A Systematic Review of IoT Integration on Health Monitoring System

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ABSTRACT

The Internet of Things (IoT) has had a significant impact on many fields, including the healthcare industry. It has, in particular, resulted in the development of devices that can collect and transmit data, allowing for better patient monitoring. IoT has enabled remote patient monitoring and telemedicine, which has significantly improved care. IoT wearable devices can collect and transmit data on patients' blood pressure, heart rates, and blood glucose levels. IoT could also help monitor hand hygiene compliance and track patients' moods and depression. Significantly, monitoring the symptoms of Parkinson's disease patients via IoT aids in disease management. These IoT applications have had significant implications in healthcare. IoT applications reduce healthcare costs while also improving treatment. The diagnosis becomes timely, allowing timely interventions to be implemented. IoT also enables proactive treatment and ensures the effective use and management of drug-related equipment. The main challenges are data security and the high initial implementation cost. In general, implementing IoT has had an impact on care delivery and resulted in better patient outcomes.

Keywords— Internet of Things, Patient Monitoring, Heart Rates, Blood Glucose, Parkinson's Disease

I. INTRODUCTION

The number of patients in desperate need of medical intervention is rapidly increasing as chronic illnesses become more prevalent. This has always put a strain on healthcare services and delivery. Healthcare administrators, physicians, nurses, and other health professionals are under increasing pressure to meet the growing demands on health-related issues from both the public and private sectors. Furthermore, the rising cost of medical care has had a significant impact on people's quality of life. Healthcare system development necessitates a concerted effort to seamlessly integrate with the Internet of Things (IoT), particularly to address day-to-day challenges in the sector. Without the intervention of a human, IoT connects all types of connected "Things" into a comprehensive network of interconnected computing intelligence. In this way, The Internet of Things (IoT) allows things (such as devices, cars, houses, people, and animals) to communicate with one another and with users via the internet network, thereby becoming an integral part of the Internet [1,2]. IoT has emerged as a critical component in environmental monitoring and health-care applications. Medical devices have been enabled to simplify communication, which has transformed healthcare significantly [3] & Table 1 shows list of contributions from previous reviews on IoT in healthcare. Using the internet ensures that physical devices are linked to the internet and that information is sent or received from one location or person to another [4]. The utility of these connected devices is widespread, and can include the ability for health care professionals to track and monitor health progress remotely, improve self-management of chronic conditions, aid in the early detection of abnormalities, expedite symptom identification and clinical diagnoses, provide early intervention, and improve adherence to prescriptions [5]. Hence, Medical devices which have the facility to transfer data over a network to computer interaction without the need for human intervention are termed as Internet of Medical Things (IoMT) & Figure 1 depicts the architecture of IoMT [6]. An IoMT platform is a smart system that consists primarily of sensors and electronic circuits to acquire biomedical signals from a patient, a processing unit to process the biomedical signals, a network device to transmit the

biomedical data over a network, a temporary or permanent storage unit, and a visualization platform with artificial intelligence schemes to make decisions based on the physician's convenience [7][8].

