Cloud of Things (COT) in Healthcare: Applications, Benefits, challenges and A Way Forward to Smart Healthcare

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Abstract

Healthcare in India has become the fastest growing sector, which suffers from the existence of multiple challenges on its way. Technology, especially the IoT and cloud computing significantly contribute to the growth of healthcare and introduce a new way of smart healthcare. There is a growing application of the Cloud of Things (CoT) in healthcare. The present review defines the meaning and current status of CoT in healthcare. The CoT is the integration of cloud computing and IoT technologies. CoT and healthcare are two terms that are related to the use of cloud computing and IoT technologies in healthcare. The potential application, benefits, challenges, and solutions to overcome challenges faced in the application of CoT in healthcare are important areas discussed in this review. The future of CoT in healthcare has also been highlighted in this study.

Keywords

Healthcare, Smart healthcare, IoT, Cloud computing, Cloud of Things (CoT)

1. Introduction

Healthcare is one of the fastest-growing sectors in the context of services, revenue, and employment generation. The worldwide healthcare market was estimated at USD 362.1 billion in 2022, and from 2023 to 2030, it is anticipated to increase at a CAGR of 7.96%. By 2027, it is projected that the healthcare industry would produce revenues with a compound annual growth rate (CAGR) of 10.40% and a market volume of US$ 85.9 billion. There will be 1.57 billion users in the healthcare industry by 2027[1].

Healthcare is growing at an exceptional rate because of the aging population, lifestyle diseases, demand for affordable healthcare services, increasing awareness towards health, attitude transformation towards preventive healthcare, advancement in the area of healthcare technology, continuous health insurance penetration, and initiatives taken by the government are driving the healthcare sector. Healthcare can be segmented into three broad domains i.e. primary care, secondary care, and tertiary care. Figure: 1 presents the different segments of healthcare along with the care given in each segment.

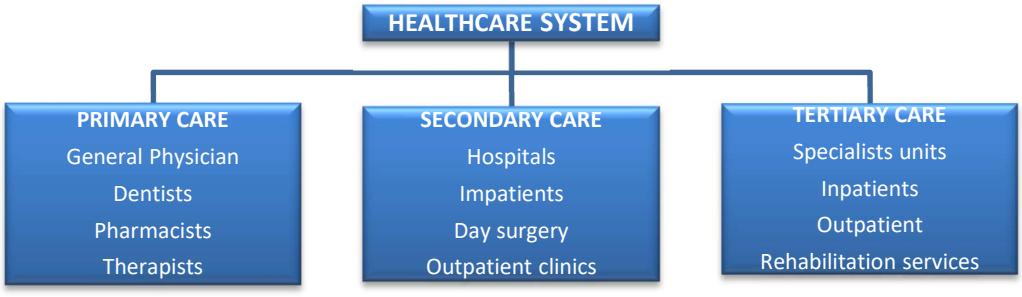

Figure: 1 Domains of Healthcare [2]
Source: Walshe K, Smith J, editors. Healthcare management. McGraw-Hill Education (UK); 2011 Sep 1[2].

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But healthcare has downsides too. An overburdened healthcare system, challenges to the supply chain, less patient access to healthcare data, disrupted healthcare business activities, etc. are some prevailing challenges the healthcare facing. The Current ways to avail healthcare facility are inconvenient and time-consuming, which is not capable of fulfilling the healthcare requirement of the growing population. This situation of the existing healthcare system enhances the need for smart healthcare facilities which support lowering the burden on the healthcare system by providing low-cost, fast, and convenient healthcare facilities for common people. Due to this, the use of technology has become increasingly important to reduce workload and improve efficiency within healthcare systems. Technology, enabled by cloud and IoT may contribute remarkably to the growth of smart healthcare. "Smart healthcare" describes the application of technology to raise the standard, accessibility, and effectiveness of medical care. Numerous applications, including telemedicine, wearable technology, artificial intelligence, big data analytics, cloud computing, and IoT can be used in smart healthcare. The amalgamation of cloud and IoT also known as cloud IoT or cloud of Things (CoT) offers an efficient solution for smart healthcare surveillance systems [3]. The present review focuses on the integration of CoT in healthcare that helps manage patients and other remote services.

