SECURE HEALTHCARE MONITORING WITH INTEGRATED IOT – A REVIEW

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Abstract

Healthcare monitoring systems have changed significantly due to IoT integration because patients can get these benefits: real-time data collection, remote health information access and intelligent decision support. This paper reviewed about IoT healthcare monitoring literature by analysing major challenges and new technologies and discussing actual system deployment. Researchers examine essential challenges related to data interoperability together with cybersecurity issues for power efficiency and system scalability, which impact both reliability and deployment success rates of these systems. The review examines how artificial intelligence, together with blockchain and fog computing, and virtual platforms, boosts the performance and security aspects of IoT-based healthcare solutions. The deployment of IoT in healthcare needs standardized methods that combine legislative measures alongside convenient designs to ensure sustainable use in different healthcare settings, according to recent research findings. Research, practitioner and policy entities find valuable guidance in this paper to establish IoT healthcare systems that exhibit resilience and security alongside accessibility.

Keywords: Healthcare Monitoring, Internet of Things (IoT), Security, Artificial Intelligence, Deep Learning, Real-time Data

1. Introduction

Recently, technological progress together with a focus on preventive healthcare practices have accelerated the advancements in healthcare monitoring throughout extended period [1]. Healthcare monitoring through IoT shows growing momentum because of statistics supporting its effect. The global IoT in healthcare market holds a forecast by MarketsandMarkets indicating a value growth prediction from $127.7 billion in 2023 to reach $289.2 billion by 2028 with a compound annual growth rate (CAGR) of 17.8% [2]. Wearable devices remain crucial to IoT healthcare implementation since Statista reports there are now 1.1 billion such devices in global use during 2022. The real-time vital sign monitoring capability of these devices helps achieve a reduction of 20% in hospital readmissions and produces better results for patients [3]. The IoT for remote patient monitoring results in lower chronic disease hospitalizations by 38% as well as 25% fewer emergency room visits for patients under treatment. The mass-produced wearable technology market that includes fitness trackers and smartwatches makes possible uninterrupted observation of vital signs including heart rate and oxygen levels and sleep patterns. Chronic disease patient monitoring became possible through telemedicine after the COVID-19 pandemic made this technology more common [4]. Healthcare systems benefit from artificial intelligence together with data analytics because they boost both early warning detection capabilities and personalized treatments and enhanced patient results [5].

The application of IoT (Internet of Things) technology in healthcare tracking and medical management has transformed the approach to patient health monitoring [6]. Smart IoT devices with wearable health monitors and connected medical equipment and smart sensors enable the monitoring and transmission of vital signs which includes blood pressure and glucose levels and ECG [7]. The constant flow of healthcare data enables medical professionals to reach appropriate conclusions while identifying early signs of disease so they can perform prompt interventions [8]. IoT technology enables remote monitoring of patients that eliminates regular hospital visits and allows medical staff to provide superior healthcare to senior citizens and patients who need extended treatment [9]. Joint operation between cloud-based technologies and artificial intelligence makes IoT healthcare solutions more precise and personalized while delivering better treatment outcomes to patients [10 -13].

The implementation of IoT healthcare monitoring runs into various substantial difficulties. The continuous network exchange of health-related sensitive data exposes healthcare systems to privacy breaches while exposing them to cyberattacks from unauthorized users [14]. The requirements of HIPAA together with GDPR regulations present essential needs that healthcare organizations find complicated to meet [15]. The main obstacle in IoT healthcare is the incompatibility between unique IoT devices and healthcare systems that operate with different communication standards which makes data cross platform connections extremely challenging. IoT devices demonstrate inconsistent reliability which results in either improper health information or safety warnings [16]. The continuous operation of wearable devices depends on their power usage and battery capacity thus affecting their suitability for extended surveillance tasks. Strong barriers to widescale adoption emerge from high installation fees and absent rural infrastructure and patients' and healthcare workers' insufficient digital competency [17]. Several vital problems must be solved when using IoT for healthcare monitoring. The continuous harvesting and sharing of personal health data exposes protection concerns because hackers can potentially breach these systems. The integration of IoT with existing healthcare systems faces challenges because different devices and platforms operate with inconsistent standards and lack interoperability capabilities [18]. The medical unreliability and imprecise readings of various IoT devices may result in the incorrect diagnosis of patients and delayed appropriate medical care [19]. Contemporary healthcare monitoring suffers from connection problems when patients reside in locations with insufficient web infrastructure [20 -23]. Scientists and ethicists remain in discussions about the ethical aspects of ongoing health surveillance because both consent issues and ownership of collected data need clarification [24]. The growing concerns about security and safety in IoT healthcare highlight the necessity of implementing enhanced protection standards and regulatory frameworks and device quality requirements to create secure IoT applications for healthcare [25].

