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Internet of Things brings Revolution in eHealth: Achievements and Challenges

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Abstract

The medical field has benefited greatly from the technological revolution around our world, as well as the introduction of artificial intelligence (AI) and the Internet of Things (IoT). IoT aims to make life easier and more convenient by bridging the various gaps in connecting various devices that people employ. A wide range of applications and technologies, including wearable device development, advanced care services, personalized care packages, and remote patient monitoring, benefit healthcare professionals and patients. These technologies gave rise to new terms such as the Internet of Medical Things (IoMT), the Internet of Health Things (IoHT), e-Health, and telemedicine. With the advent of technology and the availability of various connected devices, smart healthcare, which has grown in popularity in recent years, has been positively redefined. Through the selection of literature reviews, we systematically investigate how the adoption (and integration) of IoT technologies in healthcare is changing the way traditional services and products are delivered. This paper outlines (i) selected IoT technologies and paradigms related to health care, as well as, (ii) various implementation scenarios for IoT-based models. It also discusses (iii) the various advantages of these applications and finally, (iv) a summary of lessons learned and recommendations for future applications.

Keywords: E-health; Internet of Things (IoT); Internet of Health Things (IoHT); Internet of Medical Things (IoMT); Telemedicine; Smart Healthcare

1. Introduction

With recent technological advances, various areas of life sciences, medicine, engineering, and computer applications have grown rapidly over the last few decades. These advancements have aided in the development of better, more efficient healthcare systems and facilities capable of meeting the needs of people with disabilities. Healthcare systems are organizations or systems of people and institutions dedicated to the prevention, maintenance, diagnosis, or recovery of physical injuries, mental disorders, or mental well-being, particularly through trained and qualified

professionals. The range of rural and urban facilities is broadening today, but there is still room for improvement, particularly in the rural surroundings. Since the late 1990s, the Internet of Things (IoT) has been critical to revolutionizing the current understanding of the healthcare space, as well as its efficiency in the development and improvement of healthcare services and applications used to address a variety of challenges. Internet of Things (IoT) refers to physical devices that are embedded with sensors, computing power, and other technologies that connect to and exchange data with other devices via the internet and possibly other communication networks [1]. IoT can be combined with rapidly emerging technologies such as deep learning techniques, blockchain, 5G, cloud computing, and data analytics to improve healthcare products and services. It has now broadened global communication and interaction with our immediate surroundings. We see it used in home appliances with connections around electronic devices [2], appliances, agriculture with smart irrigation systems [3], healthcare [4, 5], business [6], environmental and waste management [7], and other areas. We have seen enormous growth and progress, particularly in health care, because in the past, all patients would have to visit hospitals when they had challenges, and this is gradually being phased out with remote smart monitoring devices that still help physicians make informed decisions, replacing traditional bedside devices. There has also been significant progress in the implementation of robot assistance during complex surgical procedures, which helps with cutting any body part with minimal impact and tends to help the patient recover quicker. This revolution has also given birth to the concept of nanotechnology, which employs nanomaterials, biological devices, and nanoelectronic biosensors to precisely deliver targeted treatments in the human body [8]. Furthermore, data and intelligence collection have become much easier, as seen in 2019 during the outbreak of the dangerous COVID19 virus. Doctors were able to closely monitor patients and respond quickly. According to Statistica [9], the number of IoT devices is forecast to increase between 2020 and 2030, from 9.7 billion to more than 29 billion. China is also said to be using approximately 5 billion IoT consumer devices. Furthermore, more than 70% of healthcare providers now use these devices for collecting data and curation, and the overall market value is expected to exceed $ 534.3 billion [Figure 1]. At every level, IoT applications have incredible scalability features, and many researchers are investigating improvements in current systems and power management for many of these devices [10]. Therefore, the main goals and contributions of this research work can be seen in the identification of telemedicine and e-health IoT applications.