2. Cloud of Things (CoT)

The integration of cloud computing and IoT technologies is known as CoT [4]. It focuses on bringing IoT to the cloud, where all IoT capabilities and devices can be approached as a service through the cloud (e.g., sensing as a service SenaaS). In CoT, as a middleware cloud makes a transparent interaction between users/applications and things [5]. This interaction between Cloud and IoT benefits each other. The virtual unlimited storage and computing resources of the cloud can benefit IoT, whereas IoT provides the cloud the chance to extend its services to real-world things [6].

The CoT offers data monitoring, storage, processing, analysis, and visualization capabilities for IoT devices, as well as enables communication and collaboration among users [3]. The scope of CoT is promoting smart applications and services that promote the extension of the cloud through things, which opens new issues as well as opportunities [6, 7]. It can be practiced for different purposes and areas such as healthcare, education, environmental monitoring for smart homes, smart cities, villages, mobility, surveillance and logistics, etc. [3]. It develops communication links between heterogeneous devices and handles ever-increasing data demands [8, 9].

3. Cloud of Things (CoT) and Healthcare

CoT and healthcare are two terms that are related to the application of IoT technologies and cloud computing in healthcare. Cloud computing refers to the on-demand availability of data storage and computing resources managed by external service providers over the Internet. The network of physical devices and objects that are linked with connectivity, software and sensors, which help them to gather and exchange data is known as IoT. By using cloud-based platforms and IoT devices, CoT creates a system that allows healthcare providers and patients to analyze and share health-related data accessed through different locations and sources and thus empowers them by enabling healthcare services more accessible and affordable. It involves the collection, dissemination, and analysis of data gathered from various medical devices, sensors, and wearable through a network of cloud-based platforms [10]. The data so collected securely transmits to the cloud, where it can be stored, processed, and analyzed. Additionally, by streamlining the process of collecting patients' essential data, CoT enhances the quality of healthcare processes and the actual healthcare services.

In healthcare, CoT offers numerous benefits such as remote patient care, real-time monitoring of vital signs, data analytics, medication adherence, and improved healthcare delivery. This allows timely intervention and personalized care by detecting abnormalities and changes in health conditions. For the purpose of handling large volumes of healthcare data cloud-based platform offers storage capacity, scalability, and computational power[3,4,11] which further offers advanced analytics techniques such as artificial intelligence and machine learning for gathering valuable insights from the collected data. These insights further contribute to early disease detection, predictive modeling, and recommendation of personalized treatment. It also supports in seamless integration and interoperability of diverse healthcare systems, devices, and platforms, enabling efficient exchange of data and collaboration among healthcare providers Figure: 2 presents the functioning of the cloud in case of remote monitoring of patients.

