Chapter 5
Wearable Smart Devices for Remote Healthcare Monitoring to Detect Cardiac Diseases

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5.1 Remote Healthcare Monitoring

RHCM is expanding in acceptance as both patients and healthcare office workers desire health to be kept track of the exterior of clinical environments. RHCM is also named remote patient observation of the exterior of clinical settings. In other words, RHCM refers to the procedure of utilizing technology to observe patients in non-clinical settings, like inside the house.

5.1.1 Introduction

Relative Humidity Control Monitor (RHCM) has been proposed as a proportion of a prompt interferences and precaution healthcare prototype in which patients are observed over not just at an intermittent doctor call on. Now a days as outpatients using mobile devices and wireless analysis strategies. Contemporary reinforce this model of care, manifesting improvement in patient quality of life, and minimum cost incurred in healthcare. The essential indiction of stalking for chronic conditions was utilized with quick interposition.

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D. J. Hemanth et al. (eds.), *Internet of Medical Things*, Internet of Things,
https://doi.org/10.1007/978-3-030-63937-2_5

5.1.2 Significance and Components of Remote Healthcare Monitoring System

The design of technology making changes to both patients and healthcare executive intensive situations are said to be attended at an earlier stage. Though the costs involved are found to be higher, monitoring of patients in a remote manner is probably to become a chief element of the precautionary health protection in the future. Some of the significance of RHCM systems are listed below:

- Healthier gain to healthcare
- Better quality of life
- Harmony of mind and everyday assertiveness
- Better assistance, schooling, and assessment

5.1.2.1 Remote Healthcare Monitoring Assistances to Patients: Healthier Gain

In a nation where a sizeable escalation in the frequency of insured has made it more cumbersome for certain patients to acquire caregivers, RHCM boosts the potentiality for healthcare professionals to treat considerable patients. The likelihood of more healthcare establishments cuddling remote healthcare monitoring unlocks the door to heightened access for patient care globally.

5.1.2.2 Remote Healthcare Monitoring Assistances to Patients: Better Quality of Life

Moreover, RHCM also has the potential in enhancing the patient's quality of life and patient care. This is due to the fact that RHCM connects healthcare professionals instantly virtually with pertinent patient information. It makes their day-to-day chores efficient and mitigates the probability of expenditure resulting in apparent advantages to patient care.

5.1.2.3 Remote Healthcare Monitoring Assistances to Patients: Harmony of Mind and Everyday Assertiveness

Salient as patient relief and consultation are, the advantages of RHCM go beyond that, providing patients the assurance that someone is looking out for their healthcare and welfare daily. Let us consider a cardiac patient whose heartbeat is being monitored for days, prompting the patient to feel very much scared. Providing a crossover and an association for that patient in the home will create an image that the healthcare group goes along with the patient.

5.1.2.4 Remote Healthcare Monitoring Assistances to Patients: Assistance, Educating, and Assessment

With RHCM assistance provided to essential patients, it also bestows thickened levels of assistance, knowledge with the requirements of remote monitoring, and assessment in an intermittent manner compared with the conventional healthcare model.

5.1.2.5 Components of the Remote Healthcare Monitoring System

The devices utilized in RHCM are analogous to smartphones and tablets. It is constructed to acquire evaluation and link with a particular prerequisite or a healthcare professional for transmission of medical information. Patients would need to employ particular sensors that transfer patient physiological data to healthcare professionals. Figure 5.1 shows a block diagram of the components of the RHCM system.

The healthcare professionals then utilize this patient medical information so that timely assessment of the patient's conditions is made and assistance is said to be given accordingly. A detailed description of the block diagram is presented below.

Input Devices

Devices that stay with the patients besides the sensors that not only provide a systematic transfer of the patient's conditions via information about several factors but also support to the patients by administering certain factors as follows:

- Reminders
- Caution messages
- Appointments with the doctor
- Providing intellect cooperation

Here, the patient enters the data manually, or the sensors automatically detect and input the data into the device. Moreover, input devices may also be a sensor connected onto a patient's garments, mundanely adhered to a patient by one or more steer, or implanted in a watch, cleat, clothing, and so on. Other forms of input devices include:

- Computers
- Android phones
- Landline phones

The above said equipment are utilized for patients to take up data manually or wirelessly through a local storage device. These devices are key elements that make a remote healthcare system different from any other healthcare system.

