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A Review of Healthcare in the Future: Internet of Medical Things (IOMT) for Improving Quality of Life

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Abstract: ***In order to improve patient comfort, provide better and more inexpensive health care options, and make it simpler for people to get high-quality treatment in the comfort of their own homes, medical equipment is now being connected to the Internet of Medical Things (IoMT). This study's main goal is to shed light on the design and application of IoMT (Internet of Medical Things) technologies inside the healthcare system. The information was obtained from a number of sources, including review articles published in different publications. IoMT has been successful in reducing the price of digital healthcare systems as well as how much energy they consume. Sensors can assess anything from physiological processes to emotional reactions. They can be employed to anticipate illness before it materializes. IoMT has been successful in reducing the price of digital healthcare systems as well as how much energy they consume. Sensors can assess anything from physiological processes to emotional reactions. They can be employed to anticipate illness before it materializes. The phrase "Internet of Medical Things" describes the widespread use of healthcare delivery options that might be done at home. Millions of lives could be saved while less stress is placed on traditional healthcare facilities like hospitals by making such systems sophisticated and effective for early prediction of serious illnesses. Thanks to developments in IoM, patients and clinicians can now access real-time data.***

Keywords: Internet of medical things, Remote healthcare monitoring (RHM), Sensor, Zigbee, Ozone therapy.

1. Introduction

Access to high-quality medical care is a vital component of human rights, yet it is not commonly available. The advancement of the world's economy, environment, and society, as well as the lifestyle that goes along with it, have been connected to a startling increase in the prevalence of chronic diseases including diabetes, leukemia, and cardiovascular disease. The greatest threat to human health is posed by these chronic illnesses. Also, as more people seek medical attention as a result of an infectious disease spreading, the demand on healthcare resources increases. For instance, the rapid spread of COVID-19 is currently straining the world's healthcare infrastructure. Patient and data management suffers in situations like these [1]. These days, industries related to healthcare and cutting-edge technology [2, 3] play significant roles in daily life, including healthcare systems [4]. The main goal of adopting current technology in medicine is to facilitate communication between patients and medical professionals. As a result, medical products and services will be more efficient and simpler to access [5–9].

The Internet of Things (IoT) is a subset of the Internet of Things (IoMT), which deals with connectivity and communication between things. The IoT is called the IoMT when these things are specifically related to the medical business, such as dosimeters, pulse oximeters, etc. [10].

IoMT describes the real-time monitoring of patients' vital signs using mobile computing, medical sensors, and cloud computing, as well as the use of communication technologies to send data to a cloud computing framework. Physicians can access the data to efficiently monitor, diagnose, and treat patients. The dependability and safety of traditional medical devices are combined with the Internet of Medical Things. It has the ability to handle multiple devices that are deployed for numerous patients and is general enough to handle a variety of ailments that call for incredibly varied monitoring and actuation needs. It can therefore address the problem of ageing and chronic disorders.

IoMT is already playing a crucial role in remote healthcare monitoring (RHM) [11–13] at this time. The phrase "Internet of Medical Things" (IoMT) describes the combination of Internet of Things technology and healthcare technologies (IoT). The growth of personal computing devices and technological advancements have made it possible to create the Internet of Medical Things (IoMT), which provides solutions to meet the demands of both our ageing population and those with chronic illnesses. The network that links a vast number of individual medical devices as well as tools and institutions that provide medical services, like hospitals, medical research institutes, and private businesses, is known as the Internet of Medical Things. The proliferation of linked and distributed medical devices has led to the establishment of both potentially beneficial applications, which is principally responsible for the rise of the IoMT [16].

IoMT is a class of electronic and intelligent medical devices that can gather, monitor, and improve patient health issues in real time while doing so at a cheaper cost. Fitness trackers, smart health watches, ring-style heart rate monitors, wearable blood pressure monitors (BPM), and biosensors are examples of wearable technology. Devices that can be worn on the body are called wearables [17].