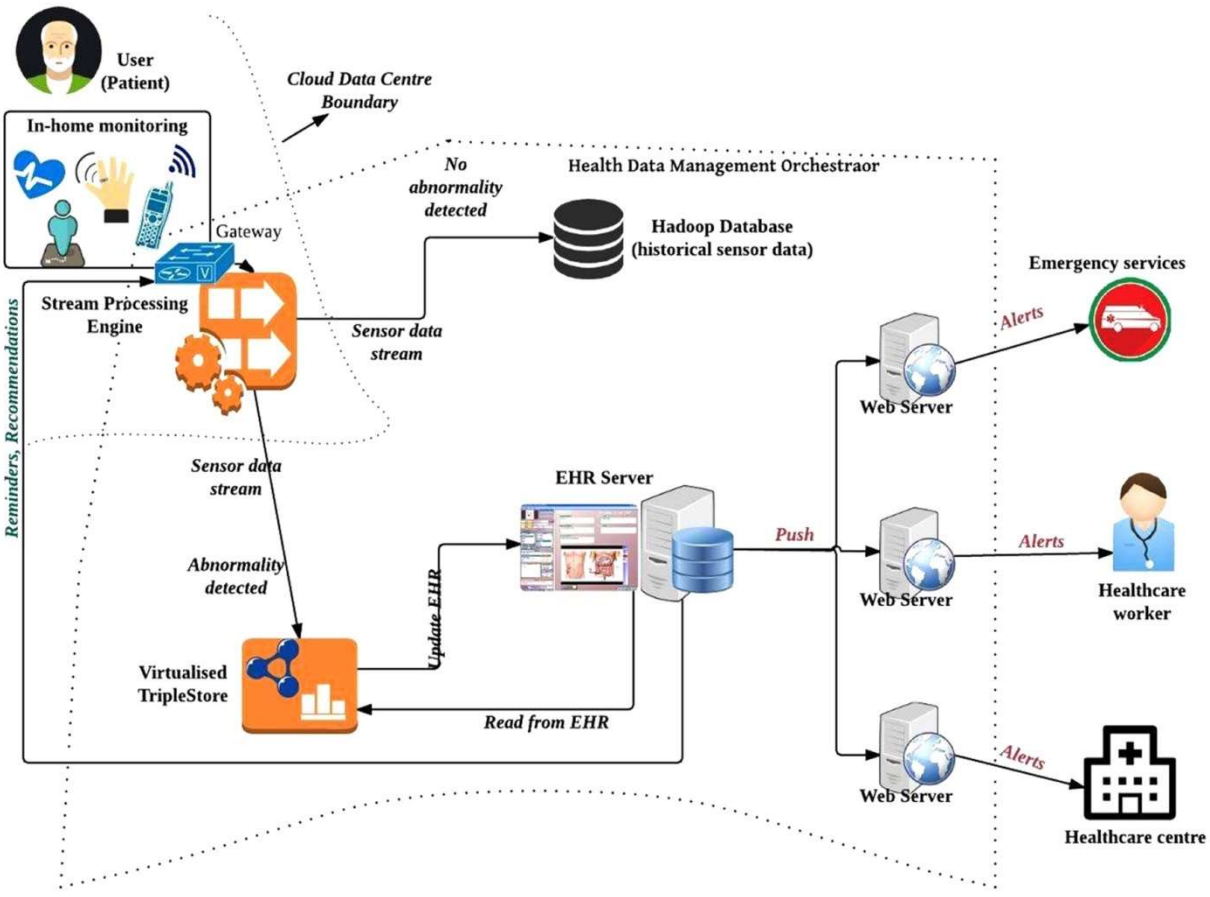

Figure: 2 Remote Healthcare applications using the CoT
Source: Shah, T., Yavari, A., Mitra, K., Saguna, S., Jayaraman, P. P., Rabhi, F., & Ranjan, R. (2016). Remote health care cyber-physical system: quality of service (QoS) challenges and opportunities. IET Cyber-Physical Systems: Theory & Applications, 1(1), 40-48 [11].

Moreover, CoT in healthcare offers opportunities for telemedicine and remote patient care. It enables virtual consultations, remote diagnosis, and treatment, allowing healthcare providers to reach and serve patients in remote or underserved areas. This technology can increase access to healthcare services, reduce healthcare costs, and improve patient outcomes. CoT in healthcare presents numerous opportunities to medical IT infrastructure and can enhance healthcare services. Additionally, by streamlining the procedure, CoT enhances the quality of the actual healthcare services as well as the processes involved in providing them. It also poses challenges

related to data security, privacy, regulatory compliance, and ethical considerations [12]. Addressing the applications and benefits of CoT in healthcare is essential to ensure the successful adoption and implementation of CoT solutions in the healthcare ecosystem and a way towards smart healthcare.

4. Applications and benefits of CoT in healthcare

IoT devices are smart devices that can collect and transmit data from various sources, such as sensors, wearables, implants, etc. Smart watches, sensors, and cameras monitor and transmit patients' vital signs and health data to cloud servers for real-time analysis and feedback [13]. These devices monitor and transmit patients' vital signs, such as blood pressure, heart rate, glucose level, and oxygen saturation, to cloud servers for real-time analysis and feedback [14, 15, 16, 17]. They can be used for various purposes in health care, such as monitoring vital signs, tracking medication adherence, detecting falls, etc. [13]. For IoT devices cloud computing provides storage, processing, analysis, and visualization of data along with remote access and control.