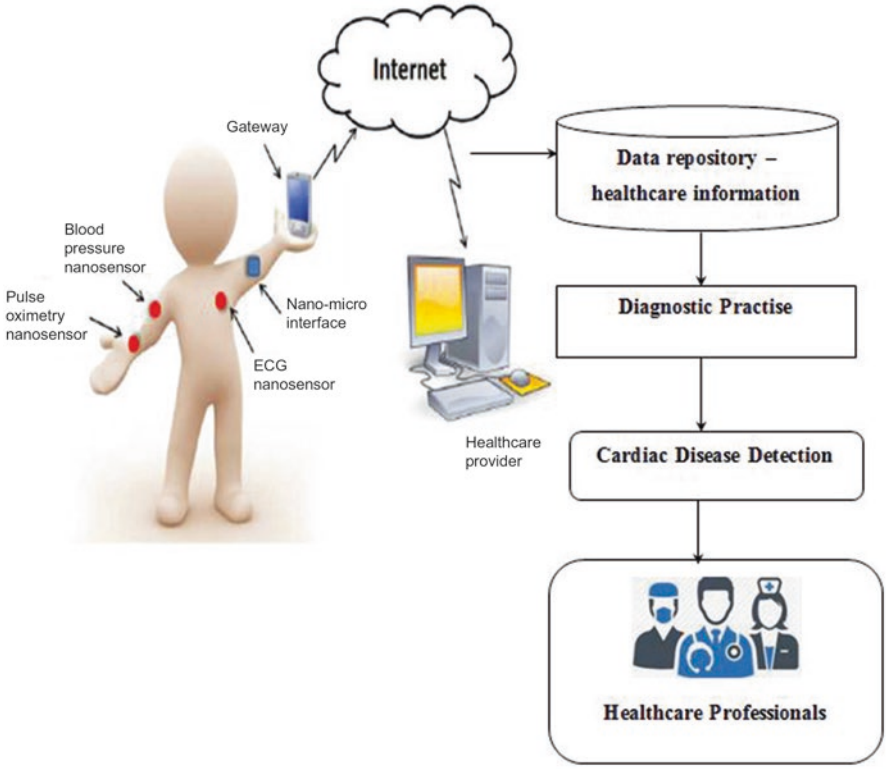

Fig. 5.1 Block diagram of components of remote healthcare

Data Repository

Relevant or pertinent information acquired from the patient has to be stored in a device which can be extracted at any point in the treatment. Hence, it is crucial that all information analogous to the patient are kept in devices like the Universal Serial Bus (USB) or in a repository which can be acquired whenever essential.

Diagnostic Practice

For a specified treatment sequence, it is indispensable to grip the information about the patient's health specifications in a USB or in a repository to be acquired whenever the need arises.

Communication Network

A network is an alternative segment of the solution that specifically assists in establishing RHCM with the patient's input device. Different types of networks are said to be available in the market nowadays, and it is predominant to make certain the potentiality of the input device to connect to the network in concern. This is said to be achieved from:

- Wireless Fidelity (Wi-Fi)
- Local area networks
- Mobile ad hoc networks
- Bluetooth establishments

The provider of the services usually acquires this network to institute patient-doctor connections.

Central Repository

Patient data is stockpiled in remote healthcare systems conserved by healthcare centers and nursing homes. This could be established by one or more of the centralized repositories relevant to a healthcare system. Healthcare software, in turn, utilizes and provide this updated data to healthcare professionals and furnishes the information corresponding to the condition of the patient for further verification, remedy, and therapy.

5.1.3 Infrastructure of IoT

Internet of Things, as a strong area of computer networks, necessitates a conventional framework to provide an aggressive circumstance for medical healthcare professionals to improve their quality of life. Moreover, a comprehensive assessment of the conventional internet frameworks necessitates being conducted to evaluate its potentialities converge to provocations of the internet of things.

The Internet of Things associates a great number of heterogeneous devices via the Internet. It should sustain a ductile layered architecture. Different types of architectures are said to be designed for the IoT [1]. A few examples are as follows:

- Three-layer architecture
- Middleware architecture
- Service-based architecture
- Product-based architecture
- Five-layer architecture

Figure 5.2 shows a sample of a five-layer architecture.