This paper reviewed the medical information by demonstrating how IoT healthcare monitoring systems have evolved and their present difficulties. Recent studies have been integrated into a single analysis explaining how IoT technology advances healthcare delivery devices while showing why it fails to gain universal acceptance. This paper divides healthcare IoT challenges into five categories, which show the present barriers IoT faces in medical settings through an organized system. The paper highlights the emerging significance of AI together with blockchain fog computing and smart sensors for resolving these issues. This review bridges the gap between current knowledge and points out future research prospects which provides beneficial information to all stakeholders involved in designing secure user-focused healthcare monitoring solutions embracing IoT technology.

2. IoT Healthcare Monitoring

The modern medical system experienced transformation through IoT healthcare monitoring which improved patient management, especially for those suffering from chronic diseases. The research by Talpur et al. (2024) shows IoT-enabled tracking methods create an extensive plan to monitor chronic diseases by maintaining continuous accurate medical data that aids in early detection and swift medical responses. Deep learning plays a central role in improving IoT system analysis and prediction through integration according to the research by Wu et al. (2023). The implementation of IoT-based systems enables nonstop patient surveillance which helps decrease hospital workload and enhances healthcare operational efficiency (Sangeethalakshmi et al. 2023). The authors of Singh and Kaunert (2024) analyzed how 5G and IoT during that period contribute to next-generation health systems alongside the necessary legal infrastructure for emerging technologies. The researchers from Vellela et al. (2023) designed a cloud-based IoT platform that enables efficient processing of large healthcare monitoring data. The researchers Irshad et al. (2023) created AI-enabled IoT frameworks which leverage advanced algorithms to identify lung cancer in its initial stages. Through their work Alshammari (2023) showed how MQTT supports efficient data communication in IoT health networks along with Praveen et al. (2023) who explained how IoT connects with Industry 4.0 for virtual hospital system data analysis. The collection of real-time health metrics through wearable devices forms a major role according to Arunkumar et al. (2023) which promotes medicine toward more proactive preventive care. The research from Li et al. (2024) presented an extensive survey of IoT healthcare applications to demonstrate its extensive capabilities in multiple healthcare sections. Mao et al. (2023) investigated sensor systems made flexible for intelligent healthcare monitoring systems which were expanded toward virtual reality environments. Scientists from Cheikhrouhou et al. (2023) formulated blockchain and fog computing security measures that provide protected and trustworthy remote monitoring systems. These research works showcase how IoT transforms healthcare by developing systems which are smarter together with more connected and have higher response capabilities.

New advancements in IoT healthcare applications now address medication security needs as well as pandemic management together with stronger system protections. Selvarasu et al. (2023) established an IoT-connected system to conduct live medication storage and temperature screening in hospitals which protected drug properties while decreasing storage-related hazards. Mukati et al. (2023) revealed that IoT technologies helped in medical patient tracking which led to enhanced healthcare delivery while minimizing healthcare worker's risk of exposure during the COVID-19 pandemic. The rising data privacy concerns led Sharma et al. (2023) to develop a blockchain framework for securing patient information in IoT operations, which offers transparent and private data management. A smart IoMT architecture was proposed by Dahan et al. (2023) to integrate AI algorithms into real-time health monitoring, which leads to improved patient care decision-making. Table 1 presents a summary of the healthcare monitoring system.

Table 1: Summary of the Healthcare Monitoring

Author(s)	Year	Focus Area	Key Contribution
Talpur et al.	2024	Chronic Disease Monitoring	Comprehensive IoT-enabled system for continuous monitoring and early diagnosis.
Wu et al.	2023	Deep Learning Integration	Real-time health monitoring enhanced by deep learning models.
Sangeethalakshmi et al.	2023	Continuous Monitoring	Improved patient care and reduced hospital workload through constant IoT-based monitoring.
Singh & Kaunert	2024	5G & Legal Analysis	Explored 5G-IoT integration and the need for updated legal frameworks.
Vellela et al.	2023	Cloud-Based Monitoring	Developed a personalized healthcare monitoring platform with cloud computing.
Irshad et al.	2023	AI in Diagnosis	AI-enhanced IoT system for early lung cancer detection using optimized deep learning.
Alshammari	2023	Communication Protocols	Emphasized MQTT protocol for efficient data transfer in healthcare networks.
Praveen et al.	2023	Industry 4.0 & IoT	IoT integration in virtual hospital systems with smart manufacturing principles.
Arunkumar et al.	2023	Wearable Devices	Demonstrated the role of wearables in proactive health monitoring.
Li et al.	2024	General IoT Applications	Reviewed broad applications and potential of IoT in healthcare.
Mao et al.	2023	Flexible Sensors & VR	IoT systems using triboelectric sensors for VR-based intelligent monitoring.
Cheikhrouhou et al.	2023	Security & Blockchain	Proposed fog and blockchain-based secure remote monitoring system.
Selvarasu et al.	2023	Medication Monitoring	Real-time storage and temperature tracking to ensure medication quality.
Mukati et al.	2023	COVID-19 Monitoring	IoT-assisted patient monitoring for safer pandemic response.
Sharma et al.	2023	Data Privacy	Blockchain-based privacy preservation in IoT-enabled healthcare systems.
Dahan et al.	2023	AI in IoMT	AI-powered IoMT architecture for smart, real-time patient monitoring.