Platforms like Telemedicine and e-health make it possible for people to quickly and remotely access healthcare services online. It consists of distant diagnosis, therapy, advice, instruction, etc. [18]. The CoT can make it easier for patients and various healthcare providers to share and save medical data including electronic health records (EHR), radiological pictures, lab results, etc. The CoT can also support telehealth applications that make use of IoT gadgets and sensors, such as video consultations, remote patient monitoring, personal health monitors, etc. [19]. Besides this Medical imaging and analysis entails the collection and analysis of substantial amounts of medical images, including X-rays, CT scans, MRI scans, and others. For storing and analyzing medical images, CoT can offer scalable and affordable computer resources. CoT can also make it possible to apply machine learning and AI methods to improve the precision and efficacy of medical picture analysis. [20].

The presence of Clinical and hospital information systems manages the administrative and operational aspects of healthcare facilities, such as patient registration, billing, inventory, scheduling, etc. The CoT can improve the efficiency and security of these systems by providing centralized and integrated data management, backup and recovery, access control, etc. The CoT can also enable real-time data sharing and collaboration among different departments and stakeholders [21]. Along with these, medical decision support systems helps medical practitioners, make clinical decisions that are supported by evidence-based standards and recommended practices. By giving users access to extensive and up-to-date databases of medical knowledge, including information on drug interactions, disease symptoms, and treatment alternatives, the CoT can improve the performance and functionality of these systems. CoT can also make it possible to use AI and big data analysis to produce individualized and foreseeable insights for medical diagnosis and therapy. [19].There are need of secondary use of health data for activities such as research, public health monitoring, quality improvement, etc. that are not directly related to patient care [22]. The CoT can simplify the gathering and combining of health data from many sources, including electronic health records (EHRs), IoT gadgets, wearable, etc. To ensure privacy and interoperability, CoT can also make it possible to standardize and anonymize health data [23].Finding new medications or altering current ones to cure ailments is a process known as drug discovery. By enabling extensive data collecting, analysis, simulation, and modeling of potential drug candidates, IoT devices might hasten the process of drug discovery. For Internet of Things (IoT) devices, cloud computing can offer data storage, processing, analysis, and visualization capabilities as well as access to shared resources and tools [13].

Cloud-based digital libraries that are accessible and stored on the cloud are collections of digital resources. They can offer simple and convenient access to a wealth of current and pertinent material, including medical literature, journals, books, reports, etc., for researchers and healthcare practitioners. By facilitating user cooperation and communication as well as data collection and transmission, IoT devices can support cloud-based digital libraries. For cloud-based digital libraries, cloud computing can offer features for data storage, security, privacy, accessibility, and interoperability [24].IoT-based applications in healthcare information systems, such as electronic health records (EHRs), clinical decision support systems (CDSSs), and personal health records (PHRs), manage and store health-related data. Through the collection and transmission of health data from diverse sources, including sensors, wearable, implants, and other IoT devices, healthcare information systems can perform more effectively and efficiently. Healthcare information systems can benefit from cloud computing's data storage, security, privacy, accessibility, and portability advantages [3, 9].

Utilizing data-driven insights, agile operations, and strategic collaborations on cloud platforms, it ensures the accessibility and affordability of necessary medications, vaccinations, and medical equipment. Big data analytics and cloud computing are useful for health analytics. It helps in gaining inputs and predictions about disease patterns, treatment, risk factors, etc. [25, 26, 27]. CoT can help healthcare organizations save on IT expenses, such as hardware, software, maintenance, and personnel. The CoT can also enable pay-as-you-go models, where healthcare organizations only pay for the resources; they use [28, 29].

CoT can help healthcare organizations increase their agility and innovation by providing access to the latest technologies and tools. The CoT can enable healthcare organizations to adopt new solutions and services faster and easier. The CoT can also enable healthcare organizations to leverage AI, machine learning, big data analysis, IoT, etc., to enhance their operations and outcomes [30]. Personal health trackers can help you manage not only your physical health but also your mental and emotional well-being. They can track your mood, stress level, sleep quality, etc., and provide you with feedback and suggestions to improve your overall health [31]. Regularly monitoring your biometric readings enables you to identify any small anomalies in your health and take preventative action before they worsen. This can reduce the need for hospitalization and save costs and time [25]. CoT can help healthcare organizations improve their collaboration and communication among different stakeholders, such as patients, doctors, nurses, pharmacists, etc. The CoT can enable real-time data sharing and synchronization across different devices and locations. The CoT can also facilitate telemedicine and e-health services. In addition to providing users with access to data, cloud computing also offers automated backups and data recovery tools in case data is ever lost for any reason [32].