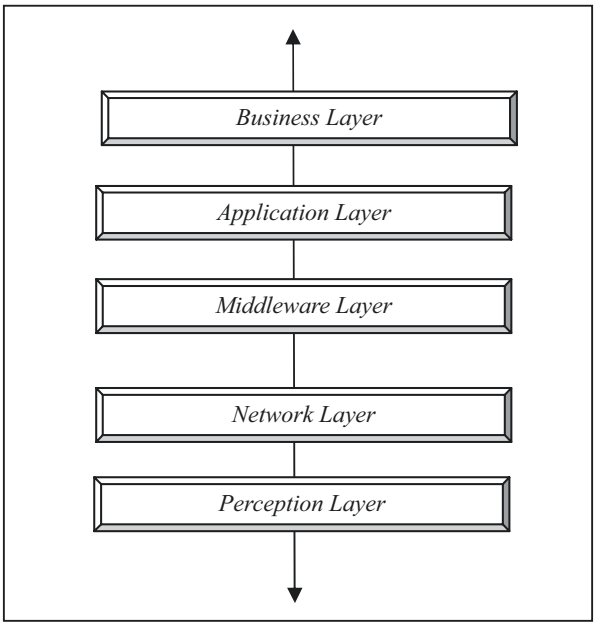

Fig. 5.2 Sample five-level architecture

5.1.3.1 Perception Layer

Initially, the layer starts with the perception of objects in the concerned layer. In this perception layer, the sensor devices acquire and progress the information, computerize the collected information from the patient, and then send the patient-sensitive information to the network layer. The perception layer comprises sensors for acquiring information like location, temperature, weight, humidity, and so on. In other words, passage of enormous data produced from disparate systems and stocked in the Internet is initiated in the perception layer.

5.1.3.2 Network Layer

In the network layer, patient information acquired from the perception layer is dispatched via a secure media to the middleware layer. Here, data are said to be transferred by utilizing technologies, which include but are not limited to:

- Radio-frequency identification (RFID)
- Global System for Mobile Communications (GSM) between devices
- Wi-Fi
- Bluetooth

The sensitive medical data acquired from the abovementioned objects are further stockpiled and refined by utilizing cloud services. A Convolutional Neural Network (CNN) based regular pattern mining model for the discovery of knowledge related to regularity in health conditions. A new convolutional neural network (CNN) learning model was introduced in [2] to identify the correlated health-related factors. A double-layer fully connected CNN structure was applied for categorizing the gathered data.

5.1.3.3 Middleware Layer

The middleware layer splits the service according to the name and address with the sensitive medical information acquired from the medical health professional. This layer in other words permits developers to operate with diversified devices irrespective of the hardware plan of action. Different intentions for the requirement of possesing an interface in IoT. First, as various technologies are prevalent on the IoT, routine calibrations are said to be a very cumbersome process.

Therefore the IoT must be coupled to heterogeneous computers. Second, there is said to exist an insistence for isolating the application layers in disparate realms. To address this, an interface is provided by the middleware. Finally, the layer also conceals irrelevant details and diversification of physical layer mechanisms to untangle the comprehensive procedures, specifically to the patients.

5.1.3.4 Application Layer

This application layer is said to be established upon patient request, entirely depending on the practicable desirability of entities like:

- Blood sugar measurements
- Blood pressure measurements

The significance of this application layer owes to the conception that it can bestow high-quality intelligent assistance to converge several patient prerequisites.

5.1.3.5 Business Layer

Finally, the business layer controls all system pursuits and assistance. The culpability of this business layer is to construct a business framework, graphical structures, and flow patterns based on the medical data acquired from the patients via the application layer.

5.1.4 *Remote Healthcare Monitoring Architecture for Cardiac Disease Detection*

The RHCM architecture for cardiac disease detection [3] involves a three-level model. They are:

- Wearable sensor
- Android/Apple device
- Web gateway

The three-level architectures are shown in Fig. 5.3.