Table 1: List of contributions from previous reviews on IoT in healthcare

ID	Year & Reference	Summary of Contributions
1	2022[9]	By properly implementing IOT technology, doctors, academics, government, and researchers can create a favorable environment for combating the COVID-19 pandemic. Certain concerns must be addressed, such as data privacy and protection from malicious attacks. In dealing with the pandemic, CIOMT provides efficient and dependable service. This technology can be used as a framework for pandemic diseases to prevent virus spread through early detection.
2	2022[10]	IOT is now successfully used in the healthcare domain, but its evolution requires the integration of all technologies. To get rid of old infrastructure in hospitals, virtualization is required. Artificial intelligence data mining tools will be required to extract meaningful information from massive amounts of data. Making critical health decisions in real time will also necessitate big data strategies for data analysis using algorithms. Although all of these technologies are used in IoT-based healthcare systems, there are some challenges, such as storage requirements, security and privacy compliance, and the need for high-speed communication.
3	2022[11]	The paper described a developed IOT-based health monitoring system based on Arduino. (e system measured a patient's body temperature, heart rate, and blood SpO2 levels and send the information to an app via Bluetooth. (This information is also sent to the LCD panel, allowing the patient to quickly see their current health status. With the help of the system Which is developed, elderly patients, asthma patients, COPD patients, patients with chronic diseases, COVID-19 patients, and diabetic patients will be able to keep their health in check over time.
4	2021[12]	In the medical field, the focus of IOT is to aid in the precise treatment of various COVID-19 cases. It simplifies the surgeon's job by lowering risks and improving overall performance. Doctors can easily detect changes in critical parameters of the COVID-19 patient using this technology. This information-based service expands healthcare opportunities by moving toward the best way for an information system to adapt world-class results as it enables hospital treatment systems to be improved.

| 5	*2021[13]*	*This paper proposed an Internet of Things (IoT)-based framework for remote monitoring, administration, and analysis of patient conditions in a typical indoor environment. The proposed infrastructure includes static and dynamic routing, as well as delay analysis and priority communications.*
6	*2020[14]*	*To fully realize the current potential of IoT in healthcare, a clear code of practice on data management, privacy, confidentiality, and cyber security concerning is required.*
7	*2020[15]*	*The application of IoT devices, i.e. the E-health concept, can also significantly improve healthcare systems. An advanced IoT-supported monitoring system could enable improved service quality and patient safety. With better patient treatment, such as timely therapy decisions and qualitative rehabilitation, the prediction of life-threatening states could be efficiently detected. In general, large healthcare systems could benefit from IoT, both in terms of efficiency and cost, which is important for hospitals.*
8	*2020[16]*	*This paper proposed an Internet of Things (IoT)-based real-time electrocardiogram (ECG) monitoring system that can operate in both real-time and store-and-forward modes. The store-and-forward mode does not have any data integrity issues and does not require a high network quality. The real-time mode, on the other hand, is difficult because transmission delay and packet loss during real-time transmission will affect data integrity, particularly for real-time ECG signal transmission.*
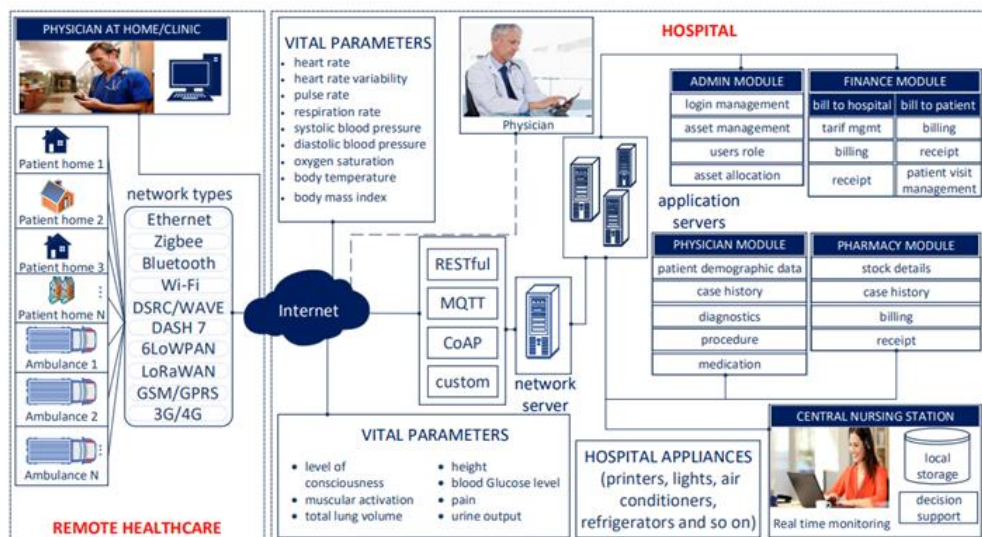
Fig. 1: Architecture of Internet of Medical Things (IoMT)[6]