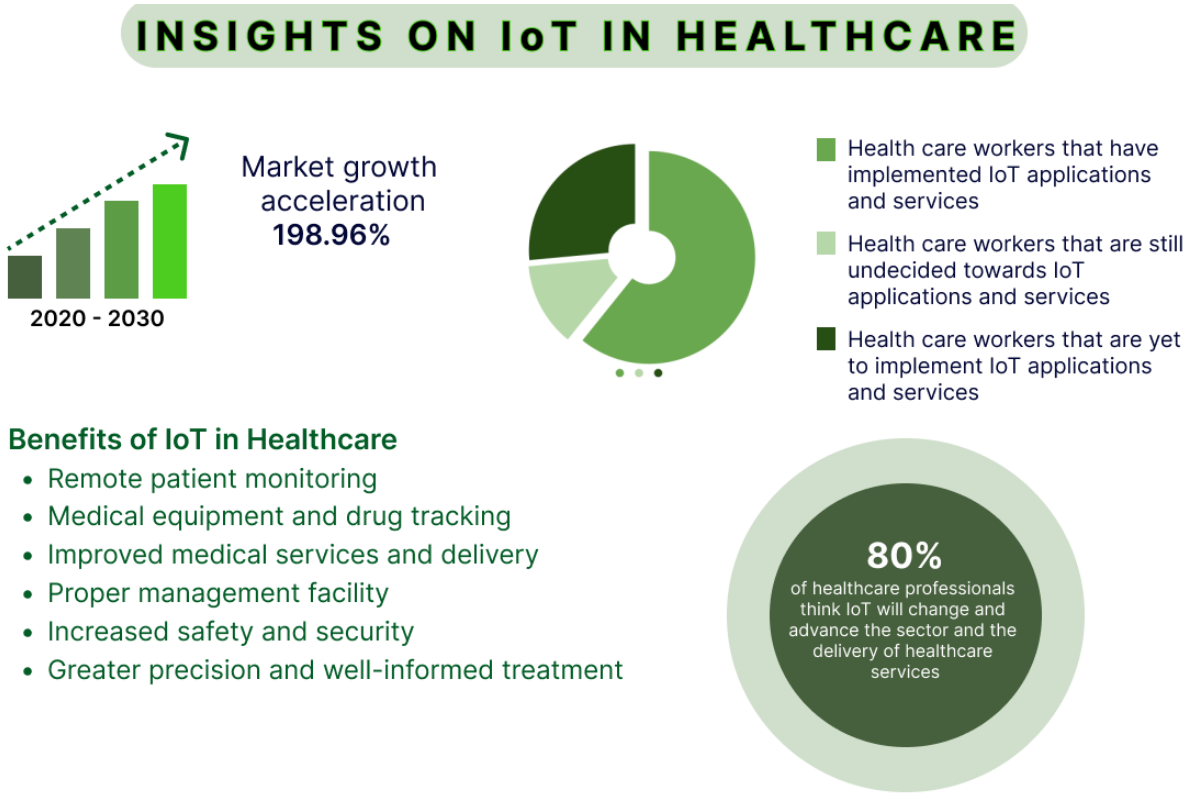

Figure 1: IoT in Healthcare 2015-2030

This research work is divided as follows: Section 2 reviews the study's literature, Section 3 provides a detailed description of the role and applications of IoT in health care, Section 4 discusses different implementation methodologies, and Section 5 breaks down the various challenges. Section 6 summarizes the findings.

2. Literature Review

This section identifies and describes telemedicine and e-health IoT applications. We chose a methodical approach to literature research that adhered to the methodology. The keywords chosen for this article's purpose and scope are "e-health," "telemedicine," "Internet of Things," "IoT," "smart healthcare," "IoT methods," and "big data." According to best practices, research journal databases such as Scopus, Web of Science, Research Gate, and IEEE Explore were chosen to avoid publisher bias.