5.1.4.1 First Level

The first level of cardiac disease RHCM involves the interface of the patient that comprises several multiple wearable sensors. These are utilized in obtaining the medical information about each patient collected at a different time interval. This first level transfers the data in a real-time manner in a wireless manner from wearable sensors that are implanted in the patient's body parts to the second level via Bluetooth.

5.1.4.2 Second Level

The second level comprises either an Android phone or an Apple phone. With these devices, the patient's information is extracted or acquired from the wearable sensors. Android phones or Apple devices have the potential to interface with the webserver using General Packet Radio Services (GPRS) or Wi-Fi networks.

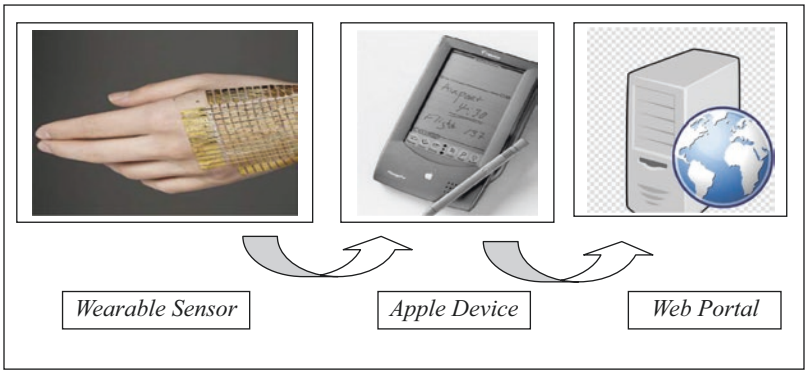

Fig. 5.3 Cardiac disease remote healthcare monitoring

5.1.4.3 Third Level

Finally, in the third level, the web server obtains the data or information from the database and hands over the data to the online database. The web server is a podium that obtains the data of patients from all over the globe with wearable sensors and portrays them on the web interface. The information here includes patient location information and his confidential information for recognition. Some of the information that can be extracted are the heart rate, blood pressure level, blood sugar level, and so on.

5.2 Communication Technologies for Remote Healthcare Monitoring to Detect Cardiac Diseases

The performance of a middleware that extends a forever distinguished programming pattern and dissociates the originator from low-level concerns, specifically the various communication technologies utilized. It is very predominant and critical to the specific extent for RHCM to detect cardiac diseases.

To keep away from probable interventions with the subsystem and also with certain other extensive communication, the IEEE 802.11 is utilized to detect cardiac diseases. This is the most remote of the channels utilized to transmit location beacons. Different communication technologies are therefore in use for remote healthcare monitories, specifically to detect cardiac diseases. To name a few are:

- Bluetooth (BLE)
- Wi-Fi
- Zigbee
- Long-range devices (LoRa)

In recent years, to impart uniform cardiac health data wirelessly to the cloud environment, LoRa is utilized. This device is a novel, exclusive, and spread-spectrum modulation strategy that permits sending the measured data from the patient at exceedingly minimum data rates to immensely extensive ranges.

5.2.1 Outline of the Remote Health Monitoring System

Automated monitoring has been shown to be effective in helping the elderly or senior citizens in the management of chronic health concerns. In an early stage with healthcare provider interference is inherently outshine. The patients who may wait for a longer period become earnestly ill before going on the lookout for treatment.

To integrated into the administration of chronic ailments, RHCM has the prospective inefficiently enhancing the patient quality of life and hence its popularity has also been heightened. In RHCM, a monitoring device needs a sensor that can assess specified data about physiological aspects. This information is passed on to both the patient and healthcare executives in a wireless manner. With the inception of sophisticated devices, RHCM enables patients to keep an eye on their health to manage chronic conditions. Two types of remote health monitoring systems are there in existence. They are shown in Fig. 5.4.

As depicted in the above figure, the elaborate description of the communication technologies, short-range, and long-range are provided below.

5.2.2 Short Range Communication Technologies

The selection of the communication technology to be chosen based on the monitoring necessitates for cardiac diseases is considered to be a paramount issue when constructing for specific disease detection. The selection of communication technology certainly is depended on the monitoring prerequisites and the configuration's features. Amongst several communication technologies in the market, one of the few for cardiac detection is ZigBee [4].