This has been made possible by digital, mechanical, and computing technologies, which have assisted in the realization of various goals in the healthcare sector. The patient monitoring is one significant development resulting from IoT in healthcare, which has significantly improved care delivery. [6]. Professionals can constantly monitor what is going on with their patients and improve interventions for a variety of health issues. This paper is reviewed the integration of IoT on health monitoring system**.**

The following is the structure of the paper: Section 2 provides a methodology of this paper to express IoT technology integrations in the healthcare industry. Section 3 focuses on IoT integration findings and discussions. Section 4 expresses significant development in healthcare based on the Internet of Things. Section 5 provides the Impact of IoT on human health care. Section 6 contains potential challenges of IoT utilization on health care system. Section 7 contains the conclusion.

II.   METHODOLOGY

The current paper examined the integration of IoT in the healthcare sector using a systematic review approach. The method enabled the identification, evaluation, and interpretation of studies pertinent to the IoT issue. The articles were found and reviewed to ensure that they provide relevant information about IoT and its impact on the healthcare sector.

Following the completion of the search, numerous studies relating to IoT in healthcare were discovered. It was critical to choose the right articles to effectively inform the audience and explain how the internet has influenced the healthcare industry. All study designs and articles completed in English and published within the last ten years met the inclusion criteria. The pieces had to be screened, which was accomplished through the quality appraisal process. The review specifically included only complete studies or articles. The articles were evaluated based on their accuracy, methodology, and relevance. Finally, the most relevant studies for the research paper could be chosen. The data was derived from studies that examined IoT integrations and impacts in healthcare.

III.   FINDINGS

The articles selected focusing on patient monitoring via IoT and the impact of IoT on healthcare, and they included a variety of information sets on the subject. It has been proposed that IoT will enable real-time monitoring, reporting, data analysis, and notification in the healthcare sector. [26]. However, this technology is difficult to use. In another article, IoT and cloud computing were discussed, as well as their implications for healthcare. According to this article, IoT improves operational efficiency, staff satisfaction, patient safety, and outcomes [19]. IoT has been suggested to be critical in measuring and monitoring vital signs [17]. For example, the Internet of Things can precisely monitor respiration and heart rates, thereby improving care delivery and patient outcomes. In relation to these findings, IoT could aid in the detection of heart attacks, allowing for timely intervention to address potential cardiac issues [21]. Heart rate readings are collected and transmitted via the internet by the system. According to the study [16], IoT enables effective patient monitoring and real-time heart rate examination via an electrocardiogram monitoring system. Physicians can monitor real-time information or access previously recorded information about the patient's condition using computers or smartphones. The use of an IoT system could improve monitoring and promote heart disease prediction [26]. The patient monitoring platforms can be collecting real-time data and sending it to clinics, hospitals, and doctors for evaluation or to patients for self-management [20]. Through timely and effective monitoring, IoT and real-time elements enable patients to take better control of their healthcare.

On the other hand, it has been analyzed that the Internet of Things has positive implications for patient care delivery [14]. IoT improves healthcare system efficiency and patient outcomes. Hand hygiene monitoring through IoT could reduce infections in healthcare organizations. [27]. IoT has been identified as critical and has the potential to assist in dealing with challenges, particularly during COVID-19. Better approaches to monitoring blood glucose and assisting patients with this aspect are possible with IoT [12]. In their findings, IoT could aid in the monitoring and management of Parkinson's disease. [13]. There is effective communication about symptoms, which allows for the management of various Parkinson's disease issues. These findings show that monitoring via IoT has been a fundamental development that has influenced changes in healthcare.

