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A Review of Smart Contract-Enabled Chronic Disease Using Telemedicine with IoMT: Revolutionizing Healthcare Delivery

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Abstract
In traditional healthcare sceneries, real-time patient record monitoring and analyzing information for the prompt diagnosis of chronic illnesses under specific health conditions is an essential procedure. Failure to diagnose chronic diseases promptly can lead to severe consequences, including patient mortality. Regarding disease diagnosis and treatment, wearable device physiological data can be analyzed by artificial intelligence (AI) to produce intelligent recommendations. Contemporary medical and healthcare frameworks leverage Internet of Things (IoT) technologies, utilizing autonomous sensors to monitor and assess patients' health conditions while recommending suitable interventions. This paper introduces an innovative hybrid approach that integrates IoMT and Telemedicine to facilitate the early detection and ongoing monitoring of three distinct chronic diseases, including asthma, brain tumors, and Alzheimer's. Furthermore, blockchain can enhance healthcare services by enabling decentralized data exchange, safeguarding user privacy, empowering data, and guaranteeing the dependability of data administration. Blockchain, wearable, and AI integration may improve current chronic illness management paradigms by moving away from hospital-centered care and toward patient-centered care. In this study, we further investigate the use of these integrated technologies in the management of chronic diseases and theoretically provide a patient-centric technical framework based on blockchain, artificial intelligence, and wearable technology.

Keywords: *Artificial Intelligence; Chronic Diseases; Smart Contract; Smart Healthcare; Telemedicine.*

1. Introduction
These days, chronic illness is the leading cause of morbidity and death globally. As a result of the aging population and rising number of dual-income households, managing chronic illnesses has become a necessity for the home care sector. As per the World Health Organization (WHO), there is an expected rise in the incidence of chronic diseases and their consequent deaths in low- and middle-income nations until 2030. In the United States, the cost of treating typical chronic illnesses like cardiovascular disease was $555 billion in 2014; by 2035, that amount is predicted to increase to $1.1 trillion. With chronic illnesses thought to be the cause of 61% of all deaths in India, they constitute a developing public health problem. Because managing chronic illnesses may be costly and difficult, Indian healthcare practitioners always look for innovative ways to improve the process's effectiveness and efficiency. Chronic diseases that are commonly seen in society comprise cancer, diseases related to the heart and brain, hypertension, chronic respiratory conditions, diabetes, obesity, joints, and neurological disorders. There is no denying that healthcare affects people's well-being. People with several chronic illnesses, particularly those in their younger years, have poorer health outcomes. This necessitates a prompt and precise diagnosis, which can be made following a hospital physical examination. Due to the necessity of hospital admission for treatment due to delayed diagnosis, healthcare expenses and length are increased, and the availability of healthcare facilities in rural and distant locations is limited. The human-centered and error-prone nature of traditional diagnosis methods can have serious negative effects on patients' health. Examples include missed or delayed diagnoses, neglecting to start follow-up care, patients' histories that are not accessible, incorrect prescriptions, and incomplete patient histories. To

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overcome these obstacles, the healthcare industry must embrace the newest IoMT, AI, Telemedicine, and Smart Contract technical innovations to lower human error.

