

A Review of IoT and Artificial Intelligence–Based Remote Healthcare Monitoring Systems for Predictive Patient Care

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ABSTRACT

The rapid evolution of digital technologies has significantly transformed healthcare systems worldwide. The integration of the Internet of Things (IoT) and Artificial Intelligence (AI) has enabled the development of remote monitoring and predictive analysis frameworks that enhance patient care and clinical efficiency. IoT-enabled wearable devices and smart medical sensors continuously collect real-time physiological data, which is securely transmitted to healthcare providers for monitoring and assessment. AI-based machine learning and deep learning models analyze this data to detect anomalies, predict disease progression, and support early clinical interventions. This data-driven approach facilitates proactive healthcare management, reduces hospital readmissions, and optimizes resource utilization. Remote monitoring systems are particularly beneficial for managing chronic diseases, post-operative recovery, and elderly care. Despite challenges related to data privacy, interoperability, and cybersecurity, IoT–AI integration holds significant potential for advancing patient-centric and value-based healthcare delivery.

Keywords: *Internet of Things (IoT), Artificial Intelligence (AI), Remote Patient Monitoring, Predictive Analytics.*

1. Introduction

The rapid advancement of digital technologies has fundamentally transformed the global healthcare ecosystem. Among the most influential innovations are the Internet of Things (IoT) and Artificial Intelligence (AI), whose integration has paved the way for intelligent, data-driven healthcare solutions. One of the most impactful applications emerging from this convergence is remote monitoring combined with predictive analysis. This approach enables continuous patient observation beyond traditional clinical environments while leveraging advanced analytics to forecast potential health risks, thereby shifting healthcare delivery from reactive treatment to proactive prevention. Remote monitoring systems utilize IoT-enabled devices such as wearable sensors, smart medical equipment, and connected diagnostic tools to collect real-time physiological data. Parameters including heart rate, blood pressure, oxygen saturation, glucose levels, temperature, and physical activity are continuously recorded and transmitted securely to healthcare providers via cloud-based platforms. This uninterrupted data flow enhances clinical visibility, allowing physicians to monitor patients with chronic diseases, post-surgical recovery needs, or age-related vulnerabilities without requiring frequent hospital visits. Such systems are particularly valuable in managing conditions like diabetes, cardiovascular disorders, and respiratory illnesses [1-4].

The integration of AI significantly enhances the capabilities of remote monitoring infrastructures. AI algorithms, particularly those based on machine learning and deep learning techniques, analyze vast volumes of structured and unstructured health data with remarkable speed and precision. These intelligent models identify hidden patterns, detect anomalies in vital signs, and predict potential complications before

they escalate into critical emergencies. For example, subtle variations in heart rhythm data may signal the early onset of arrhythmia, while irregular glucose patterns may indicate impending diabetic complications. Through enabling early detection, AI-powered predictive systems support timely clinical interventions and personalized treatment planning [5-9]. Predictive analysis forms the analytical backbone of this technological ecosystem. Through leveraging historical medical records, demographic data, lifestyle indicators, and real-time sensor inputs, predictive models can estimate disease progression, hospital readmission risks, medication non-adherence, and mortality probabilities. Such insights empower healthcare professionals to allocate resources efficiently, design preventive care strategies, and optimize treatment pathways. Furthermore, predictive systems contribute to value-based care models, emphasizing patient outcomes, cost reduction, and long-term wellness rather than episodic treatment.

Beyond individual patient benefits, the IoT-AI framework strengthens healthcare system resilience. During global health crises such as pandemics, remote monitoring reduces physical hospital visits, minimizes infection risks, and alleviates healthcare facility burdens. Additionally, aggregated data analytics at the population level assist policymakers in identifying public health trends and managing resource distribution effectively. Despite its transformative potential, this integration raises important challenges related to cybersecurity, interoperability, ethical governance, and data privacy. Sensitive patient information must be protected through robust encryption, standardized protocols, and compliance with healthcare regulations. Ensuring transparency, fairness, and explainability in AI models remains essential for building trust among clinicians and patients. Overall, the convergence of IoT and AI represents a paradigm shift toward intelligent, predictive, and patient-centric healthcare. Through combining continuous monitoring with advanced analytics, healthcare systems are evolving into proactive ecosystems capable of delivering personalized, efficient, and high-quality medical care [10-13].

