare settings.

This systematic review of systematic reviews investigates how mobile health (mHealth) initiatives, such as remote patient monitoring, affect various medical outcomes. The study analyzes data from several evaluations and assesses how well mHealth interventions affect patient adherence, self-management, and clinical outcomes. The evaluation focuses on the mHealth technologies' potential to improve patient outcomes and healthcare delivery, particularly remote patient monitoring.

WORKING PRINCIPLE

The research focuses on the most recent software architecture suggestions for smart healthcare. The key features that connect the proposed systems are modularity and multi-layered architecture. The proposed designs are depicted in Figure 2 and include the primary users, a device layer, a cloud layer, and user interaction devices.

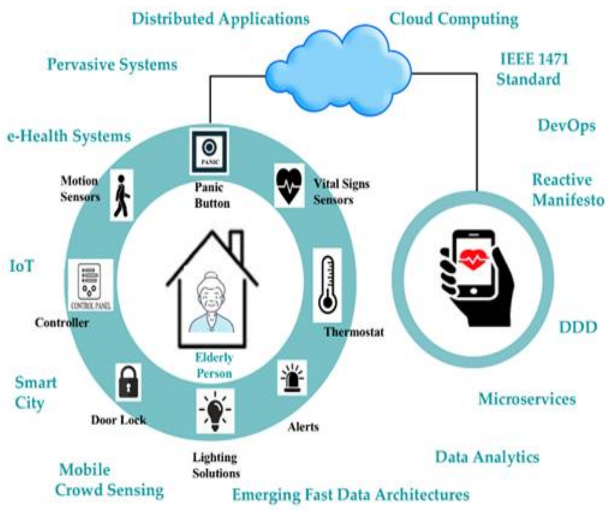

Figure 2. A general pipeline of a health monitoring system based on wearable devices [10].

A perception layer or device layer combines sensory data from several sources and streams it to the remainder of the system for processing.

Depending on the situation as shown in figure 2, the data is then processed on a local device or on the cloud. Sensors such as pressure sensors and temperature sensors are used to monitor a patient's blood pressure and body temperature. Blood pressure and heartbeat flow are monitored using the ECG sensor [9]. All of these variables are kept in an Arduino microcontroller and then uploaded to an IoT server. In the event of an emergency, a doctor monitors the

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IOT server and stops the patient from receiving therapy. It is possible to maintain track of patients in real time using this method. With this technology, we can keep track of the patient's health from anywhere in the world.

LCD Display

A liquid crystal display (LCD) is a small, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). Light is not directly emitted by LCs. Computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage are all examples of where they might be found. They're frequently more compact, lighter, and portable, as well as less expensive, more trustworthy, and easier on the eyes [11]. They have a wider range of screen sizes than CRT and plasma displays, and because they don't use phosphors, they don't suffer from picture burn-in. CRTs require more energy and are more hazardous to dispose of than LCDs as shown in figure 3. Due to its minimal electrical power consumption, this component is suitable for integration into battery-powered electronic devices.

Figure 3. LCD Display

Pressure Sensor

A pressure sensor as shown in figure 4 is a device that measures gas or liquid pressure. The force required to prevent a fluid from expanding is referred to as pressure, typically denoted as force per unit area. For the purposes of this essay, such a signal is electrical. In terms of technology, design, performance, usefulness, and cost, pressure sensors vary widely. According to a conservative estimate, pressure sensors are created by about 50 technologies and at least 300 companies around the world.

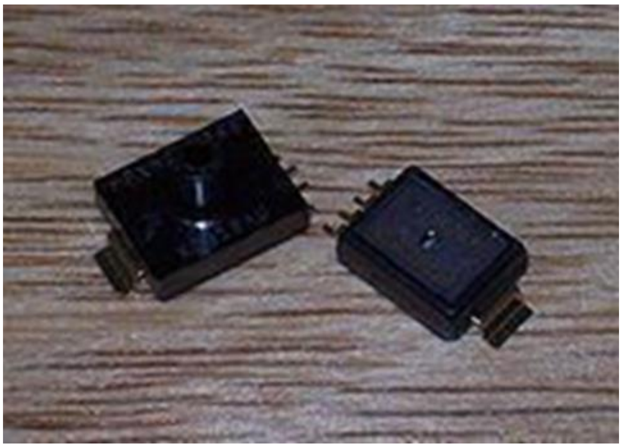

Figure 4. Pressure Sensor

ECG Sensor

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Electro cardiograms are used to monitor or record heart rhythms. The ECG is utilized when the doctor suggests that it be used to find irregularities in the rhythms. The ECG assists the clinician in doing a more thorough evaluation of patients with cardiac problems. By measuring the passage of electrical impulses through the heart muscles, ECG sensors help to increase the conductivity between the skin and electrodes. To perform an ECG, a technician must precisely place 10 electrodes on the human body. The electrodes transmit electric heart beats, which can be seen on the screen in the shape of a manner.