IV.   DISCUSSION OF FINDINGS

According to the findings of the various articles, the use of the internet of things has enabled significant advancements in the delivery of care to people. The Internet of Things will fundamentally alter healthcare as we know it. We have reached a new level of evolution in terms of how apps, devices, and people communicate with one another to deliver healthcare solutions. The Internet of Things has provided us with a new perspective and tools for an integrated healthcare network, significantly improving healthcare quality. The Internet of Things has enabled the automation of healthcare procedures that previously took a significant amount of time and left room

for error due to human involvement. Many hospitals, for example, now use networked devices to control airflow and temperature in operating rooms. [28]

The ability to connect devices to the internet has opened up exciting opportunities for healthcare organizations, and they can now provide care using devices [14]. Wearable devices that provide benefits and address various patient problems have been developed as a result of IoT. [25]. Patient monitoring has been among the most significant development in healthcare arising from IoT [16] [20]. In essence, this advancement allows professionals to effectively monitor patients while also allowing patients to monitor their own health situations. The implementation of the internet of things in healthcare has resulted in the realization of various monitoring elements.

V.   SIGNIFICANT DEVELOPMENT IN HEALTHCARE BASED ON THE INTERNET OF THINGS: PATIENT MONITORING

From the articles' findings, patient monitoring is among the most valuable functions of IoT since IoT devices are empowered to collect patient data automatically [14]. According to [20], remote patient monitoring has been a significant step forward in healthcare as a result of the use of IoT and real-time systems. The technology collects health metrics such as temperature, blood pressure, and heart rate from people who are not physically present in the hospital [11]. As a result, the Internet of Things eliminates the need for people to visit healthcare providers to have these details collected, or patients can collect the information themselves.

IoT devices gather patient information and transfer the data to another software device or application where the patients or professionals can view the report [14] Clinics and professionals can use the data to assess patient issues, and patients can use the information to manage their own health [20]. Using algorithms could aid in data analysis, allowing for the recommendation of appropriate interventions rather than concerns that require immediate attention. For example, if an IoT device detects an unusually low heartbeat in a patient, it generates an alert, allowing the physician or nurse to intervene appropriately and promptly.

Patients can monitor their vital signs and understand when it is critical to seek physical treatment, as well as engage in self-management of their various illnesses. [20]. The devices also enable doctors to implement treatments proactively, preventing complications or worsening of the situation. In essence,

this could help improve patients' wellness and health outcomes.

Significantly, IoT has been critical in the management of diabetes through effective glucose level monitoring. Monitoring blood sugar levels has long been difficult for millions of diabetics. Manually checking and recording glucose levels is inconvenient and only provides blood glucose level information at the time of the test. Period testing is insufficient to identify a problem with the patients if the level of fluctuation is significant. These issues are addressed for patients and professionals through IoT, allowing automatic and continuous monitoring of blood sugar levels[12]. Internet of Things glucose monitoring devices eliminate the need for professionals to keep manual records of blood sugar levels, and the devices may help alert patients when their sugar levels are problematic [11]. However, designing a small device that ensures continuous monitoring without causing discomfort to patients is a challenge. It would also be necessary to develop a device that uses less electricity and does not require frequent recharging. Solutions to these problems would significantly alter how patients monitor their glucose levels.

Significantly, heart rate monitoring presents some difficulties for professionals, and it is difficult to monitor patients even when they are in hospitals. Periodic heart rate monitoring is ineffective in preventing significant fluctuations, which could lead to poor patient outcomes. Significantly, traditional devices for monitoring heart rate in healthcare facilities would require individuals to be regularly connected to wired machines, affecting patient movement. IoT has changed this situation, allowing for more accurate and timely cardiac monitoring for patients [29]. With IoT, various small devices for heart rate monitoring that can take heartbeat rate are designed. It allows the patient to move freely and ensures that their heart rates are constantly monitored. [21]. The accuracy of modern machines for heart rate monitoring is about ninety percent [30]. IoT remains a reliable method of continuously monitoring patients' cardiac activity. According to [26] an IoT system could be used to monitor and predict heat disease situations, improving management and outcomes.