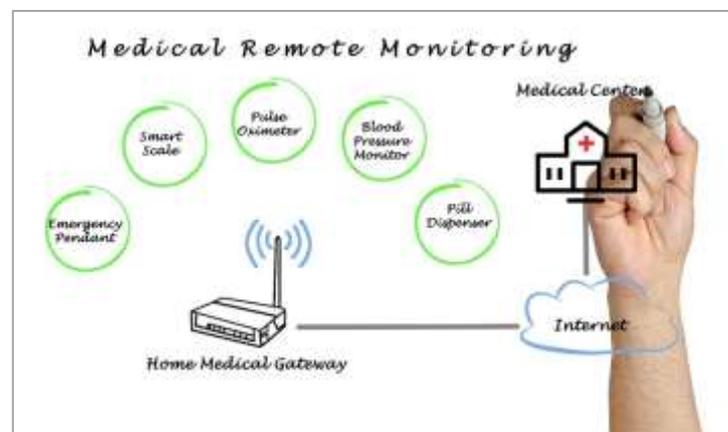


Fig 1: Architecture of IoT and AI-Based Remote Monitoring System

2. Literature Review

Sivalingam, S. M., & Thisin, S. (2024). had highlighted that intelligent automated approaches were increasingly transforming healthcare practices. Learning-based concepts had been recognized as pivotal for tasks such as interpreting acquired data and monitoring patient behaviour. Among patient-centric concerns, researchers had identified challenges related to data heterogeneity, extraction, and prediction. Efforts had been made to enhance patient monitoring using care indicators such as cost and length of stay in healthcare centers; however, AI-based predictive models had remained limited. In response, this research had proposed an AI- and Internet of Things (IoT)-integrated automated approach with smart sensors, termed the "PatientE" framework, designed to handle heterogeneous patient data. The framework had employed rule-based data extraction for distinct representation and had integrated pre-treatment information with a modified combination of Random Forest, Long Short-Term Memory (LSTM), and

Bidirectional LSTM (BiLSTM) algorithms for predictive post-treatment monitoring. The framework had aimed to facilitate real-time health monitoring, particularly for breast cancer patients, encompassing pre-treatment, in-treatment, and post-treatment phases, while improving diagnostic accuracy, cost-efficiency, and length-of-stay management. Evaluations had demonstrated its scalability, reliability, and overall effectiveness in transforming healthcare practices.

Kanakaprabha, S., Kumar, G. G., Reddy, B. P., Raju, Y. R., & Rai, P. C. M. (2024). had shown that the integration of wearable devices, big data, and artificial intelligence (AI) had significantly transformed remote patient care and health monitoring. These technologies had enabled the continuous and real-time collection of physiological and behavioural data from individuals, allowing healthcare providers to remotely assess health status. Wearable devices, including smartwatches, fitness trackers, and medical sensors, had facilitated tracking of vital signs, physical activity, and sleep patterns. The large volume of data generated, often referred to as big data, had posed both challenges and opportunities. AI had played a critical role in analyzing this data through advanced algorithms, pattern recognition, and predictive modeling. This synergy between wearable devices, big data, and AI had empowered patients to engage in self-management while supporting healthcare professionals in making informed decisions, detecting anomalies, and providing timely interventions. Collectively, these approaches had contributed to early detection of health issues and improved patient outcomes.

Mohapatra, S., Sahoo, A., Mohanty, S., & Singh, D. (2023). had highlighted its multifaceted impact, particularly within the healthcare sector, prompting a shift from traditional in-person care to remote healthcare systems. Studies had demonstrated that leveraging modern technological paradigms, including artificial intelligence (AI), cloud computing, feature learning, and the Internet of Things (IoT), had made remote healthcare increasingly feasible. Research had proposed practical frameworks integrating hardware development and predictive analytics to enable effective patient monitoring. Multiple hardware modules had been developed to collect sensor-acquired data, which were then processed using machine learning models deployed in the cloud. Prior studies had shown that this approach facilitated the generation of detailed analytics from the essential and fundamental patient data, which could then be communicated to relevant medical personnel for timely decision-making. These findings had underscored the potential of technology-driven remote healthcare systems to enhance patient monitoring, reduce response delays, and improve the overall efficiency of healthcare delivery.