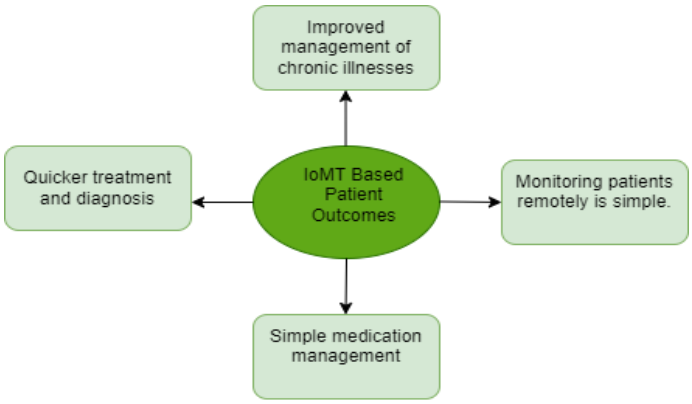

Figure 1 IoMT-based Patient Outcomes

In this research, we evaluate the security issues with the IoMT framework and investigate how Blockchain technology and telemedicine can address the latency and security issues with the conventional IoMT frameworks. Figure 1 further details the patient's result about the Internet of Medical Things (IoMT). Improving one's health is becoming increasingly important to everyone in the current society. Because of the rise in sicknesses, several new hospitals have been built. Because people like being treated at several different hospitals and transferring their medical records between them throughout their lives, patients find it difficult to get prior health information. As a result, patient interaction with medical records is dispersed, improving record management. The Internet of Medical Things (IoMT) is among these technologies that show the most promise Chronic illnesses are long-term ailments that usually worsen gradually over time. They can affect different bodily regions and result in a variety of symptoms and problems that can seriously lower a person's quality of life. Diabetes, heart disease, arthritis, cancer, and chronic obstructive pulmonary disease (COPD) are a few prevalent instances of chronic illnesses. Numerous variables, including genetics, lifestyle decisions, and environmental circumstances, might contribute to the development of these disorders. Supplementation, lifestyle modifications, and continuing medical treatment are frequently used in conjunction to manage chronic conditions. Since healthcare professionals can monitor symptoms and modify treatment programs as necessary, regular medical care is also crucial for treating chronic illnesses. In general, treating chronic illnesses holistically and addressing their social, emotional, and physical components is necessary. Many persons with chronic illnesses may live happy, healthy lives if they get continuing treatment and support. Healthcare delivery might undergo a revolutionary change due to the confluence of modern technologies like telemedicine, smart contracts, and the Internet of Medical Things (IoMT). This could especially impact the management of chronic diseases. This integrated strategy makes use of the real-time data-collecting capabilities of IoMT, the accessibility and convenience of telemedicine, the automation and security of smart contracts, and more to build a more effective, individualized, and safe healthcare system. With the advancement of blockchain, artificial intelligence (AI), and wearable technology, it is now possible to follow the health status of patients with chronic illnesses by integrating these three technologies. Wearable medical devices, such as portable electronic sensors, record, analyze, regulate, and intervene to maintain the wearer's health, and can be directly applied to the body to help manage chronic illnesses. Wearables allow for round-the-clock user monitoring and help patients with chronic illnesses receive individualized care by performing thorough, dynamic, and intelligent analyses of several health markers. High-performance computing and artificial intelligence (AI) can be used to anticipate hazards more precisely based on these multidimensional clinical and biological data sets.

1.1. Motivation

The aging population and increasing prevalence of chronic diseases like diabetes and cardiovascular disorders necessitate personalized treatment, early detection, and ongoing monitoring. The main motivation behind our research work is that the Internet of Medical Things (IoMT) enables real-time health data collection, remote monitoring, and communication between patients, healthcare professionals, and smart gadgets. IoMT offers continuous monitoring, early warning systems, better

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treatment choices, and automation through smart contracts. Smart Contract-based Chronic Diseases Telemedicine aims to improve patient outcomes, increase healthcare efficiency, and deliver individualized treatment.

1.2. Paper Organization

Here is a summary of the reminder for this paper assignment. Section 2, demonstrates the conceptual background of chronic diseases. The research that has already been done on chronic diseases is reviewed in Section 3. In Section 4, we provide a telemedicine and IoMT integrated solution for chronic disease. In Section 5, we provide a final overview of our plan and talk about the course of our upcoming research.

2. Conceptual Background

With its efficient healthcare and monitoring system, the Internet of Medical Things (IoMT) has completely changed the healthcare sector. This intelligently connects mobile sensors to humans, doctors to doctors, patients to doctors, medical professionals to medical professionals, and objects to medical professionals. Securing success requires making efficient use of data from IoT devices. The Internet of Medical Things, or IoMT, is a cutting-edge technology that links various medical equipment, gathers data and information from devices, and transfers and processes the data instantly. This creates an ecosystem that improves productivity by fusing the power of the Internet of Things (IoT) with the workflow in healthcare.