The recent advancements in IoT-enabled healthcare monitoring highlight its transformative impact on modern medical systems. The analysis demonstrates IoT directly contributes to three healthcare aspects: chronic disease supervision, real-time health observation, and advanced diagnosis achieved through persistent monitoring as well as analysis techniques. The combination of deep learning with AI and IoT finds support in research conducted by Talpur et al. (2024) and Wu et al. (2023) which has proven to boost health system performance. Patient care has improved with the advent of cloud-based platforms (Vellela et al., 2023), wearable devices (Arunkumar et al., 2023), and flexible sensor technologies (Mao et al., 2023). The combination of 5G technology with MQTT protocols and Industry 4.0 frameworks has created more efficient data handling pathways (Praveen et al., 2023) (Alshammari, 2023) (Singh & Kaunert, 2024). Blockchain technology serves as a solution for security and data privacy matters (Sharma et al., 2023; Cheikhrouhou et al., 2023). Additional IoT applications cover smart medication storage systems (Selvarasu et al., 2023) together with pandemic response frameworks (Mukati et al., 2023) to demonstrate system flexibility in critical situations.

3. Review of Healthcare Monitoring System

Recent years have witnessed major developments in healthcare monitoring systems because of digital technology progress and increased patient knowledge as well as healthcare requirements for improved efficiency and individual care. Healthcare monitoring practices depended primarily on labor-intensive data documentation along with sporadic physical appointments resulting in long delays for medical treatment. Healthcare monitoring under modern technology integration of Internet of Things (IoT) combined with artificial intelligence (AI) and cloud computing has developed into a live preventive data-based process. Advanced healthcare systems now serve to track vital signs nonstop and execute distant patient management which demonstrates health status fluctuations early to boost treatment quality and decrease healthcare infrastructure stress. An evaluation of healthcare monitoring systems is necessary at this time because it enables a better understanding of present capabilities alongside gap detection, alongside innovative solutions research to fulfill future healthcare requirements. Figure 1 illustrates the Healthcare monitoring system with the IoT environment.

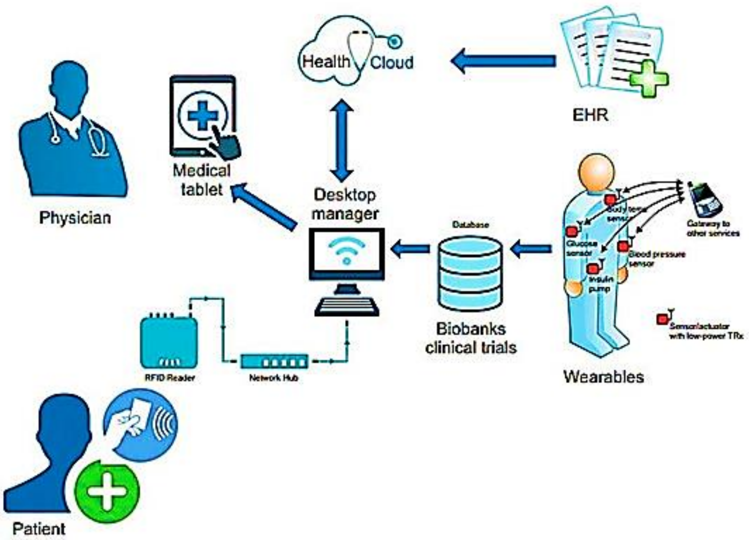

Figure 1: Process in Healthcare Monitoring [12]

