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Procedia Computer Science 260 (2025) 22–31

Procedia Computer Science

www.elsevier.com/locate/procedia

Seventh International Conference on Recent Trends in Image Processing and Pattern Recognition (RTIP2R-2024)

Safeguarding the Landscape of Mental Wellness: Analyzing Cyber Threats and Mitigation Strategies in Digital Healthcare

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Abstract

With the pervasiveness of digital technologies across various sectors, mental health care has not been left out, where the use of IoT has enhanced therapeutic practice through better monitoring of patients, collection of data, and proper alignment of treatment measures. However, the data collected for mental health is synonymous with high sensitivity; the information collected via IoT devices is prone to cybersecurity challenges which may compromise patient privacy or interfere with the treatment process. This review paper seeks to synthesize the two sides of IoT application in mental health, which are; advantages and cybersecurity threats. This paper aims at conducting a deep review of sources to ascertain the level of cybersecurity threats surrounding IoT in mental health, the performance of the current security measures, and possible future measures. It aims to identify the best measures to curb insecurity tendencies in the use of IoT in mental health. The review will contribute to the existing sources in the quest to secure health data in the rapidly evolving digital health field hence helping to create trust in secure information sharing.

Keywords: Internet of Things (IoT); Mental Health; Cybersecurity; Healthcare Technology; Data Security; Privacy Protection; Wearable Devices; Remote Monitoring; Health Data Breaches; Security Vulnerabilities; IoT Security Solutions; Network Security; Health Informatics; Patient Data Protection; Secure Communication; IoT Healthcare Applications; Privacy in Healthcare; Digital Health.

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1877-0509
10.1016/j.procs.2025.03.173

1. Introduction

The Internet of Things (IoT) has played a role in the healthcare sector, directing new ways of doing most things, more so on mental health issues. The technological shift promises improvement in the way monitoring and diagnosis are being handled, paving the way for adjustment and customization of treatment. Making the integration of IoT into mental health services enhances care but also ushers in complex Cybersecurity challenges have to be tackled to secure sensitive patient data. Most of the treatments in mental health require collecting, keeping, and analysing very sensitive personal data. This may encompass fine-grained emotional evaluations, psychiatric past, and current data on behavioural data—all acquired from diverse IoT gadgets like wearable sensors and remote monitoring systems.

Although these devices can obtain valuable data for improved patient care, they too introduce new vulnerabilities to data breaches and cyber-attacks. The nature of the sensitive data being handled makes the application the major target for malicious actors trying to exploit vulnerabilities for unauthorized access. The architecture of an IoT ecosystem in healthcare is, therefore, complex by nature, in the sense of having multiple, interconnected devices, communicating across different platforms and networks. In other words, a wearable biometric monitor or a smart therapeutic device can potentially serve as a security threat at the point of its entry.

The aims of this study are to investigate integration of Internet-of-Things (IoT) technology in mental health care with specific attention to-warning and alerting, as well-informing about risks related-so; Cybersecurity Risk-aware Advancements (CRA production). The challenge is to create a comprehensive and systematic understanding of the types of cybersecurity threats associated with IoT-based mental health applications in general, which includes unauthorized access, data breaches as well as device tampering. In addition to this, it aims to assess how effective current security mechanisms namely encryption standards like AES are at securing private medical information. Research in innovative fields such as quantum cryptography and blockchain, to alleviate the limitations found by current security practices is also included. This study, therefore, seeks to introduce such a framework that can be adjusted according to the changing attacks in IoT integrated healthcare and offer security on both data integrity as well patient privacy.

The fact that there are different security protocols from different device manufacturers doubles the challenge, since this could lead to inconsistency in security practice and vulnerability issues. Complicating the issue further is the pace at which IoT development is developed within healthcare, often outstripping the corresponding development of regulatory and security measures. It is, thus, up to the healthcare service providers and device manufacturers to navigate the landscape with new technologies and a changing regulatory environment. Compliance with such strict privacy laws as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) is almost impossible without achieving a proactive approach to cybersecurity. Some of the current strategies in use within the IoT landscape involve layered security approaches, through the use of robust encryption techniques, secure authentications of devices, and continuous security patches and updates to curb newly emerging threats. These measures, in turn, are increasingly put to the test by the growing professionalism of the cyber-attacks, which now exploit even more the smallest security gaps. It means a dynamic and constantly evolving cybersecurity strategy, protecting the system not from known dangers but predicting plausible future possible risks.