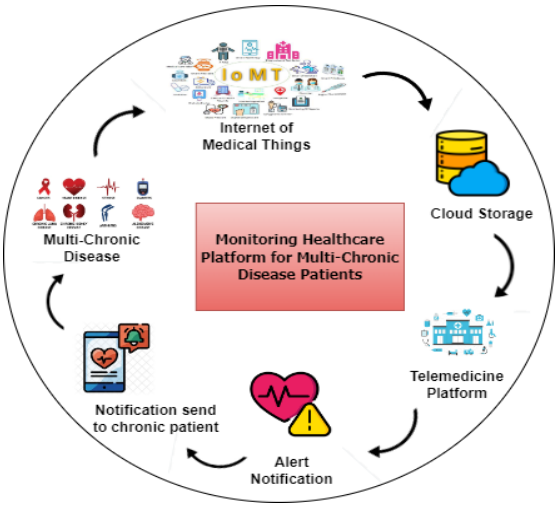

Figure 2 Tracking Patient Data on a Multi-Chronic Healthcare Platform

In a multi-chronic healthcare platform, patient data is tracked as seen in Figure 2. The graphic illustrates the operation of the healthcare platform. With its enormous effect and notable advancements in recent decades, IoMT is playing a major role in the creation of solutions related to sickness diagnoses, personal care for both young and elderly patients, control over fitness and health, and monitoring of degenerative illness. Additionally, it discusses the design ideas used in the creation of an IoMT gadget. We covered the management of chronic illness and the function of telemedicine in the next subsections. In addition, we briefly describe how real-time data may be used to enhance telemedicine and how smart contracts can be used to secure data.

2.1. Management of Chronic Diseases and the Role of Telemedicine

By facilitating simple access to healthcare services, ongoing patient monitoring, and remote consultations, telemedicine offers a solution. Frequent hospital visits are not necessary since patients may communicate with their healthcare professionals from the comfort of their homes. Regular follow-ups, prompt modifications to treatment regimens, and access to expert care are all made possible via telemedicine and are essential for the management of chronic illnesses. We have finally integrated smart contracts with telemedicine.

2.2. IoMT: Using Real-Time Data to Improve Telemedicine

By combining wearables and linked medical equipment that continually monitor and communicate patient data, the Internet of Medical Things (IoMT) improves telemedicine. These real-time data may include blood pressure, heart rate, glucose levels, and other parameters. IoMT devices can be incorporated into the body or utilized at home. They give medical professionals access to a constant flow of data that is vital for the management of chronic illnesses.

2.3. Smart Contracts: Healthcare Process Automation and Security

Healthcare procedures benefit from smart contracts' automation, transparency, and security. Smart contracts enable the automated execution of activities when predetermined circumstances are satisfied by encoding the terms of an agreement into code. Smart contracts have several applications in the

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management of chronic illnesses, including:

- **Automate Payments and Claims**: When a patient completes a telemedicine session or when the Internet of Medical Things (IoMT) devices indicate particular health indicators, automatically initiate payments or insurance claims.
- **Verify Adherence:** Keep an eye on patient's adherence to their treatment regimens and medications, automatically notifying patients or healthcare professionals of any deviations. Control Consent and Data Sharing: Ensure privacy laws are followed by automatically controlling patient consent for the sharing of health information with different parties.

2.4. The Integrated Model: IoMT-Powered Smart Contract-Enabled Telemedicine

By combining IoMT and telemedicine with smart contracts, a potent healthcare delivery model is developed that tackles the difficulties in managing chronic diseases. This integrated strategy functions as follows:

- **Continuous Monitoring:** Using telemedicine platforms, IoMT devices gather data on patients' Health conditions in real-time and provide it to medical professionals.
- **Data-Driven Decisions:** After analyzing the data, medical professionals decide on treatment programs, prescription modifications, and follow-up appointments.
- **Automated processes:** Smart contracts minimize administrative work and guarantee prompt response by automating tasks like data sharing, payment, and compliance monitoring. Enhanced Patient Engagement: Because of the integrated system's ability to provide real-time feedback, alerts, and education, patients are more involved in their treatment.

2.5. Benefits of Smart Contract-Enabled Chronic Disease Telemedicine with IoMT

The advantages of managing chronic diseases using the Internet of Medical Things emphasize the necessity to create the technology for this unique application. The global incidence rate of chronic diseases is on the rise, posing a particular concern to emerging nations.

- **Proactive Care:** Real-time data and ongoing monitoring allow for the proactive treatment of chronic illnesses, which may help to avoid complications and hospital stays.
- **Efficiency:** Healthcare practitioners may concentrate more on patient care when regular tasks are automated, as it lessens their administrative burden. Cost savings: This strategy cuts healthcare expenses for patients and providers by eliminating the need for in-person visits and hospital stays.
- **Personalization:** Based on ongoing data, treatment strategies may be customized for each patient, improving health results. Security and Compliance: Smart contracts guarantee the transparency, security, and legal compliance of every action made inside the system.