The future of healthcare systems lies in IoMTs. As it grows, it provides quicker and more affordable medical treatment

[18]. The Internet of Things (IoT) is mostly used to collect remote patient data via wearable sensors and gadgets and store it in cloud databases [19]. Caregivers are given access to this data for immediate analysis and usage [20]. The Internet of Medical Things is composed of three distinct stages: the device layer (also known as the body sensor network or BSN), the cloud service layer, and the fog layer. shown in Fig. (**1**).

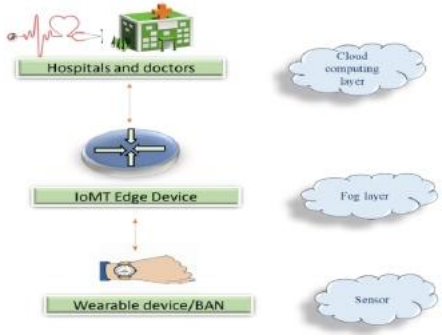

Figure 1: Three stages of the internet of medical devices

BAN gathers the sensor data and transmits it to a gateway node. The transmission layer stores the data and performs an analysis using the standard threshold values to identify any irregularities. Additionally, the data might be sent to the cloud, where it would be kept and put though a variety of calculations. Physicians and other medical professionals can log in, check and confirm diagnoses, and take the appropriate actions using an online portal.

The information above indicates that the system's design is inadequate for crisis management due to the significant delay in results. For further processing, the cloud gets data on patient health from BAN sensors. Because of the increase in system latency, patients in urgent situations cannot get an immediate analysis. The newly emerging fog and edge computing concepts are resolving this latency issue [1]. A system of emergency alerts is set up at a layer of fog, with predetermined thresholds for the various metrics being tracked.

It has been discovered that measuring physiological variables requires continuous data analysis, whereas measuring environmental elements just requires a fixed system [22]. RHM [23–28] is a method for continuously gathering health data. This includes keeping an eye on your body's health, your physical activity, your diet, your medications, and your behaviour. Wireless health information transfer to patients and medical professionals is made possible by cloud computing [29, 30]. IoMT offers real-time, rapid, remote, and accurate sickness detection as a result, which enhances decision-making. During this process, a vast amount of data is gathered, assessed, and tracked [11].

Most people don't get routine medical checkups because of their busy lives today. However, the cost of providing healthcare services is rising, and governments pay a sizable sum of money to cover these expenditures each year. There is a significant demand for real-time, remote healthcare monitoring in order to address all of these issues [22].

1.1. IOMT (Internet of Medical Things) working

The majority of IoMT systems function in the following essential levels, which are connected to one another using wired or wireless connections and comprise a wide range of technologies, devices, and sensors [20].

Infrared sensors, medical sensors, radio frequency identification (RFID) cameras, and sensors are all included in the perception layer, the lowest stratum of the IoMT, which is integrated with data sources including health monitoring devices and mobile applications (GPS). The sensing systems identify things, locations, demographics, and magnitudes, notice changes in their environment, and then transform this information into computerised data with the aid of trustworthy, wired or wireless network communications that act as a higher-performance transport medium.

1.2. Gateway Layer

The sensors must communicate with the gateway in order for them to operate as intended, as was previously indicated. Using networks that can share and centralise information, this connectivity must be established. The transmission's range may be extremely little or comparatively large, and it may cover a large area. Wireless Fidelity, Zigbee, and radio frequency identification (RFID) are a few examples of short-range communication. Cloud computing, blockchain technology, and other forms of wide-ranging communication are examples [37].

Many kinds of gateways are listed below Fig. (**2**).