2. Literature Review

The Internet of Things (IoT) is revolutionizing the manner in which healthcare is delivered, with devices not only having real-time monitoring capabilities but also reaching forward to pre-empt the needs of patients. In human mental health, IoT eases the way for innovative treatments that take advantage of real-time data analytics and individualized care interventions. Technologies may monitor physiological indices such as heart rate and sleep patterns that are key for managing conditions like depression and anxiety. The comprehensive study of [1] highlights the transformational potential of IoT in different healthcare domains, especially its scalability and capability to handle diverse data streams. Review paper cover a wide overview of IoT applications in healthcare, with a more general focus on the wider implications and potentials. The devices and data streams have to be protected from breaches. And this is where the issue of privacy emanates, whereby stringent measures of strong encryption and authentication protocols have to be put in place to protect any sensitive health information from any kind of access by malicious intruders. Comprehensive reviews, such as that by [22], delve into the spectrum of cybersecurity challenges in IoT and thereby reveal insights into systemic vulnerabilities and strategic counter-measures.

The specific IoT application in this field of mental health raises particular security concerns. Devices used within a mental health setting have been created to gather very sensitive data, and if it is used illegitimately, serious

consequences can be caused. [3] detail various threats, including unauthorized access and data tempering, that could be sabotaging the therapeutic processes and patient trust. Because IoT devices are highly connected, this even lead to magnifying the vulnerabilities. [4] highlight the challenges in ensuring these devices are not vulnerable to sophisticated cyber-attacks evading traditional security measures. The same group also underlined the necessity for deploying sophisticated forensic techniques that could trace back and give the attack vectors of breaches post the incidence occurrence. Such forensic challenges are discussed in review articles like [23], which shed light on the security protocols and methodologies that need to be specifically improved in IoT environments.

The literature further suggests some advanced, suitable security solutions for IoT to counter the threats. One such approach is the promising blockchain technology for decentralized data control, further improving secure data transactions. Some of the important contributions to mental health include improvement in the traceability and tamper prevention of data [5]. Furthermore, machine-learning-based anomaly detection techniques in IoT security. Discuss how this might be done and how machine learning might be applied to pre-emptive identification and mitigation of any unusual patterns that might indicate a cybersecurity threat, thereby protecting sensitive mental health data before the breach. Review papers such as [24] discuss the incorporation of these technologies within the medical sector, evaluating them as efficient and promising in future deployment.

Moreover, literature has evolved that underscores the need for continuous change in adapting security protocols to changes with emerging technologies. Outline a systematic framework that will aid in the analysis of all security challenges and the update of protective measures in real-time, a critical strategy given the dynamic nature of IoT and cyber threats. Reviews of the nature of IoT security provided in [25] make a claim for its being dynamic and propose an adaptive nature in frameworks evolving with technological advancements and emerging threats. Privacy is also a significant concern for many mental health IoT applications, since devices often capture very private information. Regulatory compliance, therefore, is key to ensure that the handling of data conforms to very tight legal standards. Studies have pointed out that IoT devices have to follow international laws on privacy, which change a lot from continent to continent. For example, the EU General Data Protection Regulation (GDPR) is so strict that under its requirements, IoT devices would have to respect requirements for data consent and privacy [8]. In the U.S., this requirement is based on the Health Insurance Portability and Accountability Act (HIPAA), which mandates organizations to take protection measures that guarantee patient data privacy and data security [9]. This is not just following these regulations out of legal compliance but, more importantly, this is developing trust with the user, something very important for mental health applications.

Modern research makes a point of the changing cybersecurity landscape in IoT, which is now also taking healthcare into account. For an example, [28] has looked at the adaption of AI-driven methodologies responsible for securing mental health data on IoT platforms eliminating zero-day attack periods with real-time threat detection. Also, an extensive study has been conducted over the way quantum-resistant algorithms could enable IoT systems to remain secure in long-term despite upcoming cyber threats [29]. Moreover, [30] discusses the implementation issues in a decentralized IoT architecture for mental health applications (which are becoming increasingly prevalent recently) and also point out that these architectures can collaborate to reduce their attack surface by lowering dependence on single points of failure.