Guadao Zhang et al. [11] carried out a systematic review of numerous IoT-based healthcare management solutions and the various implementations used by various researchers. The work was classified into different categories that addressed how patient information and data are collected, shared, and stored, as well as other security frameworks. Hamidreza et al. [12] examined various Deep Learning (DL) applications with IoT integration and characterized their work as

analyzing medical diagnosis and differentiation applications, personally tailored and home-based applications, disease prediction algorithms, and human psychology recognition. Security is a widely discussed issue in IoT, and Ismail [13] examines various security challenges as well as major privacy issues such as cyberattacks, data confidentiality, and location privacy, amongst many others. The author also discusses various threat types, their severity, and how AI can be implemented in ways that protect users' data while maintaining confidentiality. Further on data privacy and the benefits of blockchain technology, Noshina et al. [14] integrate blockchain technology's potential as a promising security precaution against various cyber threats and attacks. The authors discuss a variety of blockchain-based security mechanisms, emphasize potential challenges it poses in the healthcare system, and provide an analysis of various recommended blockchain-based security solutions. Fatima et al. [15] present an exploratory study on the impact of IoT devices in E-Health, with a particular focus on the recent pandemic COVID-19 and its variants. The authors illustrate the impact of using IoT devices such as the H2 tensiometer, medical refrigerators for storing medications, an adult home monitoring system, and records for managing all personnel to mitigate COVID-19 and its variants transmissions.

3. Role of IoT in Healthcare system

IoT in healthcare is based on the collection and storage of patient data, and there is a growing global trend in healthcare that is prophylactic, predictive, and personalized, with the need for digitization in the field underlying these trends. The Internet of Medical Things (IoMT) is a recent concept that is increasingly being used to describe the connectivity of medical advanced technologies. These products are used for data analysis, data transmissions such as medical images, and physiological and living organism signatures. The IoMT industry is broadly classified into the following categories:

3.1 E-Health

The World Health Organization (WHO) defines eHealth as the provision of medical care using cutting-edge electronic information and communication technology. Text messages, Emails, websites, and mobile applications are used by healthcare providers and patients to communicate and dialogue [16]. These services include but are not limited to, telemedicine, cardiological monitoring, electronic prescription medication or health record keeping, remote counseling, and physical and psychological diagnosis and treatment. This method of providing healthcare, which places highly qualified medical professionals in a centralized location, is becoming more popular in geographically large regions where access to healthcare is severely constrained or nonexistent. Some of its popular solutions include Telehealth, wearable technology, eHealth records, hospital information systems, and mobile applications created specifically for health-related needs, such as patient monitoring and maintenance. eHealth facilitators and executives are trying to maximize IoT equipment and technologies such as Wireless Body Sensor Network (WBSN), smart clothing, motion detector sensors that transmit data via GSM or Zigbee protocol, GPS

Smartsoles, and perhaps even low-throughput secure connections including Near Field Communication (NFC).

3.2 Telemedicine

In Greek, "tele" means "distance," and in Latin, "mederi" means "healing." The combination of both terms results in "Telemedicine," and it is defined as the use of information and communication technology to provide medical services for the diagnostic test, treatment, prevention, research, and assessment of ailments, as well as the exchange of useful information for the training of healthcare providers. Telemedicine has many applications, including patient care, professional training, research, government, and environmental health [17]. Since the early 2000s, telemedicine has rapidly expanded, utilizing technologies like enhanced internet access, connectivity, and video transmission, particularly mobile phones and Voice over Internet Protocols, for the remote monitoring of chronic patients (VoIP system wherein the authors develop a rural-specific telemedicine model that serves as an interface between clinicians and patients, having provided all of the system's built-in technology and functioning both online and offline.

3.3 E-Health Equipment Management System

In hospitals or clinics, the E-health equipment management system effectively takes information about medical staff and patients. The effective use of information systems promotes management performance within the context of human, physical, structural, organizational, and environmental factors. These systems are designed to assist hospitals in developing, monitoring, and managing devices to facilitate safe, effective, and cost-effective use and maintenance of their devices. All healthcare providers must manage their resources, keep their spending under control, and guarantee the quality of their health care [18].