Multiple studies investigate the various ways in which IoT technologies improve health monitoring systems in different medical fields. Praveen et al. (2023) demonstrated that Industry 4.0 smart manufacturing principles enable the creation of virtual hospitals which depend on IoT for healthcare data analysis to enhance monitoring efficiency and accuracy. The research by Arunkumar et al. (2023) examined IoT wearables to demonstrate their role in ongoing patient health data acquisition which leads to real-time remote healthcare monitoring. The research paper of Li et al. (2024) revealed the extensive healthcare capabilities of IoT devices through a detailed analysis of their diagnostic applications and therapeutic functions as well as their ability to engage patients throughout various medical settings. The research by Mao et al. (2023) presented a new system which integrated flexible triboelectric sensors into medical Internet of Things (MIoT) for both virtual reality monitoring and other healthcare applications. Cheikhrouhou et al. (2023) presented a lightweight blockchain and fog-computing framework that focused on creating secure remote patient monitoring protocols to handle healthcare data privacy and reliability issues. The work of Selvarasu et al. (2023) ensures medication safety through their development of IoT-based systems for hospital drug temperature tracking leading to drug quality maintenance. The application of IoT technologies assisted healthcare workers by enabling remote patient care and safety protocols during the COVID-19 pandemic according to Mukati et al. (2023).

The Sharma et al. (2023) integrated with Singh et al. (2023) present various advanced methods to improve security features and intelligence capabilities and accessibility of IoT healthcare technologies. The researchers at Sharma et al. (2023) created a blockchain system for privacy protection which addresses IoT healthcare data security by maintaining unalterable patient data safety. Healthcare systems attained better reliability alongside operational efficiency through a deep learning method orchestrated by blockchain from Kumar et al. (2023). Dahan et al. (2023) developed a smart Internet of Medical Things architecture with artificial intelligence algorithms to conduct real-time healthcare monitoring and predictive diagnostics which leads to better and swifter healthcare decisions. Subha et al. (2023) established an IoMT technology-based remote health monitoring solution that tracks vital signs because it helps monitor patients including elderly and chronically ill patients living in rural areas without proper medical care. Tutul et al. (2023) implemented IoT and machine learning technology to create a smart food monitoring system for preventive healthcare purposes although this system falls outside medical practice. The research by Singh et al. (2023) presented a real-time health monitoring system built around Arduino hardware to deliver IoT-based care at affordable prices that broadened health technology access. These innovations demonstrate how the convergence of IoT technology with AI systems and blockchain networks and machine learning capabilities transforms healthcare into a bulletproof and intelligent system that is accessible for everyone. The overall summary of the existing literature are presented in Table 2.

Table 2: Summary of the Existing Literature in the Healthcare Monitoring with IoT

Reference	Method	Results	Limitations
Praveen et al. (2023)	Industry 4.0-based virtual hospital using IoT for data analysis	Improved efficiency and accuracy in patient monitoring	Limited to smart manufacturing environments
Arunkumar et al. (2023)	Wearable IoT devices for patient monitoring	Enabled continuous and real-time health tracking	Device dependency and data accuracy concerns
Li et al. (2024)	Comprehensive literature review on IoT in	Showed broad applicability of IoT	Lacks empirical implementation data

	healthcare	in diagnostics and treatment	
Mao et al. (2023)	Flexible triboelectric sensors in MIoT with VR applications	Enabled immersive, intelligent health monitoring	High implementation cost and complexity
Cheikhrouhou et al. (2023)	Blockchain and fog-enabled remote monitoring system	Ensured secure and reliable patient data transmission	Requires infrastructure and computing power
Selvarasu et al. (2023)	IoT-based monitoring for medication temperature/storage	Improved drug quality assurance	Limited to hospital environments
Mukati et al. (2023)	IoT-enabled COVID-19 patient monitoring	Reduced exposure risk, improved remote care	Context-specific to pandemic conditions
Sharma et al. (2023)	Blockchain-based privacy preservation framework	Secured sensitive health data in IoT systems	Scalability and integration with existing systems
Kumar et al. (2023)	Blockchain + deep learning for secure data transmission	Enhanced security and intelligence of healthcare systems	Complex system architecture
Dahan et al. (2023)	AI-driven IoMT for real-time monitoring and diagnosis	Enabled predictive and automated patient care	Requires AI training and validation
Subha et al. (2023)	IoMT for remote healthcare monitoring	Beneficial for rural and aging populations	Connectivity and power limitations
Tutul et al. (2023)	IoT and ML for smart food monitoring	Promoted preventive health through food safety	Indirect healthcare application
Singh et al. (2023)	Arduino-based IoT health monitoring system	Low-cost, accessible remote care	Limited processing and scalability