- The Zigbee protocol was designed by the Zigbee Alliance. To start with, it was formulated as a standard for home automation. In the later years, it was publicized, and its practicability has been broadened to reshape it to several other applications also.
- Zigbee has the potential to inspect radio channels to record the information involving cardiac detection with the slightest intervention, which is then chosen and utilized by the entire device involved in the Zigbee network.
- Zigbee permits an utmost transmission speed of 250 Kbps connecting devices with a detachment of covering 50 m. Zigbee at present accounts for one of the

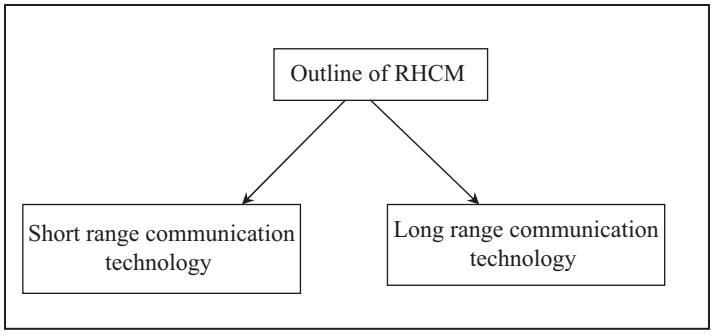

Fig. 5.4 Outline of communication technologies

most comprehensively utilized protocols for cardiac remote healthcare monitoring.

5.2.3 Long-Term Monitoring Systems

Long-term monitoring systems or long-range technologies in comparison with the conventional communication technologies permit kilometer-wide wireless communications. In long-term health monitoring system, an ECG remote monitoring system was introduced in [5] which offers a high-quality ECG signal.

This involves a star topology with radio frequency ranging between 860 MHz and 1020 MHz.

- The data range of long-range monitoring systems lies in between 290 bps and 50 Kbps with an overall range of 15 Km.

Therefore, the LoRa involves a high communication range with a minimum data rate forming the best selection for remote healthcare systems monitoring cardiac diseases. This is because with this range of communication, it ensures the absolute interface between the wearable sensors measuring the cardiac disease data.

5.2.4 Challenges in Remote Healthcare Monitoring

RHCM has the prospect to metamorphose patient care entirely. If executed comprehensively, it will reorganize the circumstance and empower healthcare assistances to supervise their resources much efficiently. Some of the challenges [6] faced are:

- Patient data reliability
- Patient data precision
- Real-time access to patient data
- Network connection and compatibility

5.2.4.1 Patient Data Reliability

The medical data about cardiac disease communicated over any RHCM plan of action to be reliable enough to converge the levels essential of healthcare. It will require vigorous data management executions, comprehensible frontiers of possession, and rigid reliability standards. The challenges are no fewer critical for clinics and sophisticated hospitals that peril a third party that could be muddle along putting their patients' reliability and seclusion at menace.

5.2.4.2 Patient Data Precision

Controversially the most complicated challenge facing RHCM of cardiac disease concerns patient data precision. Medical professionals will be anticipated to recognize and handle patients from the perspective of the data concerned. This is because of the reason that the medical professionals even have to handle or treat a chronic patient with these highest probable accurate data.

5.2.4.3 Real-Time Access to Patient Data

The relocation of information necessitated for RHCM to work is possibly a lengthy and intricate procedure and comprises a voluminous transfer. Initially, data must be acquired via the patient's wearable sensors. If the data being acquired is on a mobile network, then patient data has to traverse via the network provider's framework via voluminous data centers. Upon the occurrence of interruption in any one of the hops, the patient's sensitive and intensive data are said to be hindered in arriving at its stopping place.

5.2.4.4 Network Connection and Compatibility

The victory of RHCM hangs laboriously on the connection and compatibility of the network and the wearable sensors. This is specifically true when interferences could containment the diagnosis, in the case when necessitates continuous monitoring of heart conditions.

5.3 Remote Healthcare Monitoring to Detect Cardiac Disease

In RHCM, the wearable sensors involved had substantially minimized the load of patients and distributed an excessive life care style with minimum menace. Beyond the patient associate, the mechanics manifesto is being strengthened in every predicament and deciphers all patient medical-associated issues remotely. Some of them are listed below.