4. Various Implemented IoT based methods

With the integration of numerous technological solutions like AI and blockchain, the healthcare industry is one of the world's fastest adopters of IoT. The use of various IoMT devices enhances the effectiveness and quality of the various medical services provided. This section summarizes the various IoT solutions implemented in the various studies analyzed in Table 1.

Table 1. IoT-based solutions in Healthcare systems

Reference	Proposed Solution	Findings
[19]	The authors show the benefits of incorporating both cloud and fog computing into IoT architectures, resulting in faster	Their proposed method demonstrates that this model will have several benefits, including faster treatment delivery, sustained data backup, shorter wait times, and well-organized healthcare services. The limitations stem from a

	data collection, analysis, and evaluation.	lack of appropriate interoperability techniques in real-world settings, particularly in larger hospitals.
[20]	Description of an IoT-enabled autonomous smart hospital management system that includes data mapping and event-driven workflow definition.	This model enables proper management of patient records, doctor appointments, lab management, and operational care, among other things. Because power management may not be feasible for an extended period, the limitations emanate from having to manually replace the batteries.
[21]	The COVID-19 pandemic had also caused a shortage of medical equipment, such as ICU beds, ventilators, and defibrillators. The authors have implemented a management system on an existing Total Hospital Information Systems to address this issue.	This model comprises hardware, software, communication layer, data analysis, and humans which improves medical services, management of quality of information, and necessary data required by medical personnel while scaling up Intensive Care Unit (ICU) performance.
[22]	Implementation of the SADL model for management of patient records.	Based on the Fast Healthcare Interoperability Resources (FHIR) format, the authors proposed a scalable and accurate deep learning (SADL) model with electronic patient health records. The SADL model's deep learning method using FHIR representation can predict multiple medical events from multiple centers without harmonizing site-specific data. Furthermore, the proposed method was validated using unconfirmed electronic health record (EHR) data from two academic medical centers in the United States, with 216,221 adult patients hospitalized for at least 24 hours, improving prediction accuracy.
[23]	A novel machine-learning-based security model capable of assessing the overall condition of a smart healthcare system	This model monitors and correlates the vital signs of various connected devices in a smart healthcare system to understand changes in the patient's physical function and distinguish between benign and malicious activities. It works by detecting malicious behavior in the system using four different machine learning-

		based detection approaches (artificial neural networks, decision trees, random forests, and k-nearest neighbors).

5. Challenges

The healthcare sector is seeing extraordinary technological developments as well as their application in attempting to solve health-related issues in recent years. IoHT has transmogrified the healthcare industry through the use of embedded sensors, cloud services, and telecommunication. This, however, like other technologies, still faces specific challenges and opportunities for future research.

5.1 Security and Privacy

When designing security and privacy architectures for networks, security and privacy services that use IoT-cloud-based e-Health platforms must be fully aware of all inherent risks and threats. All vulnerabilities and threat vectors must be taken into account for each system layer, and security and privacy concerns must be recognized and addressed proactively. Many doctors and healthcare professionals prefer to maintain patient records on computer systems or local systems that are not networked due to security and privacy concerns. Infrastructure development is necessary for medical record exchange so that doctors can do so while protecting patient data security [25].

5.2 Power Consumption

To permit the long-term acquisition of bio-signals outside of a hospital environment, Wireless Body Sensor Nodes (WBSNs) have become a practical/portable alternative. Patients' real-time IoT-based health is regularly monitored via WBSN outside of a hospital setting. These WBSNs use wireless transmitters and bio-sensors to collect signals from a patient's body and communicate them in real-time to a server in a private or public cloud. These WBSNs contain hardware for signal processing before signals are sent to the cloud. All of these operations taking place simultaneously in energy-constrained WBSNs result in significant power consumption, which reduces their operating lifetime [26].