SNIGDHA, E. Z., HOSSAIN, M. R., & MAHABUB, S. (2023). had indicated that advances in artificial intelligence (AI) and data analytics had significantly transformed healthcare by enabling predictive insights and enhancing clinical decision-making through real-time patient monitoring. Researchers had developed AI-driven healthcare trackers that collected, analyzed, and interpreted patient data to support proactive care. These systems had integrated wearable sensors, electronic health records, and cloud computing to provide personalized recommendations and real-time health updates. The trackers had employed feature engineering, automated data cleaning, and augmentation to ensure data reliability, while predictive modeling had been used to detect patterns, anticipate health risks, and support early interventions. Experimental findings had shown that such AI-based systems improved diagnostic accuracy, patient engagement, and clinical efficiency compared to traditional monitoring approaches. Studies had also reported enhanced anomaly detection, disease prediction, and tailored healthcare guidance. Subsequent research had focused on deep learning models and real-time AI decision support to further improve predictive accuracy and patient outcomes.

Ch, R., Sudheer, P., & Kumar, P. D. (2023). had shown that the convergence of modern technologies such as 5G, the Internet of Things (IoT), and artificial intelligence (AI) had created unprecedented opportunities for innovative solutions. Several IoT-based applications had emerged, particularly in healthcare, enabling the development of eHealth and mHealth solutions for ambient assisted living (AAL). Researchers had highlighted practical challenges in healthcare systems, including service delays and high costs, which had sometimes resulted in serious consequences, such as untimely fatalities from cardiac events. To address these issues, real-time patient monitoring and prompt intervention had been emphasized as critical requirements. Studies had demonstrated that IoT-enabled wearable devices, such as biosensors, had facilitated remote patient monitoring (RPM) systems, allowing vital signs to be transmitted to clinicians in real time. These systems had been reported to reduce treatment delays, lower healthcare costs, improve patient quality of life, and enhance healthcare service efficiency, while also identifying gaps for future research and development.

Alshamrani (2022) stated that in 2022, the Internet of Things (IoT) and artificial intelligence (AI) were two of the fastest-growing technologies in the world. With more people having moved to cities, the concept of a smart city was not foreign. The idea of a smart city was based on transforming the healthcare sector by increasing its efficiency, lowering costs, and putting the focus back on a better patient care system. Implementing IoT and AI for remote healthcare monitoring (RHM) systems required a deep understanding of different frameworks in smart cities. These frameworks occurred in the form of underlying technologies, devices, systems, models, designs, use cases, and applications. The IoT-based RHM system mainly employed both AI and machine learning (ML) by gathering different records and datasets. On the other hand, ML methods were broadly used to create analytic representations and were incorporated into clinical decision support systems and diverse healthcare service forms. After carefully examining each factor in clinical decision support systems, a unique treatment, lifestyle advice, and care strategy were proposed to patients. The technology used helped to support healthcare applications and analyse activities, body temperature, heart rate, blood glucose, etcetera. Keeping this in mind, the paper provided a survey that focused on the identification of the most relevant health Internet of Things (H-IoT) applications supported by smart city infrastructure. This study also evaluated related technologies and systems for RHM services by understanding the most pertinent monitoring applications based on several models with different corresponding IoT-based sensors. Finally, the research contributed to scientific knowledge by highlighting the main limitations of the topic and recommending possible opportunities in this research area.

Kishor & Chakraborty (2022) mentioned that Artificial Intelligence (AI) was widely implemented in healthcare 4.0 for producing early and accurate results in 2022. The early predictions of disease helped doctors make early decisions to save the life of patients. Internet of things (IoT) was working as a catalyst to enhance the power of AI applications in healthcare. The patients' data were captured by IoT-sensor, and analysis of the patient data was performed by machine learning techniques. The main aim of the work was to propose a Machine learning-based healthcare model to early and accurately predict different diseases. In this work, seven machine learning classification algorithms such as decision tree, support vector machine, Naïve Bayes, adaptive boosting, Random Forest (RF), artificial neural network, and K-nearest neighbour were used to predict the nine fatal diseases such as heart disease, diabetics breast cancer, hepatitis, liver disorder, dermatology, surgery data, thyroid, and spect heart. To evaluate the performance of the proposed model, four performance metrics (such as accuracy, sensitivity, specificity, and area under the curve) were used. The RF classifier observed the maximum accuracy of 97.62%, sensitivity of 99.67%, specificity of 97.81%, and AUC of 99.32% for different diseases. The developed healthcare model would help doctors diagnose the disease early.