5. Challenges of CoT in healthcare

While CoT offers numerous benefits, there are also challenges and considerations related to data security, privacy, regulatory compliance, and ethical implications. The successful adoption and implementation of CoT in healthcare depends on addressing these issues.

5.1. Security and privacy issues:

CoT involves the storage and transmission of sensitive and confidential data, such as patient records, medical images, lab reports, etc. This data is vulnerable to unauthorized access, theft, loss, or breach by hackers, malicious insiders, or third parties [33]. The interconnected nature of CoT devices and systems increases the vulnerability to cyber security threats, including data breaches and unauthorized access. CoT also needs to comply with various regulations and standards available in different countries and regions such as the Health Insurance Portability and Accountability Act (HIPAA) 1996 and General Data Protection Regulation (GDPR) 2016, etc.,

that protect the privacy and security of health data [34]. The interconnected nature of CoT devices and systems increases the vulnerability to cyber security threats, including data breaches and unauthorized access.

In addition, strong authentication, end-to-end encryption, keeping a clean machine, and implementing access controls bolsters healthcare data protection by restricting access to patient information and certain applications to only those users who require access to perform their jobs should be practiced to solve the issue of security and privacy. Access restrictions require user authentication, ensuring that only authorized users have access to protected data. Using efficient data management methods to store, process, and analyze healthcare data in the cloud. This can help reduce the time to market for IoT healthcare solutions, as well as enable insights backed by advanced analytics and AI.

5.2 Interoperability and compatibility issues:

CoT involves the integration and communication of various devices, platforms, applications, and services that may have different protocols, formats, standards, or architectures [35]. This may cause interoperability and compatibility issues that affect the functionality and performance of the CoT. CoT also needs to ensure the quality and reliability of data across different sources and systems [36].

There are different laws and regulations regarding data protection, privacy, and ownership in different countries and regions, which pose challenges for cloud computing and IoT services that operate across borders [37]. Interoperability standards and central regulations can help to harmonize the legal and technical aspects of cloud computing and IoT in health care [38].

5.3. Reliability and availability issues:

CoT depends on the availability and performance of cloud services and network connectivity. Any downtime, outage, or disruption of these services or networks may affect the accessibility and delivery of CoT. It also needs to ensure the scalability and elasticity of cloud resources to meet the varying demands and needs of healthcare applications [38, 39]. Therefore, careful analysis and a customized design are needed to achieve the optimal balance between reliability and availability for each CoT application.

5.4. Regulatory and ethical issues:

CoT involves the use and reuse of health data for various purposes, such as research, public health surveillance, quality improvement, etc. This may raise regulatory and ethical issues regarding the consent, ownership, control, and accountability of health data. CoT also needs to ensure the transparency and trustworthiness of cloud services and providers [38, 39].

To address them effectively, CoT applications need to adopt a multidisciplinary approach that involves collaboration among various disciplines such as law, ethics, medicine, engineering, computer science, and social science. They also need to follow ethical principles such as respect for persons, beneficence, non-maleficence, justice, and accountability [40]. By doing so CoT applications can ensure that they are not only innovative and beneficial but also responsible and trustworthy for patients and society as a whole.

5.5. IoT devices will increase the attack surface:

The more devices are connected to the cloud, the more vulnerable they are to cyberattacks that can compromise the privacy and security of patients' data and health records [10].

Implementing strong security features and protocols for IoT devices and cloud services. This can help protect the data from unauthorized access, modification, or loss, as well as ensure compliance with privacy and regulatory standards such as HIPAA.

5.6. Legal and regulatory issues:

There are different laws and regulations regarding data protection, privacy, and ownership in different countries and regions, which pose challenges for cloud computing and IoT services that operate across borders [36].

Therefore, CoT applications need to establish clear legal frameworks and contracts that define the roles, rights, duties, obligations, and liabilities of each actor and stakeholder involved in CoT applications [40]). They also need to provide mechanisms for dispute resolution and redress for any affected parties.