- Boosting chronic circumstance administration
- Narrowed nascent circumstances and readmissions
- Minimized load on healthcare systems
- Better patient consequences
- Improved quality of life

From the above-said factors, the objective of RHCM is to relay messages in a prompt manner and also early detection of a critical worsening condition.

5.3.1 Early Heart Disease Prediction

One of the well-known diseases that affect several people both during their mid-age and in the senior age is heart disease. In either case, it may also result in a higher mortality rate. Also, heart disease is found to be more common in men than in women. Even it is said that around 17 million people die due to cardiovascular disease (CVD) [7] globally every year and it is found to be highly identified in Asia. For research on heart disease, the Cleveland Heart Disease Database (CHDD) is used as the de facto database. Some of the risk factors involved are:

- Age
- Sex
- Smoking habits
- Hereditary
- Cholesterol level
- Poor diet practices
- Obesity
- High alcohol usages
- High blood pressure
- High diabetes

In addition to the above forces identified, certain other factors also play a major role:

- Eating practices
- Irregular exercise or absence of physical activity
- Obesity

Moreover, different types of heart diseases are said to be prevalent all around the globe. To name a few, the following are samples:

- Coronary heart disease
- Congestive heart failure
- Congenital heart disease
- Myocarditis

Even though above factors are said to play a major role in detecting heart disease, it is a cumbersome process to evaluate the odds of heart disease manually. However, RHCM is utilized to predict heart disease.

5.3.2 Remote Patient Monitoring in Heart Disease Patients

RHCM applications permit minimizing the risk concerning heart failure in patients susceptible to this state with the aid of cardiac resynchronization wearable sensors that can transmit patient cardiac health information to a centralized database. This information can be regularly monitored, and patterns can also be obtained. Therefore assisting patients to maintain stable health, enhancing their quality of life, and reducing the overall fatality rate are important. Figure 5.5 shows a schematic view of remote patient monitoring (RPM) in heart disease patients.

Due to a vibrant way of life, several people are agonizing from heart diseases. To minimize the risk of heart failure, technology has made several advancements including cardiac resynchronization treatment and the pacemaker. This in turn refers to that the RHCM enhances the patient quality of life, reduces the fatality rate, and minimizes the period of stop off in hospitals.

5.3.3 Cardiovascular Monitoring System and Remote Monitoring

In the past few years, medical wearable sensor makers had analogously manageable chores to conduct specifically intensified on monitoring hospitalized patients and fabricating tools. Tools such as pacemakers have helped eliminate or prevent problems in cardiac patients' health enabling them to live a normal life.

However, nowadays, with the maturity of digital healthcare, even manufacturers and medical professionals are under vigorous pressure to do something extra—collecting information and compiling for medical analysis in a real-time environment. To be specific, they have been asked to identify new methods of timely patient data

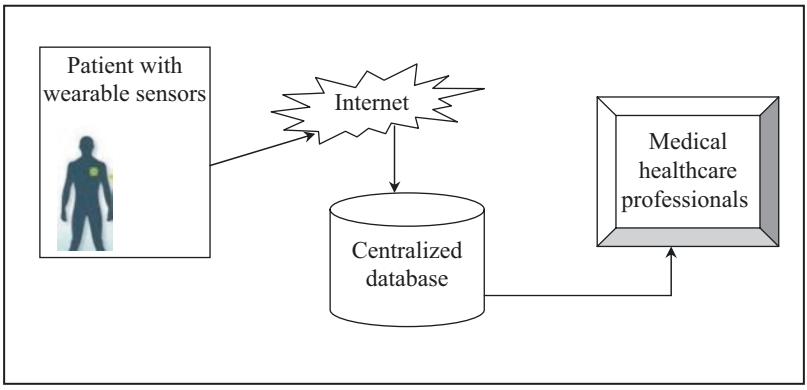

Fig. 5.5 Schematic view of heart disease remote patient monitoring

collection, so medical professionals can acknowledge swiftly pertinent changes in the patient's status.

Remote cardiac monitoring, in particular, has emerged as a target for device makers who realize that their products can close gaps in the existing toolset and offer lifesaving benefits to a fragile population. Ultimately, RPM helps providers offer decentralized services that are gradually replacing many of those delivered inside hospital walls. With Medicare paying for remote monitoring, providers have every reason to get on board with RPM.