The development of a low-power IoT-based e-health surveillance hardware prototype has been made possible by optimizing the various design parameters by introducing the right amount of approximations. This requires the development of a methodology to perform the best trade-off between the quality of the signal, the consumption of energy, and the usage of bandwidth.

5.3 Scalability

In the field of e-health, there are many different implements available, including mobile devices and data collection applications. Combining these factors in one system may modestly reduce health inequities and enable significant improvements in healthcare quality. The Internet of Medical Things (IoMT) has recently been the foundation for several smart healthcare systems that collect and analyze data on infectious diseases such as body fever, the flu, COVID-19, difficulty breathing, etc. with the lowest possible operating costs. However, storing health information on a secure cloud and improving the energy efficiency of the illness diagnosis system are the two most significant research hurdles in such applications. Additionally, a large number of cybercriminals have been actively trying to hack medical equipment through data loss and the creation of phony certificates as a result of the IoMT technology's explosive growth. There is therefore a lot of research interest in the growth of contemporary technologies for IoMT-based healthcare applications that secure health data and provide trusted communication to protect against attackers [27]. Recent advancement in smart e-health includes the development of an energy-efficient IoT e-health system that integrates the medical cloud with artificial intelligence and homomorphic secret sharing seeks to improve the maintainability of illness diagnosis systems and enable trustworthy communication.

5.4 Standardization

The process of standardization involves creating compatible technologies and enforcing requirements for certain standards and characteristics to guarantee compatibility, interoperability, and safety. The application of IoT services benefits the healthcare system greatly, including providing solutions for standardization to the various healthcare standards available. The goal of standardization is to achieve results though not compromising laws, standards, or patient lives in a given environment. It is difficult to enforce uniformity because the healthcare system is constantly changing, making it difficult to meet the various constraints. IoT, on the other hand, helps in bridging the gaps by providing a fundamental interoperability platform for diversified application scenarios, as well as technical specifications that outline a basic fundamental structure, security, bridging, and other requirements that enable devices to communicate with one another [28-29].

6. Conclusion and Future Scope

In recent decades, astounding technological advancements have been made, and they have been used to address health-related issues in the healthcare sector. Medical solutions are now available at the click of a finger on our smartphones, tablets, and computers. Through the use of intelligent sensors, cloud technology, and communication technologies, the Internet of Things (IoT) has completely revolutionized the medical industry. This research aimed to prioritize IoT applications in medical services, eHealth, and telemedicine. This study delves into some IoT applications in

healthcare to gain a better understanding of the industry. We highlight some of its applications in medical diagnostics and differentiation, home and personal health applications, and disease prediction applications. The Internet of Things, like any other technology, presents unique challenges and opportunities for future research. Overall, the findings of this study should be useful to medical practitioners, students, and researchers involved in healthcare IoT.

References

[1] M. Kusek, "Internet of Things: Today and tomorrow," *2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, 2018, pp. 0335-0338, DOI: 10.23919/MIPRO.2018.8400064.

[2] S. K. Vishwakarma, P. Upadhyaya, B. Kumari, and A. K. Mishra, "Smart Energy Efficient Home Automation System Using IoT," *2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU)*, 2019, pp. 1-4, DOI: 10.1109/IoT-SIU.2019.8777607.

[3] A.R. Al-Ali, Ahmad Al Nabulsi, Shayok Mukhopadhyay, Mohammad Shihab Awal, Sheehan Fernandes, Khalil Ailabouni, IoT-solar energy powered smart farm irrigation system, *Journal of Electronic Science and Technology*, Vol. 17, Issue 4, 2019, 100017, ISSN 1674-862X, DOI: 10.1016/j.jnlest.2020.100017

[4] Sangeethalakshmi K., Preethi Angel S., Preethi U., Pavithra S., Shanmuga Priya V., Patient health monitoring system using IoT, *Materials Today: Proceedings*, 2021, ISSN 2214-7853, DOI: 10.1016/j.matpr.2021.06.188

[5] M. N. Bhuiyan, M. M. Rahman, M. M. Billah and D. Saha, Internet of Things (IoT): A Review of Its Enabling Technologies in Healthcare Applications, Standards Protocols, Security, and Market Opportunities, *IEEE Internet of Things Journal*, Vol. 8, no. 13, pp. 10474-10498, 2021, DOI: 10.1109/JIOT.2021.3062630.