6. Future of CoT in healthcare

The future of CoT in healthcare holds significant potential for transforming it into smart healthcare. Here are some key aspects that are expected to shape its future:

6.1. More innovation and digitization:

With the use of CoT the future of healthcare will be more innovative and digitalized. This means using CoT to enable new use cases, such as personalized medicine, precision medicine, digital therapeutics, and smart hospitals [41]

6.2. Advanced Data Analytics:

CoT will keep utilizing advanced data analytics techniques, such as machine learning and artificial intelligence, to extract useful insights from the enormous amounts of healthcare data created [42] .These analytics capabilities can support the early detection of diseases, personalized treatment recommendations, and predictive modeling for improved patient outcomes.

6.3. More accessibility and affordability:

CoT will improve the reach and quality of health care, especially for underserved and remote populations [43].

6.4. Precision Medicine and Personalized Healthcare:

CoT can contribute to the advancement of precision medicine by enabling the collection, integration, and analysis of diverse patient data, including genomics, clinical records, and environmental factors. This holistic approach can support personalized healthcare interventions and treatments tailored to individual patients.

6.5. More collaboration and integration:

CoT will facilitate data sharing and interoperability among different healthcare stakeholders, such as providers, payers, patients, researchers, and regulators [44].

6.6. More efficiency and quality:

CoT will optimize the performance and outcomes of healthcare processes, such as diagnosis, treatment, monitoring, and prevention [45].

6.7. More empowerment and engagement:

CoT enhances the participation and satisfaction of patients and healthcare workers in their healthcare [44].

7. Conclusions

Across the healthcare sector, CoT has a wide range of applications. CoT application in healthcare is only supporting human efforts rather than replacing human involvement and opening a new way of smart healthcare where an individual is capable enough to monitor and analyze the symptoms and approach the healthcare provider while located remotely. On the other side, many challenges exist on the path of CoT applications, which requires a framework to overcome the situation. The present review discusses the application of CoT in healthcare, a solution towards smart healthcare, the challenges faced on the path of its application, and recommendations to solve the problem.

CoT-based transformation in healthcare has the potential to open a way of smart healthcare by improving the overall sector through cost reduction and better access to quality healthcare. This could be possible through a strong collaboration between the key stakeholders of the CoT healthcare ecosystem. With the application of CoT, many healthcare-related problems can be solved.

Even after continuous efforts in this regard, many challenges exist on the path of its widespread adoption and implementation. Issues related to security and privacy, interoperability and compatibility, reliability and availability, regulation and ethics, massive inputs of generated data, obsolete existing software infrastructure, high-power consumption, and legal and regulatory issues are the main ones in this regard. Exploring the unknown, leveraging the power of digitalization, building strong partnerships, embracing positive cultural change, and adopting interoperability standards and central regulations are some of the required measures to apply CoT in the healthcare sector for a new way of Smart healthcare.

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References:

[1] https://www.statista.com/outlook/dmo/ecommerce/beauty-health-personal-household-care/health-care/worldwide?kw=&crmtag=adwords&gclid=Cj0KCQjwzdOlBhCNARIsAPMwjbxf5ieNZmALYzcySjkUxeBYbyL0xFKb0-OIlxAN0s_O-tejb5Zxng0aAh2aEALw_wcB
[2] Walshe K, Smith J, editors. Healthcare management. McGraw-Hill Education (UK); 2011 Sep 1.
[3] Aazam M, Huh EN, St-Hilaire M, Lung CH, Lambadaris I. Cloud of things: integration of IoT with cloud computing. Robots and sensor clouds. 2016:77-94.