4. Review of Deep Learning in Healthcare Monitoring with IoT

Modern medical technology operates at higher levels of intelligence through IoT-based healthcare monitoring systems the integration of deep learning technology which produces predictive and personalized results. Deep learning technology within artificial intelligence demonstrates exceptional skills in processing high quantities of intricate medical data deriving from IoT devices including wearables and sensors together with remote monitoring platforms. Real-time analysis combined with disease detection and vital anomaly detection and enhanced clinician decision-making are possible through this combined capability. The ever-expanding amount of healthcare data challenges traditional data analysis techniques since they cannot effectively uncover important insights. Through deep learning models healthcare professionals can detect distinct patterns and emerging trends which standard methods fail to show. The advancement represents an essential tool for managing ongoing diseases while it helps identify vital events including strokes and heart attacks and along with remote healthcare surveillance in clinical and residential areas. The review reveals essential knowledge of deep learning technology in IoT healthcare systems while identifying both upcoming applications and necessary actions to establish ethical and successful implementation shown in Figure 2.

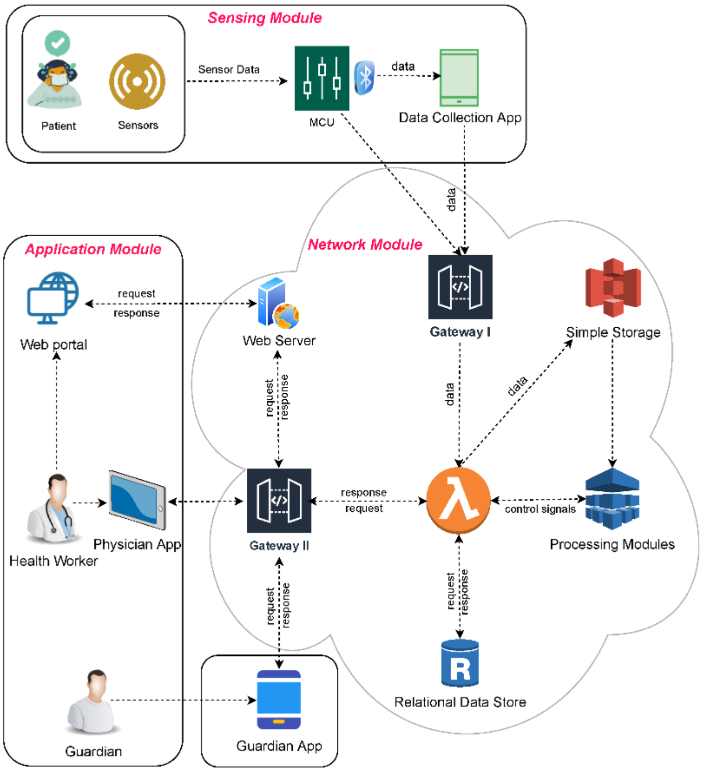

Figure 2: Architecture of Deep Learning in Healthcare Monitoring [15]

The recent studies from Kumar et al. (2023) to Rahman et al. (2023) showcase a wide range of deep learning and IoT-integrated innovations in healthcare monitoring systems. The blockchain-orchestrated deep learning model developed by Kumar et al. (2023) provides secure and intelligent data transmission for IoT-enabled healthcare and achieves secure transmission as well as accurate medical diagnoses. Singh et al. (2023) demonstrated an accessible approach by creating real-time monitoring solution with IoT and Arduino which showed how low-cost adaptable health technologies work. Deep learning approaches adopted by Khanna et al. (2023) examined ECG signal data to establish accurate disease identification methods while demonstrating the potential of biomedical data for automatic healthcare evaluation. The research of Sharma et al. (2023) produced EHDHE which serves as a blockchain framework to secure digital healthcare documents. Shaik et al. (2023) analyzed the extensive use of AI in remote patient monitoring while identifying the present deployment scenarios and explaining the management and ethical hurdles involved with remote patient monitoring. Through their research Ahmed et al. (2023) showed how disease detection benefits from data processing methods that employ IoT with deep feature fusion. Shah and Khang (2023) studied IoT technologies that work with the metaverse to develop future health ecosystems which focus on immersive patient care. A review by Singh and Singh (2023) showed the convergence of blockchain along with AI and IoT in healthcare and agriculture that leads to expanded multidisciplinary effects across both sectors. The researchers at Hosseinzadeh et al. (2023) constructed an IoT-based system to monitor elderly health which evaluated holistic elderly health status through biological together with behavioral indicators.