BP Sensor

The circulatory system's blood pressure is monitored with a blood pressure sensor. The largest pressure collected from the blood arteries is called systole pressure. The average range is 100-140mmhg. The lowest pressure exerted on the blood vessels is diastole pressure. The typical range is 60-90mmhg. A healthy adult's blood pressure should be 120/80mmhg.

Electrocardiogram

An electrocardiogram (ECG or EKG, abbreviated from German Electrocardiogram) is a graph produced by an electrocardiograph that depicts the heart's electrical activity over time. Depolarization and repolarizations multiple waves and normal vectors can be studied to acquire useful diagnostic information. It is the gold standard for diagnosing cardiac arrhythmias. It directs treatment and risk stratification for people who have a suspected acute myocardial infarction as shown in figure 5. It can help you discover electrolyte abnormalities [12].

Figure 5. Heart Rate sensor.

SIMULATION OF PROPOSED METHOD

The Proteus Design Set is a proprietary software tool package primarily used for electronic design automation. The software is used by electronic design specialists and technicians to create schematics and electronic prints for printed circuit board manufacturing as shown in figure 6.

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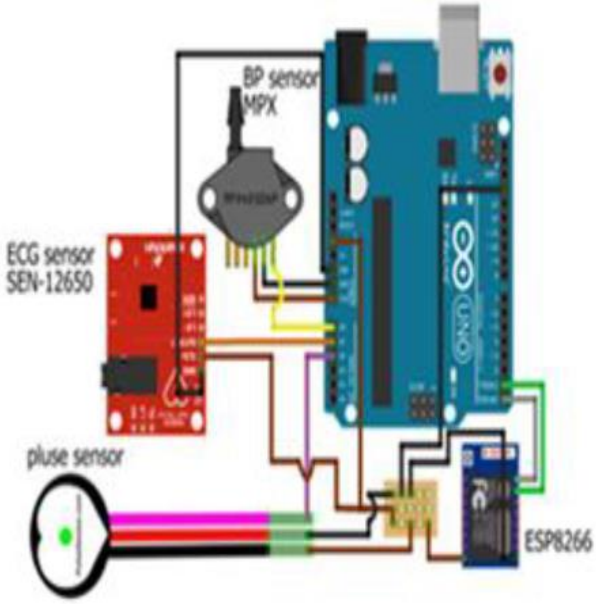

Figure 6. Circuit Diagram of Proposed system.

Hardware Implementation

The term "uno" means "one" in Italian, and it was chosen as the name for the Arduino Software (IDE) 1.0 release. The Uno board and Arduino Software (IDE) version 1.0 were the reference versions of Arduino, however newer releases have since overtaken them. The Arduino Uno board is the first of a series of USB Arduino boards and the platform's reference model; for a complete list of current, historical, and obsolete boards as shown in figure 7.

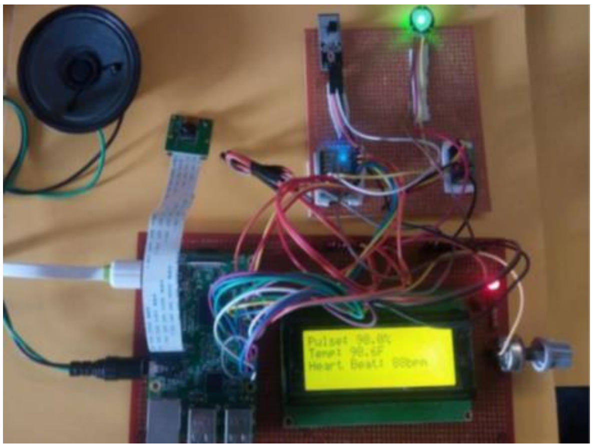

Figure 7. Snap shoot of hardware implementation.