[4] Aazam M, Khan I, Alsaffar AA, Huh EN. Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. InProceedings of 2014 11th International Bhurban Conference on Applied Sciences & Technology (IBCAST) Islamabad, Pakistan, 14th-18th January, 2014 2014 Jan 14 (pp. 414-419). IEEE..
[5] Cavalcante E, Pereira J, Alves MP, Maia P, Moura R, Batista T, Delicato FC, Pires PF. On the interplay of Internet of Things and Cloud Computing: A systematic mapping study. Computer Communications. 2016 Sep 1;89:17-33.
[6] Botta A, De Donato W, Persico V, Pescapé A. Integration of cloud computing and internet of things: a survey. Future generation computer systems. 2016 Mar 1;56:684-700.
[7] Babu SM, Lakshmi AJ, Rao BT. A study on cloud based Internet of Things: CloudIoT. In2015 global conference on communication technologies (GCCT) 2015 Apr 23 (pp. 60-65). IEEE..
[8] Darwish A, Hassanien AE, Elhoseny M, Sangaiah AK, Muhammad K. The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. Journal of Ambient Intelligence and Humanized Computing. 2019 Oct;10:4151-66.
[9] Ullah I, Akhtar KM, Shahzadi I, Farooq M, Yasmin R. Encouraging knowledge sharing behavior through team innovation climate, altruistic intention and organizational culture. Knowledge Management & E-Learning. 2016;8(4):628.
[10] IoT in Healthcare: Benefits, Use Cases, Challenges, and Future. May 5, 2020. Retrieved from: https://www.intellectsoft.net/blog/iot-in-healthcare/
[11] Shah T, Yavari A, Mitra K, Saguna S, Jayaraman PP, Rabhi F, Ranjan R. Remote health care cyber-physical system: quality of service (QoS) challenges and opportunities. IET Cyber-Physical Systems: Theory & Applications. 2016 Dec;1(1):40-8.
[12] Cresswell K, Williams R, Sheikh A. Using cloud technology in health care during the COVID-19 pandemic. The Lancet Digital Health. 2021 Jan 1;3(1):e4-5.
[13] Kaur M, Sugadev M, Kaur H, Mahmood MR, Maheshwari V. Healthcare Internet of Things: A New Revolution. Ambient Intelligence and Internet of Things: Convergent Technologies. 2022 Dec 20:301-37.
[14] Farhan L, Hameed RS, Ahmed AS, Fadel AH, Gheth W, Alzubaidi L, Fadhel MA, Al-Amidie M. Energy efficiency for green internet of things (IoT) networks: A survey. Network. 2021 Nov 29;1(3):279-314.
[15] Abdulmalek S, Nasir A, Jabbar WA, Almuhaya MA, Bairagi AK, Khan MA, Kee SH. IoT-based healthcare-monitoring system towards improving quality of life: A review. In Healthcare 2022 Oct 11 (Vol. 10, No. 10, p. 1993). MDPI.
[16] Alshamrani M. IoT and artificial intelligence implementations for remote healthcare monitoring systems: A survey. Journal of King Saud University-Computer and Information Sciences. 2022 Sep 1;34(8):4687-701.
[17] Rathi, V.K., Rajput, N.K., Mishra, S., Grover, B.A., Tiwari, P., Jaiswal, A.K. and Hossain, M.S., 2021. An edge AI-enabled IoT healthcare monitoring system for smart cities. Computers & Electrical Engineering, 96, p.107524.
[18] Kelly JT, Campbell KL, Gong E, Scuffham P. The Internet of Things: Impact and implications for health care delivery. Journal of medical Internet research. 2020 Nov 10;22(11):e20135.
[19] Pradhan B, Bhattacharyya S, Pal K. IoT-based applications in healthcare devices. Journal of healthcare engineering. 2021 Mar 18; 2021:1-8.
[20] Moghaddasi H, Tabatabaei Tabrizi A. Applications of cloud computing in health systems. Global Journal of Health Science. 2016 Oct 28;9(6):33.
[21] Applications Of Cloud Computing In Healthcare. 18 Jan 2022. Retrieved 18 April 2023 from: https://www.ridge.co/blog/cloud-computing-in-healthcare/
[22] Rathi BS, Kumar PS, Show PL. A review on effective removal of emerging contaminants from aquatic systems: Current trends and scope for further research. Journal of hazardous materials. 2021 May 5; 409:124413.
[23] Moghaddasi H, Tabatabaei Tabrizi A. Applications of cloud computing in health systems. Global Journal of Health Science. 2016 Oct 28; 9(6):33.