3. Related Work

S. Tarumi, W. Takeuchi, G. Chalkidis, S.R. Loya, J. Kuwata, M. Flynn, K.M. Turner, F.H. Sakaguchi, C. Weir, H. Kramer, D.E. Shields, P.B. Warner, P. Kukhareva, H. Ban, K.Kawamoto et. al. [1] This study aims to use artificial intelligence to improve the treatment of chronic illnesses. By encapsulating prediction models in an OpenCDS Web service module and delivering model outputs through a SMART on FHIR web-based dashboard, an AI-driven clinical decision support system (CDSS) was developed. This CDSS allows patients and doctors to choose alternative treatment plans based on prediction results, evaluate patient parameters, and set treatment goals. E. Badidi et. al. [2] examines Edge AI plays a crucial role in early health prediction, enhancing public health through wearable technology for tracking infectious diseases and early diagnosis of chronic illnesses. However, challenges and limitations exist, and further research and strategic investments are needed for its widespread use in healthcare. The article emphasizes the need for more research, cooperation, and strategic investments to fully harness the potential of Edge AI in healthcare.

D.K. Murala, S.K. Panda, S.P. Dash et. al. [3] propose a blockchain-based patient-centered technology architecture for managing chronic diseases, utilizing a Metaverse setting. Patients and

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doctors must register on the blockchain network, and avatars accompany guests. A log of patient data is collected during consultations, which Explainable Artificial Intelligence models use to predict illness development. The study acknowledges limitations and suggests further research. S. Rubaeah, I.S. Mangkunegara, P. Purwono et. al. [4] mentions that the health industry has widely adopted IoT technology, offering benefits such as improved data security. However, due to private medical records, developers and users must be mindful of data security. Research on data security in IoT-based health systems is extensive, and this conversation aims to enhance the benefits and security assurances of IoT development. M. Dadkhah, M. Mahraeen, F. Rahimia, K. Kimiafar et. al. [5] This study explores the use of IoT in managing chronic diseases in developing nations. It uses a latent Dirichlet allocation approach to identify key topics and structural coding to list deployed technologies. A fuzzy analytic hierarchy approach ranks prevalent chronic disease categories based on their importance for IoT use. The research findings include lists of IoT technologies and the most discussed chronic diseases. N. Nigar, A. Jaleel, S. Islam, M.K. Shahzad, E.A. Affum et.al. [6] propose A hybrid approach combining IoT and machine learning is being developed for early identification and monitoring of six chronic diseases: Alzheimer's, COVID-19, pneumonia, diabetes, heart disease, and brain tumors. The method uses benchmark and real-world datasets in a cloud-based environment, and ANOVA tests show significant differences in accuracy. This could help medical professionals and the healthcare industry in early detection of chronic illnesses. E. Yadav, S. Bhattacharya, A. Baur, A. Majumder, H. Samanta, S. Mondal et. al. [7] The study uses the latent Dirichlet allocation algorithm and structural coding to identify key subjects in literature and technologies for managing chronic disorders. Fuzzy analytic hierarchy classifies common disorders based on IoT application, with diabetes mellitus and cardiovascular illness ranking as top priorities. S. Fatima et. al. [8] explains that machine learning classifiers play a crucial role in the early detection of chronic illnesses like cancer. K-nearest neighbor, Decision Tree, and Support Vector Machine classifiers are highly successful in prostate, lung, and breast cancers. However, Decision Trees and KNN show impressive abilities in specific cancer types. Continuous improvement and modification of prediction models are needed to enhance patient outcomes. K. Azbeg, O. Ouchetto, and S.J. Andaloussi et. al. [9] outline proposes a Blockchain-based system for medical IoT equipment protection, enhancing security and privacy in healthcare systems. The system enables remote patient monitoring, addressing security concerns through encryption and scalability. The data is stored in an off-chain database and encrypted using Ethereum Blockchain. A.J. Aljaaf, D. Al-jumeily, H.M. Haglan, M. Alloghani, T. Baker, A.J. Hussain, J. Mustafina et. al. [10,12] We employ This study uses predictive analytics to analyze data parameters and class attributes, identifying 30% as the optimal subset for predicting chronic kidney disease. Four machine learning-based classifiers were assessed, with the best results showing an AUC of 0.995, sensitivity of 0.9897, and specificity of 1. J. Liu, Z. Zhang, N. Razavian et. al. [11] The study presents a multi-task architecture that integrates structured data and free-text medical notes to predict disease starts. It evaluates deep learning architectures like hierarchical models, LSTM, and CNN. The method handles negations and numerical values without disease-specific features. Results show text-based models perform better than structured data, and performance is enhanced by models that use both raw text and numerical values. N.R. Pradhan, S.S. Rout, A.P. Singh et. al. presents a blockchain-based remote patient health record monitoring system prototype, addressing data loss concerns and security vulnerabilities. It presents a solidity-based smart contract running on an Ethereum virtual machine, authoring smart contracts and utilizing the Ethereum protocol to manage patient health data. The system automates sensor data collection and interaction with a decentralized application, enabling alert transactions for patients and medical professionals when combined with web3, metamask, and truffle environments. R. Islam, A. Sultana, and M.R. Islam et. al. provide an overview of previous studies on machine learning-based methods for clinical decision-making (CD) prediction, comparing findings and research