Continuously monitoring the heart assists medical health professionals in acquiring the information to evaluate the heart's health state. In specific time, devices involved in cardiovascular are utilized in diagnosing the heart condition, or else they are also utilized in assisting a heart ailment. A novel two-step predictive framework was introduced in [8] for high-risk heart patients. The framework is important for other biomedical signals, namely, photoplethysmography (PPG), pulse oximeter (Pleth), and electroencephalogram (EEG).

5.3.4 Remote Cardiac Monitoring

For at-risk patients, detected with cardiac deformities resulting in heart symptomatic circumstances, medical health professionals utilize cardiac monitors to identify the severity. These cardiac monitors continuously monitor heart activity and send intensive data to electronic health records, therefore, empowering more comprehensive problem-solving.

With the help of these devices, even perforations are not even left due to the reason that it does not have to be separated for charging on a day to day base. This recognize unusual indications for consistently keeping an eye on high-risk patients. The processes involved are as follows:

- Through remote cardiac monitoring, critical information obtained from the patient's wearable sensors are said to be communicated to a medical healthcare professional directly.
- With this consistent and continuous monitoring, medical healthcare professionals are permitted to assess the patient's heart activity without the presence of the patient physically.
- The main reason for effective monitoring is due to the small device nature acquiring and sharing the most prerequisite information is said to be done in a significant manner. This is said to be achieved whenever the cardiac monitoring device coincides with the transmitter and shares the collected data.
- The transmitter then transmits the vital information with the medical healthcare professional via a secure web server that is said to be accessed only by the patient's medical healthcare professional team.

Some of the benefits of remote cardiac monitoring to mention a few are:

- Lesser in propria persona is required
- Economizing patients time and money
- Minimization in hospitalizations
- Curtailing time consumed in recognizing clinical events
- Higher probability of survival rate
- Fewer follow-up visits
- Found to be extraordinarily salient in this era of COVID-19

5.4 Smart Healthcare Future Challenges and Barriers Relevant to Cardiac Diseases

The future of organizational alimentation in cardiac healthcare necessitates capable heads to intent for any prospective issues. In the next 5 to 10 years, medical healthcare professionals should anticipate experiencing an abundance of issues. The following just to name a few are examples:

- Administrative and strategy changes
- Developments in medicine and technology
- Issues about sponsoring and education

Medical healthcare professionals should understand the fusion of these ultimatums. Some of them are:

- Time and money for cardiac disease medical research
- Providing state-of-the-art facilities
- Utilization of modernized equipment and wearable sensors
- Educating both medical healthcare professionals and patients

Connected health utilizes smart and mobile applications with wireless devices like Bluetooth, Wireless Fidelity, and long-range devices so patients are connected with their medical healthcare professionals without having to visit them in person routinely. Connected health has progressed into smart healthcare wherein the traditional smartphones are utilized with wearable sensors to monitor blood pressure, glucometers, and smartwatches to validate patient monitoring uninterruptedly even when patients are in their homes. Smart cardiac healthcare is anticipated to keep expenses related to hospitals low and obtain treatment in a timely and precise manner.

5.4.1 Authentication and Authorization Issues

Smart healthcare devices can give rise to patient security and privacy. A novel Integrated Circuit Metric (ICMetric) technology was presented in [9] which involves providing a security key, an authentication scheme applied to authenticate separate

devices. Some of the issues faced by both the medical healthcare professionals and patients are listed below:

- Unauthorized access to smart healthcare devices could generate a significant risk to patients' health as well as to their sensitive medical personal information.
- Associated instruments together with healthcare and mobile wearable sensors acquire, combine, evaluate, and transmit sensitive medical information to the cloud computing environment. Here the device layer is said to be highly susceptible to spoofing attacks, cloning, and so on.
- Denial of service (DoS) attacks can influence medical healthcare systems and even influence patient protection to a greater extent.
- The abstain discernment of prospectively security menaces residues a provocation due to the frequency and complication of transpiring software and hardware susceptibilities.
- The insufficiency of security grades of these smart healthcare devices in addition to the potentiality of strong search engines makes these wearable sensors highly susceptible to all types of attacks [9].
- In recent years, several wireless networking mechanisms have also been designed in the smart healthcare framework, like Wireless Fidelity, Bluetooth, and so on that are being utilized in providing long connectivity to several wearable sensors. Security mechanisms of these wireless devices against Sybil attacks and worm whole attacks must be imposed.
- A centralized repository of information about the personal history of the patient, family background, and medical data has to be preserved and protected from both hackers and malicious software to provide proper security and privacy mechanisms.