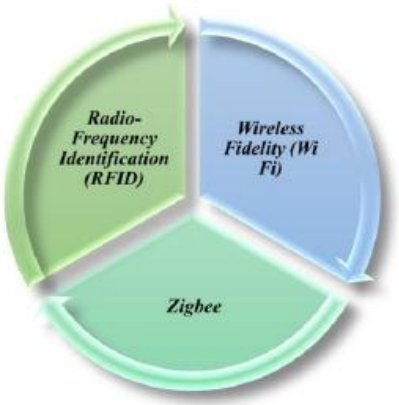

Figure 2: Different types of gateways

1.2.1. Radio-Frequency Identification (RFID)

It has a microprocessor, an antenna that can identify a specif ic object in the surroundings, and a user who interacts with t he tag through radio waves to transmit or receive data in the form of an electronic product code (EPC).

1.2.2 Zigbee

Its mesh network architecture enables seamless data transfer between medical equipment. It makes sure that information is distributed even when some of the equipment isn't working properly. Zigbee uses a frequency band similar to Bluetooth's (2.4 GHz), but its communication range is much wider. Data aggregation and analysis are made possible by the processing centre, end nodes, and routers that make up

this system. Zigbee offers a high network capacity and transfer rate, as well as a low power consumption.

1.2.3 (Wi Fi) Wireless Fidelity

It has a greater broadcast range than a typical wireless local area network (WLAN). Due to its quick and efficient network construction capacity, greater smartphone compatibility, and ability to offer stringent control and security, it is a widely used gateway method in hospitals. However, much higher power usage and unstable networks are the main limiting issues.

1.3 Administration Service Layer

The extraction of relevant information from vast amounts of raw data requires the employment of tools that are part of the management service that can operate more quickly by utilising analytics, safety precautions, process modelling, and device monitoring.

The Secure Sockets Layer Application Programming Interface (SSL API) is used for secure communication. It makes it possible to gather data from a patient's sports, the Internet of Medical Things, and smartphone technologies, such as comprehensive electronic medical records (EMRs). Following that, this data is uploaded to the cloud, where it can be utilised to influence decisions on therapeutic measures [15].

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The two main duties of the application layer are information analysis and the provision of application-specific services. In order to make conclusions about potential diagnosis and treatments, the application layer uses artificial intelligence (AI) and deep machine learning to evaluate EMR data and track evolving patterns in the collected data using a number of daily and weekly plots.

2. IOMT Impacting Healthcare

The healthcare sector is impacted by IoMT in a number of different ways. While using IoMT at home, on the body, in the community, or inside a hospital, these changes become most obvious. [39] (Fig. **3**)

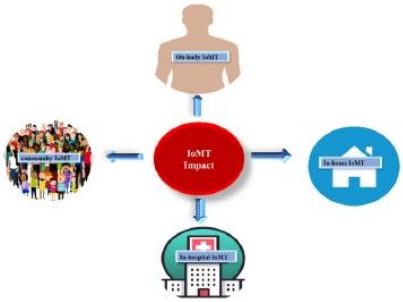

Figure 3: Impact of IOMT

2.1. In-Home IOMT

Individuals can use a technology called in-home IoMT to send health information from their homes to other locations, such their primary care doctors or hospitals (IoMT).

For instance, remote patient monitoring (RPM) involves sending data from recently discharged patients' hospitals, such as blood pressure or oxygen levels, for evaluation by their doctors. By spotting issues before they become serious, this may aid in reducing hospital readmissions.

The usage of IoMT devices in conjunction with telemedicine may also prove to be beneficial when it comes to providing continuous therapy outside of the patient's surroundings. For instance, personal emergency response systems (PERS) can rapidly alert emergency workers to potentially life-threatening situations like cardiac arrest

2.2 On-Body IOMT

On-body shopper IoMT devices are wearable health indicators that can be measured for individual usage and shared with healthcare professionals. Anyone can buy these devices because they are offered for sale online. These gadgets have the potential to act as early warning systems for health issues that are more serious in nature in addition to being able to monitor a standard metric, like heart rate. The Apple Watch, for instance, can notify users of irregular heart rhythms.