[6] Veena Prasad Vemuri, Priya, V. Ramesh Naik, Vijesh Chaudhary, K. RameshBabu, Mesay Mengstie, Analyzing the use of internet of things (IoT) in artificial intelligence and its impact on the business environment, *Materials Today: Proceedings*, Vol. 51, Part 8, 2022, pp 2194-2197, ISSN 2214-7853, DOI: 10.1016/j.matpr.2021.11.264

[7] M. Karthik, L. Sreevidya, R. Nithya Devi, M. Thangaraj, G. Hemalatha, R. Yamini, An efficient waste management technique with IoT based smart garbage system, *Materials Today: Proceedings*, 2021, ISSN 2214-7853, DOI: 10.1016/j.matpr.2021.07.179

[8] Pradhan Bikash, Bhattacharyya Saugat, Pal, Kunal, IoT-Based Applications in Healthcare Devices, *Journal of Healthcare Engineering*, 2021, pp 1-18, DOI: 10.1155/2021/6632599.

[9] [Online] https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/

[10] Zadtootaghaj Parang, Mohammadian Ayoub, Mahbanooei Bahareh, Ghasemi Rohollah, Internet of Things: A Survey for the Individuals' E-Health Applications, 2019, Vol. 11, pp 102-129, DOI: 10.22059/JITM.2019.288695.2398.

[11] Guodao Zhang, Nima Jafari Navimipour, A comprehensive and systematic review of the IoT-based medical management systems: Applications, techniques, trends, and open issues, *Sustainable Cities and Society*, Vol. 82, 2022, 103914, ISSN 2210-6707, DOI: 10.1016/j.scs.2022.103914

[12] Hamidreza Bolhasani, Maryam Mohseni, Amir Masoud Rahmani, Deep learning applications for IoT in health care: A systematic review, *Informatics in Medicine Unlocked*, Vol. 23, 2021, 100550, ISSN 2352-9148, DOI: 10.1016/j.imu.2021.100550

[13] Ismail Keshta, AI-driven IoT for smart health care: Security and privacy issues, Informatics in Medicine Unlocked, Vol. 30, 2022, 100903, ISSN 2352-9148, DOI: 10.1016/j.imu.2022.100903.

[14] Noshina Tariq, Ayesha Qamar, Muhammad Asim, Farrukh Aslam Khan, Blockchain and Smart Healthcare Security: A Survey, *Procedia Computer Science*, Vol. 175, 2020, pp 615-620, ISSN 1877-0509, DOI: 10.1016/j.procs.2020.07.089.

[15] Fatima Zahra Fagroud, Hicham Toumi, El Habib Ben Lahmar, Mohamed Amine Talhaoui, Khadija Achtaich, Sanaa El Filali, Impact of IoT devices in E-Health: A Review on IoT in the context of COVID-19 and its variants, *Procedia Computer Science*, Vol. 191, 2021, pp 343-348, ISSN 1877-0509, DOI: 10.1016/j.procs.2021.07.046