For remote patient monitoring (RPM) with smart healthcare support to be possible, hardware implementation is essential. The main technological and hardware elements used to implement RPM systems are covered in this section. RPM relies heavily on wearable technology, including smart watches, fitness trackers, and medical sensors. The physiological data that these patient-worn devices record include heart rate, blood pressure, respiration rate, temperature, and activity levels. Additionally, the devices may have sensors for electrocardiogram (ECG) readings, oxygen saturation, or glucose levels. By enabling the ongoing monitoring of biomarkers associated with particular

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medical disorders, biosensors play a significant part in RPM. For instance, glucose biosensors are employed in RPM systems for managing diabetes, enabling patients to continuously monitor their blood glucose levels.

In RPM systems, applications for mobile devices are crucial for data collection, transmission, and patient interaction. To send data securely and instantly, Bluetooth, Wi-Fi, and cellular networks (3G, 4G, or 5G) are frequently used. Through the use of these communication technologies, healthcare personnel can access, evaluate, and store patient data in the system of the healthcare provider. Vital signs, medical records, and patient reports are only some of the data that remote patient monitoring creates. For safely storing and analyzing the gathered data, effective data management and storage solutions, including cloud computing, are essential. Real-time monitoring, data analytics, and individualized treatment choices are made possible by cloud-based technologies that let healthcare professionals access and analyze patient data from any location.

Effective care coordination and continuity depend on the seamless integration of RPM systems with already-existing health information technology (IT) systems, such as electronic health records (EHRs). Integration makes it possible for medical professionals to access patient information from multiple sources, including RPM devices, and makes sure that the information is added to patients' electronic medical records [14]. Patient data must be protected from unauthorized access using strong encryption mechanisms, secure data transfer routes, and compliance with privacy laws (like HIPAA). To protect the privacy and accuracy of patient data, procedures are used like user authentication, access controls, and data anonymization.

RESULTS

Human body features such as heart rate, body temperature, and blood glucose level are crucial in determining normal and abnormal health conditions.

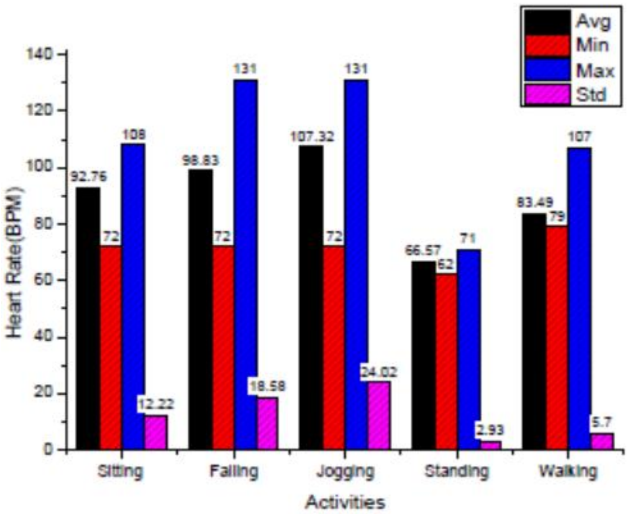

Figure 8(a). Heart Rate during 5 Activities

Wearable sensors were used to track heart rate, body temperature, blood glucose level, and body location. Table 1 shows the statistical statistics of Task Level Management of Elderly Patient Health Monitoring Services subjects sensing data. During the trial, an average heart rate of 73.4 was reported. The number of times a heart beats per minute is used to calculate heart rate. The goal of a healthy heart function is to provide the proper amount of blood at the right rate to the body's various tasks. The heart rate will increase if you run or stroll quickly, for example. The average body temperature was 97.1 degrees Fahrenheit, and the average blood glucose level measured using a glucometer sensor was 5.61. The acquired data were statistically analyzed using minimum, maximum, average, and standard deviation.