The hand medical monitoring system described by Yu et al. (2023) incorporates optimal EMG feature selection and machine learning to raise physical rehabilitation precision levels. Awotunde et al. (2023) studied AIoMT frameworks where they emphasized that security measures and privacy protections must be implemented for real-time operations in these intelligent health systems. A fuzzy logic and IoT-based intelligent diagnosis system for cardiac arrhythmia and COVID-19 patients forms a core part of Rahman et al.'s (2023) work which demonstrates hybrid AI models' significance in monitoring complex multiple medical conditions. These research works demonstrate the continuous advancement of deep learning and IoT technologies in healthcare monitoring, involving improved security features alongside real-time data understanding and patient-tailored care models. In table 3 presented the heathcare monitoring system integrated with the deep learning.

Table 3: Summary of Deep Learning in Healthcare Monitoring

Reference	Method	Results	Limitation
Kumar et al. (2023)	Blockchain-orchestrated deep learning for secure data transmission	Enhanced security and diagnostic accuracy	High computational complexity and resource requirements
Singh et al. (2023)	IoT and Arduino-based integrated real-time health monitoring	Low-cost, scalable solution for remote healthcare	Limited to basic health metrics and hardware scalability
Khanna et al. (2023)	Deep learning with ECG signals for disease diagnosis	High accuracy in biomedical disease prediction	Reliant on quality and volume of ECG data
Sharma et al. (2023)	Blockchain-based EHDHE for healthcare document security	Improved confidentiality in IoT healthcare ecosystems	Scalability challenges in large healthcare networks
Shaik et al. (2023)	AI for remote patient monitoring	Broad applicability and real-time insights	Data privacy, management, and ethical issues
Ahmed et al. (2023)	IoT-enabled COVID-19 screening with multi-layered feature fusion	Effective detection through integrated data processing	Narrow application to pandemic-specific use cases
Shah & Khang (2023)	Metaverse-enabled IoT for futuristic healthcare	Immersive healthcare environments proposed	Still in conceptual and early experimental stages
Singh & Singh (2023)	Review of Blockchain, AI, and IoT in healthcare and agriculture	Identified interdisciplinary potential	Lacks experimental validation or implementation
Hosseinzadeh et al. (2023)	IoT-based elderly monitoring using biological and behavioral data	Comprehensive monitoring of elderly health	Sensor reliability and privacy issues

Yu et al. (2023)	Machine learning for EMG-based hand health monitoring	Optimized physical therapy assessments	Requires individualized EMG calibration
Awotunde et al. (2023)	AIoMT for real-time healthcare monitoring with privacy focus	Improved security and responsiveness in health systems	Security frameworks still under development
Rahman et al. (2023)	Fuzzy logic and IoT for cardiac arrhythmia and COVID-19 diagnosis	Accurate and adaptive diagnostic system	Requires validation across larger populations

5. Challenges in IoT-enabled Healthcare Monitoring

Healthcare monitoring through IoT implementations both benefits patient care and generates multiple obstacles in its path. Multiple research reports have identified different major factors that impede both successful implementation and continued operation of IoT-based healthcare systems. According to Talpur et al. (2024), IoT provides constant disease monitoring for chronic patients yet faces essential obstacles concerning device connection standards and data link-up methods and protection requirements. According to Wu et al. (2023) deep learning implementation within Internet of Things systems has limitations because it faces issues with data privacy and compute-intensive requirements for live analysis. Sangeethalakshmi et al. (2023) pointed out that patient data management complexity hampers the achievement of IoT monitoring potential because of inadequate data handling and analytics processes. According to Singh and Kaunert (2024) patients need protected data and reliable systems through strong legal guidelines and infrastructure compliance when merging IoT and 5G technology. The cloud-based solution faces challenges according to Vellela et al. (2023) which includes delays and scalability issues during health data processing. The research of Irshad et al. (2023) proposed a deep learning hybrid framework for lung cancer diagnosis together with an admission that model training becomes complicated when facing restricted medical datasets that contain significant imbalance. The study presented by Alshammari (2023) analyzed MQTT communication protocol issues which affect the security and scalability of IoT health applications when used in complex networks. The study conducted by Praveen et al. (2023) pointed out the problems linked to data synchronization together with quality control in virtual hospital systems. The continuous operational ability of wearable technologies encounters usability challenges and power management problems according to Arunkumar et al. (2023).