Although important progress has been made in the implementation of IoT technology to mental health care, there are several key gaps that remain within current research. However, they also expose an obvious need in the research and practice of security; namely how we tackle these challenges posed by mixing IoT with mental health, nudging at whether current practices are enough. This study intends to fill the most important gaps outlined in these points:

- Lack of robust, adaptive security frameworks specifically designed for IoT-enabled mental health applications.
- Insufficient integration of advanced encryption techniques, such as quantum cryptography, within existing IoT security protocols.
- Limited research on the ethical implications of IoT in mental health, particularly concerning patient privacy and data consent.
- Inadequate real-time threat detection mechanisms using machine learning or AI in IoT-based mental health systems.

2.1 Advanced Security Protocols and Future Directions:

Development and implementation of the next generation of advanced security protocols specifically geared towards IoT in mental health are being researched. These include next-generation firewalls, intrusion detection systems, and the use of artificial intelligence for continuous monitoring and response [11]. Moreover, the arising potential of quantum cryptography as practically unbreakable encryption is emerging as a long-term solution for IoT communications security [12]. With this progressing development of IoT technology, the cybersecurity approaches to safeguard it have to be developed as well. More research is focused on the development of more adaptive, proactive security systems that can predict and counter any intended breach. These technologies integrated into mental health IoT applications promise enhanced, more secured features, while they have all the potentials to bring revolutionary changes to the treatment and management methodologies of the diseases related to mental health.

The consideration of ethical issues is very important, especially when deploying IoT technologies in sensitive areas like mental health. There is a potential for IoT devices to put the patient under some kind of perpetual surveillance, raising serious ethical issues concerning the autonomy and self-consent of the patient. Such discussions in the literature underline the fact that if guidelines for deployment and use are to be meaningful, then they will have to be underpinned by clear ethical standards. It is important, therefore, that full disclosure of what data are being collected and how they are utilized, including access, is made to the patients [13]. In the study [14], we have observed the development of an ethical framework that combines consideration for patient safety with the innovation potential of IoT technologies in healthcare.

We are talking about a billion IoT devices, so the data volumes that get generated are, in fact, huge. The main issue then becomes how to handle that data and, at the same time, secure it. Exactly in this case, modern techniques of data management should be applied with special attention to the demands for integrity, data confidentiality, and availability. [15] looks at ways in which big data analytics may be applied to the information sourced from IoT in order to bring about improved decision-making in mental health care while ensuring that the practices of managing such data comply with stringent security standards. Further, the use of these modern and advanced technologies can also help identify patterns of something that would be indicative of a security breach or threat beforehand [16].

2.2 Emerging Trends and Future Prospects in IoT Security:

Moving forward, the literature implies that the IoT field in mental health will further develop with added focus on bettering the security measures. With the rise of blockchain technology, it has also been identified as a potential game-changer in the securing of IoT devices. Decentralization of blockchain would, therefore, protect against tampering and unauthorized access; it is strong enough to provide integrity problems with a solid solution in mental health IoT [19]. With the rise of 5G technology, it is very promising for improved performance and security of IoT devices that ensure better speeds and reliability in connections, which will make a huge difference in real-time health monitoring systems [20].