Sujith et al. (2022) noted that in the rapidly growing world of technology and evolution, the outbreak and emergences diseases had become a critical issue. Precaution, prevention, and controlling the diseases by technology had become the major challenge for healthcare professionals and health care industries. Maintaining a healthy lifestyle had become impossible in the busy work schedules. Smart health monitoring system was the solution to the above poses challenges. The recent revolution of industry 5.0 and 5G had led to the development of smart cum cost-effective sensors which helped in real-time health monitoring of individuals. The SHM had led to fast, cost-effective, and reliable health monitoring services from remote locations which were not possible with traditional health care systems. The integration of blockchain framework improved data security and data privacy of confidential data of patients to prevent the data misuse against patients. Involvement of Deep Learning and Machine learning to analyse health data to achieve multiple targets had helped attain preventive healthcare and fatality management in patients. This had helped in the early detection of chronic diseases which was not possible recently. To make the services more cost-effective and real-time, the integration of cloud computing and cloud storage had been implemented. The work presented the systematic review of SHM along with recent advancements in SHM with existing challenges.

Arulkumar et al. (2022) mentioned that a whole host of apps now used IoT (Internet of Things). Smart car parks, smart homes, intelligent cities, smart environments, manufacturing areas, agricultural fields, and health management processes were all implementations of the IoT. In healthcare, such an application made medical instruments more successful by allowing patient health tracking in real-time to capture patient data and minimize human error. In this manner, patient health surveillance was tracked over the IoT. Health IoT was the solution for integrated real-time surveillance of people with psychiatric disabilities at low costs and traffic between the results of patients and the diagnosis of diseases. They had seen the health tracking system that gathered simple parameters including heart rate, temperature, blood pressure, and growth parameters up to now. They addressed in this study the control of the brain waves of the patient and the real-time detection of patient condition. They used a mobile headset that dealt with EEG technology to gather data from brain signals. The performance effect indicated the pattern of the waveform. The key objective was to provide optimized benefit to patients with mental disabilities in this proposed project by collecting data from brain signals with 24 channels.

Motwani et al. (2021) aimed to propose a smart predictive healthcare framework for patients suffering from chronic diseases and were under observation at home. To appropriately predict the patient's actual health status and for better recommendation and assistive services, the framework utilized a novel Deep Learning (DL) model. The DL model utilized the big data of patients' vital signs, context data such as activity, medication, and symptoms collected through Ambient Assisted Living (AAL) systems. They applied a DL model with novel cost optimization for categorical prediction. The model was a component part of the Intelligent Module at the patient's end. The experimental study was carried out on patients suffering from Chronic Blood Pressure (BP) disorders. The imbalanced dataset collected over a period of 1 year and sampled every 15 min. The highest overall accuracy achieved for the proposed model was 99.97%, which was up to 8.8% better than one of the existing models. F-score for emergency cases had been enhanced by 12%, 39%, and 12% for Hypertensive, Hypotensive, and Normotensive patients', respectively. The experimental outcomes revealed that the proposed model could predict patients' conditions (emergency, warning, alert, and normal) with more accuracy. Also, their model could handle imbalanced big data, high variability of vital signs, and all kinds of BP patients. Thus, they considered that the proposed framework was valuable for the management of chronic diseases.

Jeddi & Bohr (2020) stated that telehealth and remote patient monitoring had expanded the reach of traditional clinical practice by removing geographical barriers as well as clinical limitations. Would this lead to increased value in healthcare? Were clinical outcomes going to improve alongside the delivery of better patient experiences? Would technology make the delivery of healthcare more sustainable? Despite most of them feeling like they could not work, live, or play without their mobile phones, they had only been in existence (as they knew them today) for the last 20 years. However, the continuous advancement of technology and capability had affected healthcare and brought medicine, first into their homes and increasingly into their pockets. The future of telehealth fit into a consumer world that expected high quality, instant access, and personalized health propositions. As the demand for personalized medicine rose, more devices were released to capture vital signs, well-being metrics, and background data. In the clinical setting, this could allow real-time monitoring and pre-emptive doctor/patient interactions to prevent adverse incidents. At the very least, these developments offered the chance for richer and better-informed clinical decisions to be made based on longitudinal metrics. None of this was happening in isolation, and in fact, some of the biggest companies in the world (e.g., Apple) had made their intent clear with devices such as watches which had engaged people to perform remote monitoring even when they were not “patients.” This combined with the increasing number of health apps (325,000 in 2017) was changing the way people engaged with their health and interacted with clinicians. It was expected that telehealth and wearable technology allowing remote monitoring would continue to play an increasingly significant role in almost all future healthcare delivery models from prevention to recovery and everything in-between.