Li et al. (2024) conducted a wide-ranging analysis of IoT healthcare which showed the necessity for standardization and data governance and heterogeneous system management. Mao et al. (2023) demonstrated a sensor-based system innovation yet highlighted problems during real-life implementation regarding sensor operational endurance and interface limitations with current systems. Cheikhrouhou et al. (2023) introduced a blockchain and fog computing secure system which faced scalability issues alongside power efficiency challenges. The authors demonstrated IoT potential for medication safety improvements in Selvarasu et al. (2023) before showing that system failures constituted a risk for drug spoilage. Mukati et al. (2023) demonstrated how IoT worked in COVID-19 pandemic situations but exposed infrastructure deficiencies in rural areas alongside the requirement for qualified personnel to execute IoT systems properly. The long-term success of IoT healthcare monitoring depends on effective solutions for encountered difficulties. Sharma et al. (2023) developed a blockchain platform as a solution for resolving privacy problems in IoT healthcare systems. The security methods established by blockchain-based systems protect patient data but create problems for real-time operations because they add complexity to both computations and system growth. The researchers at Dahan et al. (2023) integrated AI algorithms within their smart IoMT system for patient care monitoring applications. The investigators emphasized data management problems caused by extensive heterogeneity in data sources and demanded repeatedly updating analytical models to preserve their predictive capability. Subha et al. (2023) investigated the use of IoMT technology for remote health monitoring services which target patients residing in rural areas without proper medical care. Research findings showed that internet unreliability along with insufficient power systems coupled with technological divides act as barriers to technology implementation. Tutul et al. (2023) developed a smart food monitoring system involving IoT and ML although it did not directly assess patient care outcomes but confirmed data quality and sensor calibration and environmental challenges that hinder extended health monitoring. Kumar et al. (2023) developed a blockchain-orchestrated deep learning system to protect healthcare IoT systems data transfers. The security and intelligence benefits of their model are limited by the severe processing difficulties that result from executing deep learning algorithms alongside blockchain at once on IoT devices with restricted resources. According to Singh et al. (2023) a cost-effective Arduino-based solution for real-time health tracking was developed although this system faced the issues of limited memory, unstable sensor performance and difficulties in combining with other smart systems.

Deep learning systems and IoT integration for disease diagnosis through ECG examinations received analysis from Khanna et al. (2023). The study indicated initial positive results but recognized two substantial issues regarding diagnosis model performance across divergent patient groups and inconsistent ECG measurement quality. Sharma et al. (2023) developed the EHDHE model with blockchain integration for healthcare documents security purposes. The researchers pointed out processing performance issues and latency-related delays that occur during high-throughput data handling processes. Shaik et al. (2023) completed a thorough assessment of AI-based remote patient monitoring systems by analyzing advantageous aspects and main challenges including data bias and the need for clear AI decision explanations and resilient validations in genuine clinical practice. The researchers at Ahmed et al. (2023) established a smart healthcare system dedicated to COVID-19 screening operations through the implementation of multi-layered feature fusion techniques within IoT environments. Their satisfactory accuracy rate faced limitation because their system had difficulties with real-time processing along with reduced model interpretable features and inadequate adaptability to new virus strain changes. Multilayer fusion models delivered notable operational challenges for IoT platforms due to their high processing requirements and energy needs.

Shah and Khang (2023) presented contribution of metaverse technology and IoT for creating health systems of the future. The vision brings forward immersive interactive healthcare delivery settings. Such systems face challenges from infrastructure complexity as well as a combination of high hardware costs with cybersecurity risks and problems related to massive data synchronization to reach widespread viability. In their analytical review Singh and Singh (2023) established a synthesis of Blockchain technology together with IoT applications and AI applications that serve both healthcare fields and agricultural needs. The convergence of these technologies provides enhanced data security and infrastructure automation, but healthcare organizations face major challenges because of infrastructure differences between systems and high-cost barriers as well as inconsistent regulatory requirements in the healthcare sector. Hosseinzadeh et al. (2023) demonstrated an elderly monitoring system which tracks elderly behavior using IoT technology through biological indicators. This monitoring system delivers proactive healthcare, but the study documented three major barriers including sensitive data protection requirements and inaccurate sensing devices as well as older individuals' technological avoidance and dissatisfaction with long-term continuous patient tracking.

The researchers at Yu et al. (2023) created a hand medical monitoring system which applies machine learning alongside an optimal set of EMG features. The system demonstrates expert diagnosis for neuromuscular testing yet its performance decreases when users move sensors randomly and the presence of signal noise and individual customization needs prevent wide-scale deployment unless regular recalibration occurs. Awotunde et al. (2023) examined the incorporation of AIoMT for real-time healthcare system monitoring with security and privacy measures, as their study showed. The analysis revealed crucial threats including data breaches and malware attacks and encryption weaknesses in present medical IoT deployments which requires sturdy lightweight security solutions designed for resource-strict medical IoT equipment. The authors Rahman et al. (2023) created a diagnosis system which integrates IoT technology with fuzzy logic to detect cardiac arrhythmia and COVID-19 symptoms. The model showcased adaptability features together with interpretability capabilities, yet the researchers identified fuzzy rule complexity along with edge device latencies and structural scalability issues as major implementation problems. Each time the authors presented the results they emphasized the necessity of testing medical IoT devices in operational settings to surpass theoretical limits.