In particular, infection control has been a major issue in many healthcare facilities. There hasn't been a good way to check if patients and providers in a hospital have washed their hands correctly. Essentially, this has increased the number of healthcare-associated infections. However, IoT is being used to address this issue, which could help improve patient outcomes. Many healthcare facilities use IoT devices to remind professionals and patients to wash their hands before entering different hospital rooms. [27]. These devices may provide information on the best methods of sanitization to manage

a specific risk for a specific patient. [11]. These devices have the potential to significantly reduce infection rates in healthcare facilities. However, these IoT devices will not sanitize the patient's hands and will only serve to remind people when and how to clean their hands.

It has traditionally been difficult to collect patients' mood and depression symptoms on a continuous basis. Professionals, in particular, would assess patients on a regular basis, but this cannot predict sudden mood changes, and in some cases, individuals fail to report their symptoms correctly. It is possible to address these issues and improve the monitoring of mood and depression symptoms using IoT devices. [19]. These Internet of Things devices will collect and analyze blood pressure and heart rate data, which will indicate the patient's mental status. The movement of the patient's eyes can be tracked by some devices. [31]. However, as with other traditional face-to-face assessments, the accuracy of IoT may not be complete. This technology is still a fundamental approach to improving the diagnosis and management of mental health issues.

The effective monitoring enabled by IoT has aided in the management of neurological diseases. Assessing symptoms and their severity, for example, is critical for Parkinson's disease management. Patients must be aware of how their symptoms change throughout the day and adjust their treatments accordingly. It is possible to collect disease data continuously using IoT devices [13]. The wearable sensors collect information on symptoms, allowing patients to go about their daily lives without spending the majority of their time in healthcare facilities for assessment and observation [11] [23]. Therefore, the internet of things would aid in ensuring that patients receive appropriate and adequate care at the appropriate time.

Furthermore, the Internet of Things has aided in the development of telemedicine, which has aided in the transformation of healthcare. Remote monitoring is an important component of telemedicine, and IoT makes it possible. Healthcare professionals can remotely monitor vital signs, allowing them to provide patients with timely and effective care. [17]. Furthermore, real-time interactive devices are important in telemedicine because they ensure that the patient's vital information is effectively and timely monitored for better health management. IoT-enabled devices help with patient data monitoring and access, allowing professionals to obtain health reports on a continuous basis and facilitating better and more efficient outcomes.

All of the examples above show that the Internet of Things has been a critical development that has aided in the transformation of the healthcare sector. It has aided in the monitoring and assessment of patients using electronic and internet-enabled devices, as well as the instant sharing of information. Continuous assessment and information sharing have been critical, allowing for better care than could have been provided through traditional means. It has been possible to improve care delivery, which will help patients' health and quality of life.

VI. THE IMPACT OF IOT ON HUMAN HEALTH CARE

In the various studies analyzed, the value and impact of IoT are significant in healthcare. Implementing IoT products in this industry has helped redefine healthcare. It has opened various opportunities in this sector, and they have assisted in transforming healthcare provision to patients. It has better care management and has improved specific healthcare aspects [14]. For instance, the ability to meet and assess patients remotely can reduce the cost of in-person visits [31-33]. Furthermore, the introduction of home care devices has allowed many patients to be hospitalized and monitored at home. When such cases are reduced, the cost of care is significantly reduced [14]. Patients can put the money they save towards other activities that will benefit their health and the health of their families.

The other impact of IoT is improved treatment for patients, which positively affects their lives. Because the monitoring is consistent, continuous, and automated, all data is stored in the cloud and sent to the doctor on a regular basis; the treatment processes were followed correctly. Adopting this strategy can ensure that medical care is available as soon as possible to assess the recovery process [34]. This ensures that healthcare professionals have complete and accurate information about their patients' health conditions [34]. Consequently, these professionals can make informed decisions concerning patient conditions and the needed treatment. It improves the treatment process and enhances patient outcomes and wellness]14]. Timely and accurate interventions partly explain these positive outcomes.