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methods. Techniques like LASSO, mRMR, and RELIEF are widely used, along with machine learning techniques like SVM, RF, DT, and NB. The authors also discuss hybrid models and deep learning strategies for improved outcomes and recommendations for the healthcare system.

4. Telemedicine and IoMT Integrated Solutions for Chronic Disease

In today's environment, individuals typically believe that if they have no symptoms, they are not ill or suffering from the condition. However, this does not imply that a person free of symptoms is not suffering from a chronic illness. A chronic illness is a long-term ailment that usually lasts for three months or longer and is usually incurable by vaccination or medical treatment. These illnesses may restrict everyday activities and frequently need continuing medical care. A person's quality of life can be greatly impacted by chronic illnesses, which frequently start slowly and worsen over time. Changes in lifestyle, routine monitoring, and potentially long-term treatment programs are usually necessary for managing these disorders. Several state-of-the-art technologies have introduced novel experiences to the management of chronic diseases with the emergence of the "Smart Healthcare" era. Among these, IOMT technology actively records physiological parameters and tracks the metabolic state, assisting individuals in leading healthier lifestyles and supplying a steady stream of healthcare data for illness diagnosis and treatment. But there is a tenacious problem that has to be solved: how to arrange and evaluate the data to ultimately improve the management of chronic diseases in terms of patient outcomes, quality of life, and privacy protection. The current chronic illness management models might be improved by integrating smart contracts, IOMT, and telemedicine, moving away from a hospital-centered approach and toward a patient-centered one. Figure 3 shows how integrated technologies like telemedicine and IoMT are used to treat chronic diseases. These solutions include integrated health monitoring, chronic illness management, mobile health monitoring, and operational efficiency. A synopsis of the chronic disease management paradigm is shown in Table 1. It also provides a summary, technology used, and key contributions of several writers.

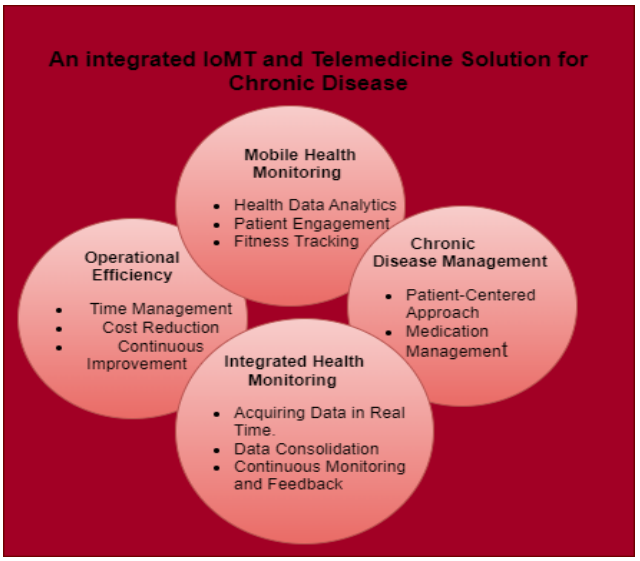

Figure 3. An Integrated IoMT and Telemedicine Solutions for Chronic Disease

4.1.Integrated Health Monitoring

With the help of IoT, a centralized network of linked devices that can generate and exchange data inside of a single system can be established. By regularly monitoring and storing all of the data, persistent information storage is made possible. Patients with many health issues contributing to lifelong suffering are said to have chronic diseases. Because people with chronic diseases require ongoing care, early detection will lower the risk. It's getting cheaper and more convenient to combat chronic diseases with IoT-controlled sensors, wearable technology, data analytics, and portable gadgets. The key takeaway is that it's frequently required to monitor and evaluate long-term medical issues. Slants in the variations of a disease can be evaluated and measured for competency in this way. All of this is made possible by utilizing an IoT platform that combines blockchain technology with artificial intelligence to provide several extra features.