6. Discussion and Findings

Currently healthcare systems benefit tremendously from IoT technology implementations which combine real-time continuous patient data collection and enhanced clinical decision quality. The examined research demonstrates multiple obstacles which prevent IoT healthcare systems from achieving optimal results in their sustainable deployment mode. Patient and data format heterogeneity create fragmented healthcare information networks due to the lack of standardized infrastructure according to Talpur et al. (2024) and Li et al. (2024). Data security and privacy stand as essential concerns during network-based transfers of personal health information. Data vulnerabilities such as weak encryption alongside risks of breaches are detailed in three studies by Wu et al. (2023), Sharma et al. (2023) and Awotunde et al. (2023) which drives blockchain adoption in healthcare systems. These methods create both efficiency burdens and performance difficulties mainly when needed to function in real-time operation. The diagnostic performance of deep learning algorithms results in better accuracy according to Irshad et al. (2023) and Khanna et al. (2023) yet remains constrained by the high processing needs and energy usage of IoT devices with limited capabilities. The adoption readiness of healthcare systems for IoT depends largely on the existing legal framework and infrastructural elements according to Singh and Kaunert (2024) along with the need for ethical guidelines and standardized compliance procedures. Remote monitoring systems in underserved regions experience usability constraints and power management challenges as well as sensor reliability issues according to Arunkumar et al. (2023) and Subha et al. (2023).

The implementation of IoT in healthcare requires solutions that deal with environmental barriers such as inadequate internet access and insufficient technical knowledge which create barriers to universal adoption. The proposed implementations by Cheikhrouhou et al. (2023) and Shah and Khang (2023) combining blockchain and fog computing and metaverse systems demonstrate promising data management and immersive care solutions yet encounter implementation difficulties because of high expenses and complex infrastructure alongside security risks. The widespread implementation of IoT in healthcare needs unified initiatives to resolve technological hurdles and infrastructural barriers and regulatory standards as well as user acceptability challenges for its continuing evolution toward better healthcare monitoring and diagnostics and personalized care. Findings on IoT-Enabled Healthcare Monitoring:

1. Standardization problems prevent different platforms from working together smoothly with their IoT devices and data communication types (Talpur et al., Li et al.).
2. The IoT systems face multiple data privacy and security risks due to their exposure to breaches and unauthorized access which requires encryption and blockchain implementation (Wu et al., Sharma et al., Awotunde et al.).
3. Better diagnostic capabilities from AI and deep learning models demand higher computational power than IoT devices possess which produces delays and inefficient energy usage (Irshad et al., Kumar et al., Khanna et al.).
4. Cloud-based and blockchain solutions face efficiency limitations while processing substantial healthcare datasets according to Vellela et al, Cheikhrouhou et al, and Sharma et al. The usability problems of IoT-enabled wearables regarding power management, comfort and long-term usability affect continuous monitoring performance (Arunkumar et al.).
5. The implementation of IoT healthcare depends on basic legal regulations as well as data governance standards which are incomplete especially with 5G technology (Singh & Kaunert). The deployment of remote medical systems through monitoring devices is limited by poor rural area infrastructure including sparse power access and unreliable internet connections and low regional technical skill level (Subha et al., Mukati et al.).
6. Healthcare diagnosis becomes disrupted by sensor inaccuracies and environmental interferences which affect sensor reliability (Yu et al., Tutul et al.). Interoperability troubles arise when IoT merges with hospital IT infrastructure because of various data synchronization and compatibility problems (Praveen et al.).

7. Conclusion

The integration of IoT technology in healthcare resulted in significant improvements for patient care while collecting data in real time and tailoring both diagnoses and managing healthcare remotely. Modern healthcare technology provides various sophisticated obstacles that prevent it from achieving its maximum potential despite its implementation. Research on device interoperability, together with data privacy protection and security vulnerability solutions and infrastructure capability enhancement for rural areas needs systematic development. The studies reviewed establish three key needs: strong legal standards combined with standardized procedures and energy-efficient scalable solutions, which are necessary to deliver reliable IoT-enabled systems. Next-generation technologies combining artificial intelligence with blockchain and metaverse systems open new opportunities which require serious evaluation because of ethical issues as well as regulatory and technical challenges. The creation of adaptable IoT healthcare ecosystems needs multi-disciplinary cooperation between clinicians and technicians together with policy developers and legal professionals to achieve security and inclusiveness as well as operational efficiency for healthcare delivery.

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