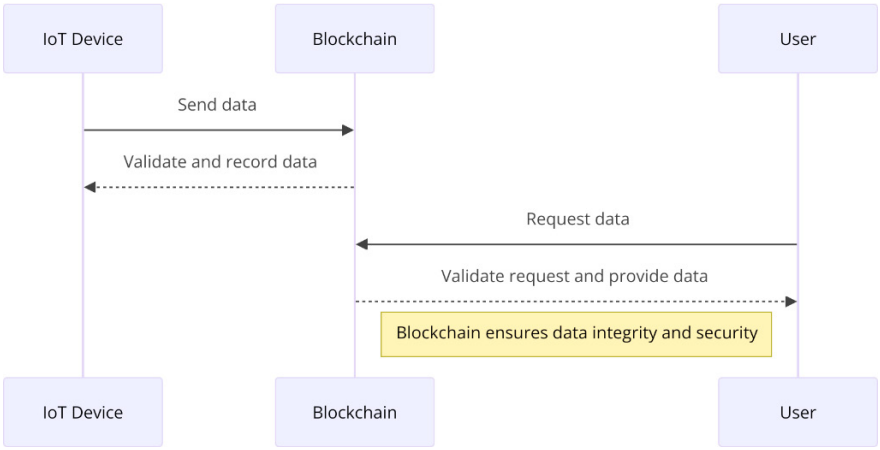


Fig. 1: Blockchain ensures data integrity and security

Recent systematic reviews have further expanded the understanding of IoT in healthcare. [26] presents a detailed synthesis of the adoption and application of IoT for smart healthcare, with findings exposing low rates of adoption by

end-users and identifying various barriers and facilitators of IoT in healthcare. According to [27], it a categorization of healthcare IoT systems on the basis of existing investigations in terms of sensor-based, resource- based, security-based, among others.

2.3 Cyber Threats in Healthcare: Trends and Financial Impact:

The number of cyberattacks on healthcare institutions is expected to triple from 2021 to 2024, propelled by the high- stakes data and rapidly growing cyber-threat landscapes. This attack is larger in size and more sophisticated, hence causing heavy losses to operational and patient care capacities each year. By 2021, it has become the most attacked health sector, touching the peak of volume and complexity against any other industry. This trend has continued in 2023, with more than 100 million people having been hit by healthcare cyberattacks, a big increase from 44 million in 2022.

The financial stakes are high: Healthcare data breaches this year cost, on average, $10.10 million per incident, up from $9.23 million a year ago. This growth represents the largest leap in cost-per-breach among all industries. This will only increase the amount of ransomware attacks and thereby adds insult to injury, seeing that nearly all healthcare organizations affected by ransomware have recovered some of the encrypted data, but at enormous financial and operational losses. It has significantly scaled up security measures in response. The focus is expanding from patient confidentiality to more complex threats such as ransomware and DDoS attacks, with healthcare providers spending more to install sophisticated cybersecurity framework. The graph below explains the trend in the number of people who will be affected by cyberattacks in healthcare, from 2021 to 2023, further substantiating the pressing need by then for strong cybersecurity measures in this industry. This then becomes one of the components that has actually spurred the increase in challenges and threats to the health sector, hence putting a high premium on strong and enhanced cybersecurity measures.

2021: Major impact on operational capacities due to data breaches.
2022: About 44 million.
2023: More than 100 million affected.