Muthu et al. (2020) conveyed that human with good health condition was somewhat more difficult in today’s life because of changing food habits and the environment. So there was a need for awareness about the health condition to survival. The health-support systems faced significant challenges like a lack of adequate medical information, preventable errors, data threat, misdiagnosis, and delayed transmission. To overcome this problem, they proposed a wearable sensor connected to the Internet of Things (IoT) based big data, i.e., data mining analysis in healthcare. Moreover, they designed Generalize approximate Reasoning base Intelligence Control (GARIC) with regression rules to gather information about the patient from the IoT. Finally, they trained the data to the Artificial intelligence (AI) with the use of deep learning mechanism Boltzmann belief network. Subsequently, Regularization Genome-wide association study (GWAS) was used to predict the diseases. Thus, if people were affected by some diseases, they would get a warning by SMS, emails, etc. After that, they got some treatments and advisory from the doctors.

Gupta et al. (2018) observed that today, as they could see, the population of the country was increasing at a very fast rate, despite their various efforts. The hospitals and medical services available for the rising population were very low. There were still many areas in their country which did not have proper medical help available. But, during these past years, there had been a huge rise in the data service providers, which had provided huge support for the Internet of Things. Hence from the support of the IoT technology, remote and rural areas could also be provided with proper health services. In most of the researches which were done on the topic, there were many loopholes like no machine learning was implemented, sensors were not secured over the network, etc. Some of these issues had been addressed in this paper with results output of the system. Further, the paper proposed a model based on the integration of machine learning with the current system to predict future diseases in the patient or that remote area.

3. Existing Methodology

S. No.	Author(s) [Year]	Proposed Work	Methodology	Conclusion
1	Alshamrani (2022)	IoT and AI for smart city healthcare transformation	Understanding frameworks, IoT-based RHM system, AI, and ML integration	Contribution to scientific knowledge, identification of health IoT applications in smart cities
2	Kishor & Chakraborty (2022)	ML-based healthcare model for early disease prediction	ML classification algorithms, IoT_sensor data analysis	Improved disease diagnosis with high accuracy using RF classifier
3	Sujith et al. (2022)	Smart health monitoring system for real-time health monitoring	Integration of 5G, blockchain, Deep Learning, and Machine Learning	Early detection of chronic diseases, cost-effective health monitoring services
4	Motwani et al. (2021)	Smart predictive healthcare framework for chronic diseases	Utilization of DL model, big data analysis, AAL systems	High accuracy in predicting patient conditions, valuable for chronic disease management
5	Arulkumar et al. (2022)	Health IoT for real-time surveillance of psychiatric patients	Brain wave control using mobile headset with EEG technology	Optimized benefit to mental health patients through real-time data collection
6	Jeddi & Bohr (2020)	Impact of telehealth and remote patient monitoring on healthcare	Integration of technology for real-time monitoring, preemptive interactions	Changing dynamics of healthcare delivery with remote monitoring and technology
7	Muthu et al. (2020)	IoT-based wearable sensor for health awareness	GARIC with regression rules, deep learning, GWAS for disease prediction	Early disease detection through wearable sensors connected to IoT
8	Gupta et al. (2018)	IoT support for healthcare in remote and rural areas	Integration of machine learning for disease prediction	Bridging healthcare gaps in remote areas through IoT technology

4. Conclusion

The integration of the Internet of Things (IoT) and Artificial Intelligence (AI) has emerged as a powerful catalyst for transforming modern healthcare through remote monitoring and predictive analysis. Evidence from recent literature shows that IoT-enabled wearable sensors and smart medical devices support continuous collection of real-time physiological data, enabling clinicians to monitor patients beyond hospital environments and improve chronic disease management. When combined with AI-driven analytics, these systems move healthcare from reactive intervention to proactive prevention by detecting anomalies early, forecasting disease progression, and supporting personalized treatment planning. Studies reviewed highlight the effectiveness of machine learning and deep learning models such as Random

Forest, LSTM/BiLSTM, and other predictive frameworks in improving diagnostic accuracy, reducing delays in clinical response, and optimizing resources such as hospital stay, cost, and follow-up workload. In addition, telehealth platforms enhanced by IoT–AI integration improve access to care, especially during public health crises, while supporting patient engagement and home-based management. Overall, IoT–AI-enabled remote monitoring and predictive healthcare represent a significant advancement toward patient-centric, data-driven, and value-based healthcare systems, with strong potential to improve outcomes, efficiency, and accessibility in the near future.

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