Additionally, The Internet of Things has had an impact on the healthcare sector by allowing for more accurate and timely diagnoses. IoT enables physicians and nursing professionals to continuously monitor patients and provide real-time data on health situations. [14]. It enables healthcare providers to detect and diagnose health issues at an early stage. It is possible to detect the condition before the disease and its complications manifest. As a result, it would aid in the implementation of timely interventions to address health issues. Hence, detailed and precise data collected automatically and without human error can significantly reduce the rate of medical errors and the financial and critical costs associated with them [35] [36].

Furthermore, the use of IoT in the healthcare sector has enabled proactive treatment. Notably, proactive

treatment entails putting in place interventions that prevent specific diseases from occurring. Because of continuous health assessment and monitoring, physicians and nursing professionals can use this treatment approach [37]. It is possible to identify some signs that could indicate the risk of the patient developing some health problems. Thus, the healthcare provider will put those strategies in place to prevent disease development in the future.

Another impact of IoT in the healthcare sector has been improved drug and equipment management. Drug management is an important area in the healthcare industry where IoT technology is making a difference by effectively solving high-cost problems in drug development as well as drug storage and preservation [20]. IoT helps patients use drugs more precisely while also assisting pharmacies and healthcare facilities in reducing drug waste [38][39]. It helps reduce the costs associated with drugs and medical equipment and improves the organization's performance.

The use of IoT has reduced errors in the healthcare sector, allowing for better outcomes. IoT devices contribute to the generation of data that enables better and more effective decision-making. Significantly, the information gathered allows for smooth operations in the healthcare sector. The smooth operation will aid in the reduction of waste, system costs, and errors [12]. In essence, this would help the healthcare organization provide better patient care while also lowering costs. Hence, implementing the Internet of Things in healthcare organizations would be critical. Healthcare charting has been another impact of IoT on healthcare [25]. This element is automated by technology, and professional work is reduced. This method has made data analysis more efficient and quicker [25]. Furthermore, IoT has provided significant assistance for mobile emergencies through improved tracking and notification. To end with this, some factors, such as a focus on the patient's needs, data accuracy, timely treatment, cost savings, fewer repeat visits, recording of the recovery process, and, most importantly, the patient's active participation in the treatment process, have a positive impact on the patient [38].

VII. POTENTIAL CHALLENGES OF IOT UTILIZATION ON HEALTH CARE SYSTEM

One of the most difficult aspects of implementing the IoT is communication; while many devices now have sensors to collect data, they frequently communicate with the server in their native language. Manufacturers each have their own proprietary protocols, which means sensors from different manufacturers may not be able to communicate with one another. This fragmented software

environment, combined with privacy concerns and the bureaucratic tendency to hoard all collected data, frequently isolates valuable information on data islands, undermining the entire IoT concept [23]. Integration of multiple devices and protocols: Another challenge for the success of IoT in health care is the diversity of devices involved in networks. It is difficult to ensure that multiple devices are connected to each other and that multiple users communicate effectively with one another. The problem is that many device manufacturers do not adhere to a common set of communication protocols and standards. Although a variety of mobile devices can be connected to the network and actively collect data, the aggregation process is complicated by different communication protocols [40]. Another challenge is security, which entails managing credentials and controlling access to patient requests and confidential information. Health care providers, for example, are granted access to devices in response to demand from the patient's sensor devices, but the Internet connection used may be a public or unstable Wi-Fi network that is easily man-in-the-middle. Many authentication techniques could be implemented so that patients can verify and authorize physicians to access their internal devices [29]. Another challenge is the complexity of data collected from wearable devices and sensors. When the rate of data generation increases, so does the complexity. The implemented system must prepare for the data complexity challenge by emphasizing fog computing layers to increase computing power and leveraging resources with efficient data preprocessing and data analysis algorithms[20]. Furthermore, IoT-based devices face numerous challenges, including data discontinuity, unknown regions, and large amounts of data transmission [41]. It generally causes some errors when transmitting data over a network. The most common problems are bit errors and packet drops. The majority of data in the healthcare sector is generated by IoT devices, which is critical for patient diagnosis. Making a proper diagnosis is impossible due to data loss, which may also pose a problem for emergency treatment. As a result, it is necessary to use fewer network transmissions while maintaining service quality [42]. The growing aging population has created numerous challenges in healthcare delivery. For example, after-stroke rehabilitation for the elderly is a new challenge that will necessitate a long-term commitment of medical and human resources [5].