2.3 Communities Iomt

It is the application of IoMT technology over a wider area. For instance, mobility services are instruments that keep an eye on patients as they drive. In a similar manner, emergency response intelligence systems are used by paramedics and first responders to maintain track of patient data outside of hospitals.

In addition to on-site and emergency care, community IoMT employs approaches that enable remote medical care.

2.4 In-Hospital Iomt

Hospitals need to be aware of how staff and patients move around the building and maintain the calibre and accessibility of their medical services over time. In order to give administrators a thorough picture of what is going on, healthcare professionals use IoMT sensors and other monitoring tools to record all of these interactions.

3. The Healthcare System's Iomt Uses a Wide Variety of Sensors

Medical equipment is commonly available, but it is expensive and consumes a lot of electricity. As a result, sensors are employed in IoMT-based healthcare systems to conserve electricity and produce affordable and cost-effective solutions.

3.1 Pulse Oxygen Metres

It is an instrument that checks the patient's blood oxygen saturation without subjecting them to any invasive treatments. Such information can be used to assess a patient's health and identify any potential problems. A blood oximeter can be used to find illnesses including asthma, pneumonia, anaemia, and other lung-related problems, among other ailments. The pulse oximetry technique has been proven to be useful for determining oxygen saturation in clinical settings. Frequently, a sensor attached to the patient's finger is used to measure SpO2. Transmissive and reflected measurements of SpO2 are available. The transmissive strategy is more common than the other. This type of pulse oximeter sends

3.2 Sensors for Pulse Rate

In order to assess the patient's cardiac condition, the rate of the patient's pulse is measured. It can be used in an emergency situation to quickly identify the problem's root cause. The pulse rate sensor that is most frequently used is the APDS-9008. A green infrared LED with low intensity is used to identify the pulse through the reflection of light that takes place in each heartbeat in order to use it as a sensor for determining the pace at which the heart is beating .

3.3 ECG Sensors

Electrocardiogram (ECG) data is necessary to verify a healthy heartbeat and level of strength. It is essential for the early diagnosis and treatment of cardiac disease. The AD8232 is a well-known ECG measurement module that may be used in a range of applications, such as a heartbeat sensor and an ECG sensor. As a result, it performs a number of different tasks and is widely used. It might be used by the device's front end as a heartbeat sensor. The low cut-off frequency of the high pass filter causes waiting time, which is reduced by the system's rapid circuit restoration capacity. Additionally, it offers an ECG Android app so that customers can check their data for medical monitoring purposes [12].

3.4 Monitor for Blood Glucose

Those who have been diagnosed with diabetes must utilise blood glucose monitors to keep proper control over their blood sugar levels. One can pick from a variety of blood glucose monitors available today on the market. In an IoT setting, they are desired [19]. It emphasises the difficulties associated with invasive blood glucose monitoring as well as the risk of contamination from discarded needles, which could lead to infections. Designing a non-invasive gadget to measure blood glucose levels is their suggested remedy in light of this. An infrared LED, a photodiode, and an AT-MEGA328 microprocessor are all parts of the sensor package for these monitors. This device measures blood sugar levels using infrared light. Moreover, several systems have intelligent alerting. Another system is IGLU.

Using a Smart Glucose Meter This system analyses the data collected from patients and looks for any anomalies using near-infrared spectroscopy and machine learning techniques. These traits make it possible for endocrinologists to observe the patient from a distance.

3.5 Sensors For Temperature

The most often used temperature sensors are the LM-35, TMP236, DS18B20, and MAX30205. In a wearable patient monitoring device, the body temperature of the patient is ascertained using the DS18B20. The MAX30205 temperature sensor serves as both a temperature gauge and an overheating warning system. The MAX30205's excellent precision and low operating voltage make it ideal for wearable technology. Its digital capabilities also make integration with any system simple.