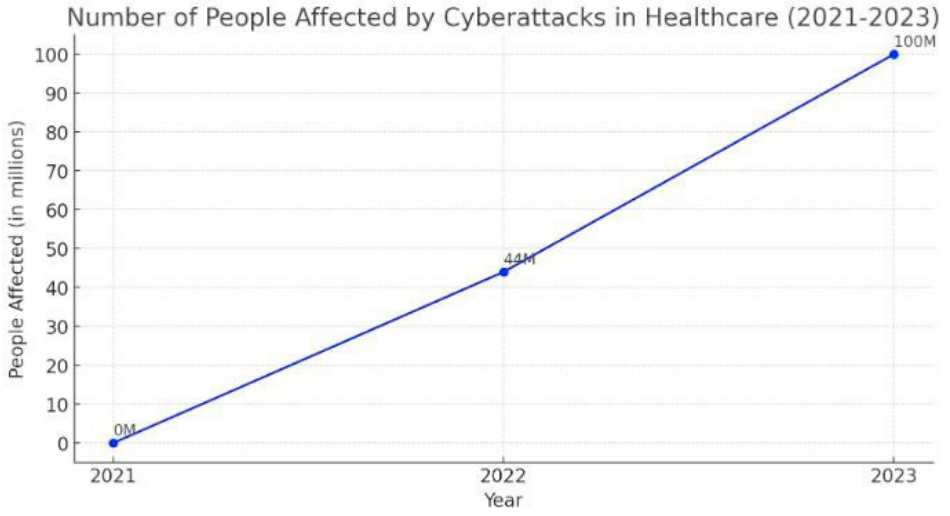


Fig. 2: Trend of People Affected by Cyberattacks in Healthcare, 2021-2023

Advanced Encryption Standard (AES) is a widely adopted algorithm that encrypts data, ensuring both its confidentiality and integrity during storage or transmission. When dealing with IOT-augmented apps for mental health we regularly find ourselves gathering and transmitting sensitive health records from one device or network to another. There AES will protect that information from being illicitly exposure by unauthorized people.

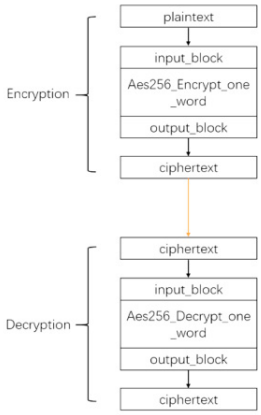


Fig. 3: AES-256 Encryption and Decryption Process Flowchart

The AES works by encrypting information with a symmetric key algorithm. This means that the same key is used for both encryption and decryption. The procedure turns clear data into gibberish, ensuring that only people with the proper decryption keys can understand what was originally said. Owing to the fact that mental health information is particularly sensitive, AES encryption takes place when data is extracted to protect patient confidentiality before it is further analyzed or processed. By integrating AES into our data workflow, we greatly reduce the likelihood of a data breach or cyberattack. Hence, IoT-enabled medical systems can be made safer in practice through this mechanism.

In the light to maintain security in IoT enabled mental health applications, AES (Advanced Encryption Standard) based encryption is an essential key to provide data confidentially and integrity. To get AES working in these systems it takes several technologies and techniques. For AES encryption you can use OpenSSL, a robust library to handle data encryption/decryption with secure methods. Further, physical security modules (HSMs) can also be used to securely manage and protect the encryption keys. Key management protocols and secure key exchange mechanisms are widely used to help keep the encryption process intact so that sensitive data remains protected from unauthorized access when stored or transferred. In complement to AES more sophisticated processes such as quantum cryptography and blockchain can be implemented for providing advanced aid in dealing with the bespoke security issues that IoT healthcare systems present us nowadays.

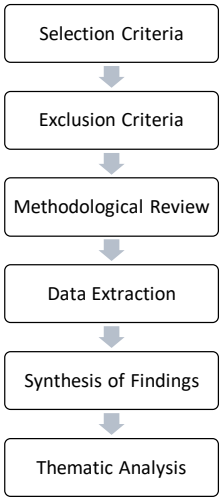
3. Discussion and Future Scope

The approach used for this systematic literature review was designed to be captured in the very large number of scholarly works that addressed matters of overlap between the Internet of Things (IoT) and their relevance to the overlapping areas of mental health and cybersecurity. This section will outline the comprehensive approach conducted in order to collect, analyse, and synthesize the relevant literature, which will aid in presenting a clear understanding of the current cybersecurity challenges and innovations within the IoT-enabled mental health applications. After this stage, the selection criteria for articles to be included in the review were applied rather strictly. Articles were selected if they were relevant to IoT in mental health settings, with special relevance to ones that address concerns of cybersecurity. Only peer-reviewed articles were considered, so as to keep the academic standards very high. But according to the exclusion criteria, articles not in the English language, not peer-reviewed, or not in direct relation to the scope of IoT in Mental Health were excluded.

Data extraction has been done in huge detail. Every article which has been selected for the inclusion has undergone detailed scrutiny. Key information extracted, thus implying the objectives, methodology, results, and conclusion of the study, with an emphasis on insights related to cybersecurity threats, challenges, and solutions in IoT-enabled applications to mental health. This was critical to pull out new insights and emerging themes from within the

scholarly discourse. The last stage of the methodology was synthesizing the findings from the literature. This process does not occur in the dimension of data aggregation but rather in dimensions of critical analysis of the emerging trends, gaps, and the points of consensus among the studies. The attempt of the synthesis was to map the current research in the landscape of IoT in mental health, where it outlined the progresses and areas that will need further research to focus. Thematic analysis helped in structuring the sections of the review that followed, providing a coherent narrative that threads the theoretical and empirical studies related to practical implications of IoT and cybersecurity in mental healthcare.