[16] [Online] Available: https://www.who.int/westernpacific/activities/using-e-health-and-information-technology-to-improve-health
[17] Dasgupta A, Deb S. Telemedicine: a new horizon in public health in India. Indian J Community Med, Vol 33 (1), pp 3-8, 2008, DOI: 10.4103/0970-0218.39234.
[18] C. Raj, C. Jain, W. Arif, "HEMAN: Health monitoring and nous: An IoT based e-health care system for remote telemedicine," 2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), 2017, pp. 2115-2119, DOI: 10.1109/WiSPNET.2017.8300134.
[19] Eike-Henner W. Kluge, Chapter 5 - Framework considerations, *The Electronic Health Record*, Academic Press, ISBN 9780128220450, 2020, pp 105-133, DOI: 10.1016/B978-0-12-822045-0.00005-8
[20] Andriopoulou, Foteini & Dagiuklas, Tasos & Orphanoudakis, Theofanis, Integrating IoT and Fog Computing for Healthcare Service Delivery, *Components and Services for IoT platforms*, pp 213-232, 2017, DOI: 10.1007/978-3-319-42304-3_11.
[21] M. Thangaraj, P. P. Ponmalar, and S. Anuradha, "Internet Of Things (IoT) enabled smart autonomous hospital management system - A real-world health care use case with the technology drivers," *2015 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC)*, 2015, pp. 1-8, DOI: 10.1109/ICCIC.2015.7435678.
[22] A. Aborujilah, A. -E. F. M. Elsebaie and S. A. Mokhtar, "IoT MEMS: IoT-Based Paradigm for Medical Equipment Management Systems of ICUs in Light of COVID-19 Outbreak," *IEEE Access*, vol. 9, pp. 131120-131133, 2021, DOI: 10.1109/ACCESS.2021.3069255.
[23] Rajkomar Alvin, Oren Eyal, Chen Kai, Dai Andrew, Hajaj Nissan, Liu Peter, Liu Xiaobing, Sun Mimi, Sundberg Patrik, Yee Hector, Zhang Kun, Duggan Gavin, Flores Gerardo, Hardt Michaela, Irvine Jamie, Le Quoc, Litsch Kurt, Marcus Jake, Mossin Alexander, Dean Jeff, Scalable and accurate deep learning for electronic health records, *NPJ Digital Medicine*, pp 1-26, 2017, DOI: 10.1038/s41746-018-0029-1
[24] A. I. Newaz, A. K. Sikder, M. A. Rahman and A. S. Uluagac, "HealthGuard: A Machine Learning-Based Security Framework for Smart Healthcare Systems," 2019 Sixth International Conference on Social Networks Analysis, Management and Security (SNAMS), 2019, pp. 389-396, DOI: 10.1109/SNAMS.2019.8931716.
[25] Butpheng, C., Yeh, K. H., & Xiong, H. (2020). Security and privacy in IoT-cloud-based e-health systems—A comprehensive review. Symmetry, 12(7), 1191.
[26] Ghosh, A., Raha, A., & Mukherjee, A. (2020). Energy-efficient IoT-health monitoring system using approximate computing. Internet of Things, 9, 100166.
[27] Rehman, A., Saba, T., Haseeb, K., Larabi Marie-Sainte, S., & Lloret, J. (2021). Energy-Efficient IoT e-Health Using Artificial Intelligence Model with Homomorphic Secret Sharing. Energies, 14(19), 6414.
[28] Nayak, Debasish Swapnesh Kumar; Pratik, Shreerudra; and Tripathy, Jogeswar (2022) "IoT Ecosystems Enable Smart Communication Solutions: A Case Study," International Journal of Smart Sensor and Adhoc Network: Vol. 3: Iss. 2, Article 6. DOI: 10.47893/IJSSAN.2022.1208
[29] H. Cha, Y. Choi; K. Lee, "Facilitating Healthcare IoT Standardization with Open Source: A Case Study on OCF and IoTivity," 2019 ITU Kaleidoscope: ICT for Health: Networks, Standards, and Innovation (ITU K), 2019, pp. 1-9, DOI: 10.23919/ITUK48006.2019.8996134.
[30] PATI, ABHILASH; Parhi, Manoranjan; and Pattanayak, Binod Kumar (2022) "IoT-Fog-Edge-Cloud Computing Simulation Tools, A Systematic Review," International Journal of Smart Sensor and Adhoc Network: Vol. 3 : Iss. 2 , Article 3. DOI: 10.47893/IJSSAN.2022.1206 Available at: https://www.interscience.in/ijssan/vol3/iss2/3