The LM-35 is most frequently used in networks of wearable sensors. Compared to the DS18B20, it has a much wider temperature range [20].

3.6 Sensor for Electromyography

The Electromyography Sensor, also referred to as an EMG, is employed to ascertain the electrical impulses generated by the muscles. Doctors and other medical professionals can monitor patients' nerve and muscle problems with the aid of this sensor. These sensors are also used in wearable medical devices that track a patient's behaviour. The creation of emotion-based intelligent information sensing systems requires EMG sensors. These systems recognise variations in facial muscle activity and link each variation to an associated emotion using EMG signals in conjunction with other biological sensors. This method can reveal the patient's compromised state of health. Moreover, Advancer Technologies is creating an EMG sensor

3.7 Blood Pressure Monitors

There has been a lot of research done on non-invasive techniques for monitoring blood pressure, such as the oscillometric method, which uses an air-inflated cuff to

squeeze blood vessels in order to measure systolic and diastolic pressures . In the alternative approach, a patient's blood pressure is calculated without the aid of a cuff. Many different biomedical sensor types, including ECG and PPG sensors, are the foundation of this procedure. A system for estimating and analysing patients' blood pressures has been developed as a result of advancements in research and study in ECG and PPG signal analysis. Long-term benefits of this strategy include cheaper hardware costs for the system and improved patient outcomes.

4. Application of IOMT in the Health Care System

4.1 During Hemodialysis, the Sensor Patch Can Detect Blood Leakage

A new technology that integrates Wi-Fi and Bluetooth Low Energy (BLE) with IoMT (Internet of Medical Things) technologies to produce a sensor patch A sensor array in the form of many rings made up this system. The sensor could detect leaks as the amount of liquid rose. The gadget also included a mapping circuit and a Bluetooth low energy module. A signal line was added to the insulating layers during manufacturing, but the sensing point was the sole area of the array that was exposed to the outside world. The method from blood leaking to detection consisted of the following three steps: (1) absorption, when the blood spread to the patch after being absorbed by the gauze;

4.2 The Best High Blood Pressure Medicine

To measure antibiotic concentrations in bodily fluids, digital (smart) medications with built-in IoMT sensors may be used, and dose tracking will provide more precise information on treatment success on an individual basis . In order to assess people with chronic high blood pressure, Naik et al. also demonstrated the use of an ingestible sensor that was CE-marked.

4.3 Tools for diagnosing digital biomarkers

That are self-powered and connected to the IoMT are currently being created. These instruments may make it possible to monitor biomarkers in bodily fluids including blood, sweat, urine, and so on in real-time. As a result, it might be simpler to discriminate between illnesses brought on by viruses and those brought on by bacteria. This is extremely helpful. The patients' response to treatment can also be closely monitored. This would show whether or not the patient is genuinely benefiting from the treatment, and it might also show whether resistance is present. [21]

4.4 Disease Monitoring and Surveillance

The main considerations for managing disease spread over the world are testing and tracking, particularly in order to reduce transmission. The usage of several different IoMT-based devices has been made in order to test and monitor infected individuals as well as to locate patients in order to monitor the probability of disease transmission. With the use of point-of-care testing (POCT) devices based on IoMT depicted in Fig., infectious diseases like malaria, dengue fever, influenza A (H1N1), human papilloma virus, Ebola virus illness, Zika virus, and coronavirus (COVID-19) may be treated more successfully (5).

Real-time testing was made possible by the establishment of an IoMT-based system by Bibi et al. in 2020.

A new smart biomarker that can detect lymph node metastases was developed by Wessels et al. in 2021 using intricate neural networks .