Fig.4: Methodological Approach for Systematic Literature Review



The research further solidified the base of the review by looking at the methodological approaches used in the reviewed studies. This analysis undertook review in the research design, sampling technique, and analytical methods used in the existing literature. In addition, the methodological gaps were identified, which are to be taken up in the perspective of future research to further refine and push forward methodologies deployed within IoT cybersecurity research. Integration of theoretical frameworks was also a major aspect of the methodology. The analysis was framed within the relevant theories and models applicable to cybersecurity, IoT technology, and mental health applications. Theoretical underpinning supported the context of the empirical findings within a wider concept landscape toward enhancing analysis depth and breadth. Finally, the data synthesized and the theoretical insights consolidated into an overall, comprehensive narrative that formed the backbone of the literature review section of the paper. This paper summarizes the findings and presents an interpretation that adds nuance to understanding the challenges, advances, and future directions of IoT cybersecurity within mental health care.

This part of the review paper focuses on the systematic review of literature regarding the use of the Internet of Things (IoT) in healthcare, particularly mental health, and the associated challenges in cybersecurity. The findings synthesize insights from recent studies with regard to the common cybersecurity threats facing IoT-enabled mental health services, effectiveness, and limits of current security solutions while at the same time exploring innovatively measures that may enhance the security frameworks.

3.1 Common Cybersecurity Threats to IoT-Enabled Mental Health Devices:

Integration of IoT in services offered at the mental health facilities will portend a lot of benefits with regard to patient monitoring and the accurateness of data collected. On the flip side, it shall come with a myriad of cybersecurity risks due to the protection of sensitive patient information. The literature review suggests that data breaches are a common problem; it involves unauthorized access to result in serious privacy invasions and breaks patient trust. The other serious risks to the patient data's integrity and confidentiality may arise from device tampering and the interception of data during transmission. These vulnerabilities do not only risk the privacy of the patient but also the effectiveness of treatment plans and overall patient's safety.

This complexity in devices of the IoT, together with their massive connectivity and the huge volume of data they handle, really serves to make these vulnerabilities worse. Sophisticated cyber-attacks exploiting these

vulnerabilities will bypass traditional security measures, leading to dire consequences for both patients and healthcare providers. Robust forensic techniques that would track the breaches must be used, and understanding these methods and motivations should be efforts that inform the development of effective security strategies.

3.2 Existing Solutions and Their Limitations:

The wide range of security provisions that have been installed in IoT systems seeks to protect not only the devices but also the information that such devices collect and transfer. Most of the IoT systems contain encryption techniques that guard data at rest and in transit; hence, unauthorized entities cannot derive meaning from the data in an easy manner. These algorithms, however, place an enormous computation burden and even a potential drain on the power-limited processing capabilities of the IoT device at scale.

Equally important are secure authentication protocols to make sure that the devices and their information are accessed and used only by authorized personnel. The protocols are critical to them; however, sometimes it is even intricate to install and administrate within systems hosting innumerable devices and users. Provided management isn't done suitably, then these complexities can result in security loopholes. The security of IoT devices also largely depends on updating the software in time for dealing with vulnerabilities as and when they crop up. It really only works if those updates are applied promptly, and that depends on the end-user's compliance and continued, sometimes inconsistent, support of the manufacturers.

3.3 Innovative Security Measures and Frameworks:

Considering these limitations of current available measures, recent advances in technology offer very promising avenues to enhance IoT security in healthcare. One of these ideas is blockchain technology, allowing data transactions to be decentralized. Decentralizing control of data, blockchain technology has the advantage of reduced risks toward tampering while improving, across the network, traceability and accountability in the exchange of data. Moreover, it is observed that a number of companies are deploying highly sophisticated machine-learning algorithms to improve security. This is where these algorithms can scan and find the patterns and anomalies in big sets of data with relation to cybersecurity threats. It can thus react in a secured manner to guard patients' data by identifying those potential risks before they become real. Integration of advanced technologies into the IoT security strategy gives significant potential to overcome the limitations of traditional security solutions. For example, blockchain can be used to create indestructible logs of device activity while machine learning can continuously watch network traffic and be in a position to monitor any response to activities that are unusual and might point to a breach.