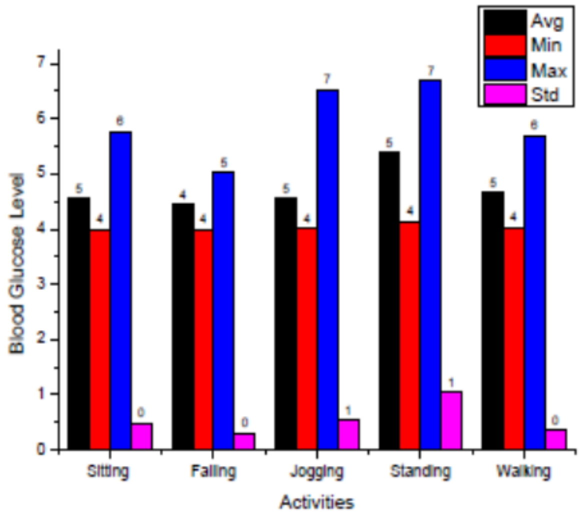

Figure 8(b). Blood glucose Level during 5 Activities

Table 1. Statistics of Collected Sensing Data

Sl. No	Aggregate Function	Heart Rate	Body Temperature	Blood Glucose Level
1.	Maximum(max)	89	98.5	6.89
2.	Minimum(min)	62	96.3	4.00
3.	Average(avg)	73.4	97.1	5.61
4.	Standard deviation(sd)	6.947	0.64	0.76

The most significant findings and observations from studies and actual RPM using intelligent healthcare technologies are presented as,

RPM has been found in numerous trials to significantly enhance patient outcomes. In the management of chronic diseases including diabetes, hypertension, and heart failure, for example, remote monitoring of vital signs, medication adherence, and lifestyle factors has led to better disease control, fewer hospitalizations, and improved quality of life. Improved self-management, higher drug adherence, and more frequent adherence to recommended treatment regimens are all characteristics of patients who actively engage in RPM programs [15]. Continuous monitoring of vital signs and symptom reports enables medical practitioners to recognize changes in a patient's health and respond quickly. This proactive approach has proven particularly effective in managing chronic illnesses, when immediate adjustments to medication regimens or lifestyle choices can prevent exacerbations and improve long-term outcomes.

Patients are encouraged to take an active role in their healthcare through RPM with smart healthcare support. By providing patients with access to real-time health data, tailored feedback, and instructional resources, patients are encouraged to actively participate in their own care. They get suggestions on how to regulate their own behavior, a better understanding of their health issues, and the chance to choose what's best for their wellbeing. This approach assists healthcare providers in providing individualized care to people who need it the most, while also increasing access to specialized therapies and decreasing unnecessary healthcare use.

Despite the many benefits, there are a few considerations that must be made if RPM with smart healthcare assistance is to be properly adopted. Data privacy and security are key considerations, thus strict protocols must be in place to ensure the secure transmission and storage of patient information. Interoperability remains a challenge since connection with existing health IT systems is required for effective information exchange and seamless care coordination. The creation of acceptable reimbursement systems and the removal of regulatory barriers are also necessary for the sustainability and growth of RPM programs.

CONCLUSION

In this research, a closed-loop IoT healthcare environment is suggested for geriatric patient health monitoring using an intelligent job mapping approach. On the proposed health monitoring architecture, an elderly patient health monitoring system was built as a case study. Based on biomedical sensors, the system might identify and alert authorities to deteriorating conditions, allowing for quicker intervention. The device is designed to monitor stress, blood pressure, and the whereabouts of elderly individuals who reside in smart homes. The Internet of Things (IoT) has enabled the development of smart health monitoring systems that are connected and interconnected. These smart health monitoring devices could be used to provide long-term care to the elderly in the setting of a smart home [13]. Smart healthcare is a safe, effective, and easy-to-implement health monitoring system that can provide high-quality care for a fraction of the cost of hospitals or assisted living facilities. In this study, we briefly covered state-of-the-art wearable devices and smartphones for basic sign monitoring, machine learning for illness diagnosis, heart disease, and diabetes), and frameworks meant to support adults in ambient assisted living [16]. The significance of software integration frameworks in smart healthcare development.

Future RPM research and development should focus on problem-solving and exploring new possibilities with smart healthcare support. The development of artificial intelligence and machine learning methodologies may have positive effects on data analytics, prediction models, and decision support systems. Through integration with telehealth services and virtual reality technologies, comprehensive remote care delivery experiences may be made available. To maximize patient involvement and personalize treatments, research on user perceptions, the adoption of RPM technologies, and patient viewpoints can be used. It is necessary to do in-depth research on the cost-effectiveness and scalability of RPM programs in order to influence healthcare policy and decision-making.

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