4.5 Monitoring of Anxiety and Stress

In today's world, stress and anxiety issues are becoming more prevalent. Ineffective stress management can lead to physical illnesses, psychological distress, and stress disorders. Those who recovered from COVID-19 had an increase in anxiety issues and other mental diseases, according to preliminary investigations. It is an inexpensive IoT-based anxiety disorder monitor that deduces emotional traits from physiological readings in a semi-immersive setting. An Internet of Things node collects data on a user's heart rate and physical activity, which is then forwarded to a Raspberry Pi 3 for processing before being published to an Internet of Things cloud. According to the validation data, this approach has a 90% accuracy rate in identifying anxiety disorders.

4.6 Epilepsy Detection

A seizure is a sudden electrical disturbance of the brain. So, in order to provide patients with the right care and therapy, it is crucial to identify or discover it as soon as possible.

Electroencephalography (EEG) data from a patient may be used in an IoMT-based technique to identify seizure start. In order to extract hyper-synchronous pulses from the brain, the system continuously examines neurological data from an EEG sensor. Then, seizure incidence is determined using this information gathering.

4.7 Ozone Therapy for Wearables

Ozone treatment has a clear advantage because it is so easy to make. Ozone can be manufactured artificially (via UV radiation) and transported by patients in compact, portable units, allowing for low-dose continuous therapy regimens while reducing the effects of higher concentrations on healthy skin cells. By exposing the wound to oxidative stress, ozonated air stimulates wound healing by increasing the production and migration of wound healing components as well as the oxygen levels at the wound site. Patients would be able to receive topically administered ozone therapy outside of a clinical setting with the use of wearable ozone producing technologies. The creation, development, and application of a wearable, portable platform for applying ozone to a wound site

4.8 Thermographers in the Air

Without any form of direct physical touch, tele-thermographic systems (TIS) are able to accurately detect an individual's skin temperature thanks to an inbuilt thermal

infrared camera with a temperature reference. These simple-to-use technologies that don't require any assistance are quite useful for spotting excessive body temperatures in densely populated areas. Using drone technology based on the IoMT, Mohammed et al. (2020) exploited thermal pictures to identify increased temperatures linked to coronavirus illness.

4.9 Insulin Injection Automatic

The Raspberry-Pi 3, which is not only affordable but also adaptable, is employed. In order to conduct a continuous checkup, data regarding four bodily vitals are acquired and shown on the website with a camera that feeds live video. There are two separate login keys available for live monitoring; one is designated for the doctor and the other is offered to the patient's family. Every time a sensor picks up an instability or anomaly, a message is sent to the doctor via the GSM module. When doctors determine that patients need insulin injections, they can do it from any location by pressing a button, which allows a small amount of insulin to be released into the patient's system [1].

4. Security and Privacy for IoMT

One of the biggest challenges facing Internet of Things (IoT) devices right now is security and privacy concerns. The Federal Bureau of Investigation (FBI) claims that due of insufficient verification and out-of-date technology, current IoMT tools are extremely vulnerable to abuse. The IoMT has been the target of numerous cyberattacks in recent years. 90% of IoT-using healthcare organisations have reportedly reported at least one security issue, according to surveys. Another study found that 35% of the more than 370 companies using IoMT experienced at least one cybersecurity compromise in 2016. At a hospital in Indiana in 2018, hackers stole patient medical information. The hospital spent a significant sum of money to acquire the

Lin et al., 2021 proposed a smartcard-based user-controlled single sign-on (SC-UCSSO) system for telemedicine. This solution enhances security and reliability while simultaneously preserving patient privacy.

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5. Conclusion

The nation's healthcare institutions are currently battling problems like a lack of vital medical specialists on staff, protracted wait times, an increase in demand for services, and a lack of funding. IoMT, or the Internet of Medical Things, is a paradigm change in the healthcare industry that has been implemented to enhance medical services, reduce the cost of those services, increase life expectancy, and accomplish a variety of other related aims. IoMT use has accelerated as a result of the development of technologies like cloud computing, fog computing, edge computing, and artificial intelligence, which has also improved its security. The advent of remote health monitoring technology has resulted in a considerable improvement to the healthcare system.

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