In addition, the costs of developing and implementing IoT technology and devices are high [43]. Nonetheless, a cost-benefit analysis shows that IoT implementation is financially feasible.

Another challenge for this technology is a lack of IoT training and education among professionals [25] & figure 2 expresses the IoT challenges in health monitoring system. Furthermore, there are issues with regular updates,

as well as some legal challenges related to this issue [25]. All of these obstacles would reduce the extent to which
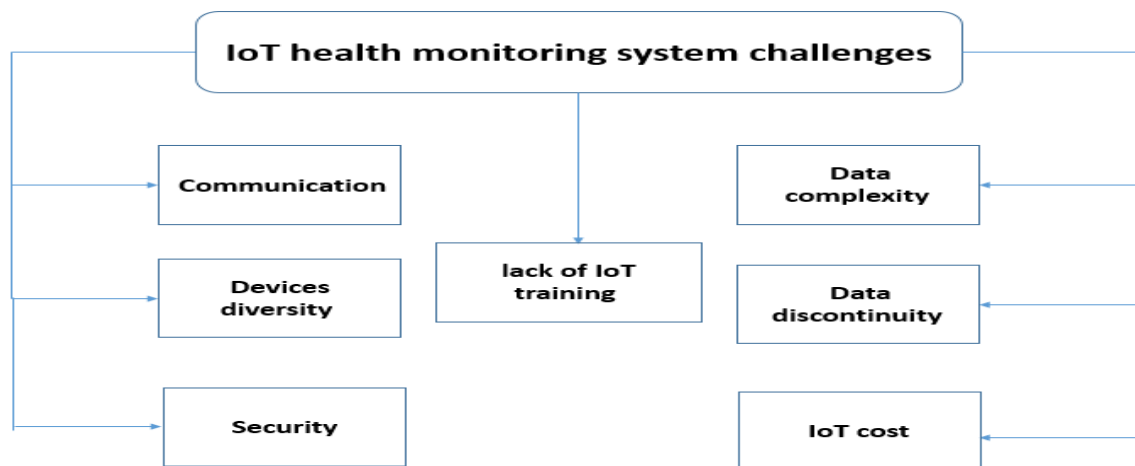
IoT achieves the appropriate and intended outcomes.

Figure 2: IoT health monitoring system challenges

VIII. CONCLUSION

The Internet of Things (IoT) is critical in the healthcare sector because it enables better and more efficient delivery of healthcare services. This has resulted in significant advancements in patient monitoring, in particular. In the healthcare sector, IoT has enabled remote patient monitoring and telemedicine. Healthcare professionals can collect data on a variety of health situations while also promoting patient wellness and health outcomes [14]. Heart rate monitoring, glucose monitoring, mental health monitoring, and hand hygiene promotion are all important components of health monitoring. The implementation of these strategies would ensure that specific effects are realized in the healthcare sector. It has the potential to lower costs, improve treatment, reduce errors, and provide timely and accurate diagnoses. It increases efficiency while also improving patient outcomes. However, IoT raises some concerns, including privacy and security concerns. There are also difficulties in integrating it with existing technologies. All of these issues must be addressed in order to improve IoT implementation and achieve the desired results.

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