It is anticipated that this study will bring about an in-depth insight to the IoT-based mental health care systems with reference to cybersecurity challenges. The research will single out fundamental vulnerabilities including unauthorized access, data disclosure and device tampering to give an insight into the key themes that make them successful IoT endpoints – especially where processing sensitive patient data is concerned. Examining status quo security measures, notably AES encryption can help in understanding the capability of existing tools to protect data as well pitfalls while countering more sophisticated and changing threats from time to time.
Besides assessing the current security situation, it will investigate novel ways of securing networks such as quantum cryptography and blockchain-based solutions. These advanced solutions are expected to provide increased security by mitigating the vulnerabilities of conventional methods. The study, at the end, should make substantial suggestions to healthcare providers; policy makers and IoT device manufacturers alike. The research endeavours to improve materials for guidance and security framework adaptability so that the cyber resilience of IoT systems in mental healthcare can be fortified against attacks, leading to a well-secured digital-healthcare patient data environment.

4. Conclusion

The health care Internet of Things (IoT) has, therefore, brought out a huge potential in the revolution of diagnostic and treatment approaches since the monitoring is improved, leading to personalized, data-driven insights. Over time, IoT devices are becoming fixtures in the health landscape that hold promise for improved patient outcomes and more efficient processes in providing care. However, in parallel with these advantages, the growth of IoT technologies introduces complex cybersecurity risks that have to be duly managed to protect sensitive patient information and ensure the integrity of medical interventions. This review systematically identified many common cybersecurity threats, which pose substantial risks to IoT-enabled mental health services. Commonly prevailing vulnerabilities included unauthorized access, data breaches, and device tampering—all pointing towards the

vulnerabilities that come along with the interconnected nature of IoT devices and the sophisticated modern healthcare data ecosystem. These security breaches can yield to jeopardized patient privacy, erode the trust in the healthcare provider, and compromise the efficacy of therapeutic interventions. Modern security solutions provide only basic security and are often implemented with limitations, including device capabilities, implementation complexity, and user compliance. Especially pronounced are the limitations in healthcare environments, given the need for real-time data access and the management of numerous IoT devices. Technologies such as blockchain and machine learning offer promising avenues for enhancing IoT security frameworks. Blockchain technology is very strong in nature, as it has a decentralized approach for the management of data. It further helps to increase the integrity and auditability of the data, thus reducing the risks of data tampering and unauthorized access. Machine learning algorithms show great promise in their capability to spot anomalies and distinct patterns within huge data streams, thus serving as an early warning system for potential security breaches before they occur.

This, however, brings to the fore that there is a crucial need for continuous research and development on security in IoT, especially for the healthcare area. Such dynamic cybersecurity threats mean that security approaches will need to not only respond to current vulnerabilities but also predict what the future might hold. The basis of this is the compelling need for the development of adaptive security technologies and frameworks that evolve in step with both technological advancements and emerging threat landscapes. Moreover, integration of IoT into mental health care needs to be taken with a lot of seriousness, especially from an ethical point of view, on matters to do with patient privacy, consent, and data integrity. The guideline and standards to control IoT in the health system must be developed and implemented with due diligence. All these should guide that IoT technologies bring benefits to the patients without risk to their safety and invading privacy and should be done, implemented in a system that shall encourage transparency and patient engagement. In conclusion, therefore, while IoT presents transformative opportunities in the delivery of mental health care, it also calls for concerted efforts among researchers, technology developers, healthcare providers, and policy-makers in addressing the major cybersecurity challenges it introduces. It means that the security of these IoT applications in the health sector is not just a technical difficulty or purely economic challenge, but it is really a moral obligation to protect patients and help in improving the quality of care in this digital era. For the findings of this review, continuing innovation, vigilance, and collaboration in the development and application of IoT in healthcare to actualize its full potential were summoned forth against the risks it carries.

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