4.2.Mobile Health Monitoring

Mobile Health Monitoring can control the vast amounts of data produced by IoMT devices. In doing so, healthcare providers are better equipped to recognize patterns, anticipate disease outbreaks, and allocate resources efficiently. Healthcare practitioners can create individualized treatment

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regimens that address each patient's unique needs by analyzing patient data. In the end, predictive analytics leads to better healthcare outcomes and more effective use of healthcare resources by enabling early intervention and preventative strategies.

Table 1 Summary of Chronic Disease Management using IoT Paradigm

Paper Title	Key Findings	Methodology Used
Leveraging Artificial Intelligence to Improve Chronic Disease Care: Methods and Application to Pharmacotherapy Decision Support for Type-2 Diabetes Mellitus	Created a CDSS powered by AI for the age of chronic illness. improved over earlier machine learning algorithms and integrated with Epic EHR.	TPEG approach
Edge AI for Early Detection of Chronic Diseases and the Spread of Infectious Diseases: Opportunities, Challenges, and Future Directions	Early AI algorithm identification. Wearable's using edge computing to monitor the spread of infectious diseases	Federated Learning and AI algorithms are used.
A Review of Internet of Things (IoT) and Blockchain In Healthcare: Chronic Disease Detection and Data Security	Healthcare quality and efficiency are improved with IoT. In an IoT-based healthcare system, blockchain guarantees data security.	IoT and Blockchain tech are used.
Use of the Internet of Things for Chronic Disease Management: An Overview	Enumerates IoT technologies for managing chronic illnesses. Diabetes and cardiovascular disease are the two main uses of IoT.	Text mining and literature analysis are employed.
IoMT Meets Machine Learning: From Edge to Cloud Chronic Diseases Diagnosis System	A hybrid strategy using IoT and ML to diagnose chronic diseases.	Machine learning techniques are applied

4.3.Chronic Disease Management

For chronic ailments including diabetes, cardiovascular disease, and respiratory disorders, IoMT devices such as wearable sensors and smart implants offer continuous monitoring. Healthcare professionals are notified of any anomalies by these devices' real-time data collection and transmission. A personalized treatment plan that is suited to the specific requirements of every patient can be developed thanks to this constant flow of information, which also enables quick, proactive interventions. IoMT contributes to better illness management by lowering the risk of serious consequences, enhancing overall patient quality of life, and keeping continuous surveillance of chronic conditions.

4.4.Operational Efficiency

IoMT solutions improve workflow procedures, automate administrative duties, and maximize resource usage to increase operational efficiency in the healthcare industry. Significant cost reductions, higher productivity, and improved overall healthcare delivery efficiency result from this. IoMT guarantees that healthcare providers can concentrate more on patient care and less on administrative duties by optimizing operations and lowering manual workload. As a result, the healthcare system is more efficient and produces better results and patient satisfaction. Furthermore, when it comes to the data communication process, security is an important aspect to consider in addition to highly developed systems for the detection and monitoring of chronic

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diseases. The health industry has implemented cloud technology to improve the efficacy of medical treatments. An increasing number of contemporary hospitals are said to be experimenting with IoMT, which records vital parameters from monitoring devices connected to the hospital core network in addition to the patient's sickness.

Conclusion

In summary, a potential area in the management of chronic diseases is the merging of IoMT, telemedicine, and smart contracts. As these technologies develop further, they might drastically improve patient outcomes, raise the standard of living for people who have long-term illnesses, and change the way healthcare is provided. One encouraging trend in healthcare is the adoption of IoMT devices for the management of chronic diseases. IoMT devices offer the potential to enhance patient outcomes and save healthcare costs by allowing healthcare practitioners to remotely monitor patients and take appropriate action when needed.

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