Moreover, certain risks involved are the geographical information of the patient with a purchase made from the medical practitioners or pharmaceutical companies that may bestow a description of a patient's health status.

5.4.2 Risk Analysis

As far as smart healthcare is concerned, risks to patients, smart healthcare workers, and medical healthcare professionals are widespread in healthcare also. Hence, it is a prerequisite for any hospital to possess a certified medical healthcare risk manager to evaluate, expand, execute, and observe a risk management plan of actions to reduce the disclosure. The role of smart medical healthcare risk managers [10] *includes the following:*

- Smart medical healthcare risk managers are instructed to operate several issues in multifaceted environments.
- Smart medical healthcare risk managers operate in the following areas:

  Financing, insurance, and claim analysis

Event, accident, and insurance management
Clinical settings
Emergency activities

- Risk managers work in both static and dynamic manner either to safeguard incidents or to reduce destructions.
- Some of the challenges faced by administrators are

Safety hazards for the patient
Mandatory rules and regulations
Probable medical error
Prevailing and succeeding policy

Hence, probable risks have to be measured and analyzed frequently. Also, their side effects have to be analyzed. Based on the risk factor analysis, smart medical healthcare managers should design, develop, and implement the plans accordingly.

5.4.3 Standardization and Validation Plans

The confronts suffered by standardization and validation plans about the prospective of smart healthcare wearable sensors to provide cost-efficient, improved experience quality and different smart healthcare services are evaluated by the complicatedness of upsurging patients.

Smart healthcare environments are exceedingly complicated and stimulating to manage as they are essential to managing with a diversity of patient circumstances under differing occurrences with a plethora of resource limitations. Several statutory bodies have designed a greater number of subsidies to bestow a robust plan of action to counter the ultimatum of providing smart cardiac healthcare solutions.

To address most of the healthcare standardization and validation issues, utilization of specific technology can assist in attaining the objective of comprehensive health protection. With mushroom growth in both technology and wearable sensors, gaining medical assistance to all sectors of the public is becoming a reality. With the most sophisticated standards, telemedicine has made easy accessibility and availability in the urban and rural sectors of the country. Also, telemedicine has been used in rural sectors where the inadequacy of medical healthcare providers and assistance provided directly due to lack of accessibility has been minimized.

5.4.4 Network Availability and Connectivity

As far as smart healthcare is concerned, it is undergoing a fast amendment from conventional hospital and professional concentric pattern to a dispersed patient-centric manner. Among several techniques involved, network availability and connectivity fire this fast metamorphosis of healthcare in a vertical fashion.

In the present scenario, healthcare broadly utilizes the prevailing 4th generation network and is constantly maturing to reconcile the requirements of future intelligent healthcare applications. With the expansion of the smart healthcare market connecting to the network, it will generate enormous data different in both size and formats also. This, in turn, will lead to complicated network traffic requirements in terms of bandwidth, data rate, and latency.

The developed state, the smart healthcare framework, also the connectivity has to be provided for a higher number of wearable sensors or devices. This in turn would necessitate the requirement to design feasible machine-type communication. However, prevailing communication technologies can compete with the existing data and devices in the network placed by different smart healthcare providers and devices in the market. Hence, the upcoming 5G network is anticipated to underpin smart healthcare applications that aid in ultralow latency, high bandwidth, ultrahigh reliability, high density, and high energy efficiency.

5.5 Conclusion

In this chapter, an overview of RHCM carried out by previous researches is presented. Various communication technologies are used for RHCM to discover cardiac diseases. RHCM is used for identifying the cardiac disease to reduce the heart failure risk. Future challenges are analyzed for authentication and authorization issues, risk analysis, standardization and validation plans, and network availability and connectivity.

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