[24] How 'Cloud Medicine' Can Change the Indian Healthcare Sector? APR 6, 2019. Retrieved from: https://www.entrepreneur.com/en-in/technology/heres-what-you-need-to-know-about-cloud-medicine/331839
[25] Aceto G, Persico V, Pescapé A. Industry 4.0 and health: Internet of things, big data, and cloud computing for healthcare 4.0. Journal of Industrial Information Integration. 2020 Jun 1; 18:100129.
[26] Smys DS, Raj DJ. Internet of things and big data analytics for health care with cloud computing. Journal of Information Technology and Digital World. 2019 Sep;1(1):9-18.
[27] What is Microsoft Cloud for Healthcare? March 8, 2023. Retrieved 8 June 2023 from: https://learn.microsoft.com/en-us/industry/healthcare/overview
[28] The 9 key benefits of cloud computing in healthcare. Retrieved 6 June 2023 from: https://www.hyland.com/en/resources/articles/benefits-of-cloud-computing-in-healthcare
[29] 10 Key Benefits of Cloud Computing in the Healthcare Industry. Retrieved 19 April 2023 from: https://www.analyticsinsight.net/10-key-benefits-of-cloud-computing-in-the-healthcare-industry/
[30] 7 benefits of having personal trackers to monitor your health. Jan 9, 2021.Retrieved 20 May 2023 from:https://goodlife.luluhypermarket.com/en-ae/electronics/7-benefits-of-having-personal-trackers-to-monitor-your-health
[31] Cloud Computing in Healthcare: Examples, Benefits & Challenges. Retrieved 15 April 2023 from: https://www.datamation.com/cloud/cloud-computing-for-healthcare/
[32] Kuo MH. Opportunities and challenges of cloud computing to improve health care services. Journal of medical Internet research. 2011 Sep 21; 13(3):e1867.
[33] Raza, S., et al.CoT for Healthcare: Challenges and Opportunities. IEEE Cloud Computing, 4(2), 20-27. (2017) DOI: 10.1109/MCC.2017.24
[34] https://www.forbes.com/sites/forbestechcouncil/2023/04/27/the-privacy-prescription-rules-restricting-health-data-use-and-how-to-employ-more-holistic-security-measures/?sh=6f96f9674584
[35] Zhang, M., et al. Internet of Things (IoT) Applications to Improve Health Outcomes in Older Adults: Scoping Review. Journal of Medical Internet Research. 2018; 20(7),e10442. DOI: 10.2196/10442
[36] Selvaraj S, Sundaravaradhan S. Challenges and opportunities in IoT healthcare systems: a systematic review. SN Applied Sciences. 2020 Jan; 2(1):139.
[37] Kuo MH. Opportunities and challenges of cloud computing to improve health care services. Journal of medical Internet research. 2011 Sep 21;13(3):e1867.
[38] Calvillo-Gamez, E., et al. (2018). Ethical Challenges and Privacy Issues in the Era of the Internet of Things (IoT) for Health and Well-being. Studies in Health Technology and Informatics, 248, 112-119. DOI: 10.3233/978-1-61499-852-5-112
[39] Ren, J., et al. (2018). A Review of Internet of Things (IoT) Approaches for Healthcare. IEEE Access, 6, 79217-79227. DOI: 10.1109/ACCESS.2018.2884728
[40] Naik N, Hameed BM, Shetty DK, Swain D, Shah M, Paul R, Aggarwal K, Ibrahim S, Patil V, Smriti K, Shetty S. Legal and ethical consideration in artificial intelligence in healthcare: who takes responsibility? Frontiers in surgery. 2022 Mar 14; 9:266.
[41] Kuo MH. Opportunities and challenges of cloud computing to improve health care services. Journal of medical Internet research. 2011 Sep 21; 13(3):e1867.
[42] https://www.mavenwave.com/industries/healthcare-life-sciences/
[43] What payers and providers can learn from successful cloud transformations in other industries? Retrieved 30 April 2023 from: https://www.mckinsey.com/industries/healthcare/our-insights/what-payers-and-providers-can-learn-from-successful-cloud-transformations-in-other-industries
[44] The future of cloud computing in healthcare. June 23, 2022. Retrieved 4 June 2023 from: https://zivaro.com/the-future-of-cloud-computing-in-healthcare
[45] THE FUTURE OF CLOUD: HEALTHCARE. April 30, 2021. Retrieved 22 May 2023 from: https://www.capgemini.com/insights/expert-perspectives/the-future-of-cloud-healthcare/.