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The Evolution of Internet of Things (IoT) in Global Healthcare

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Abstract:- The evolution of IoT in technological advancement has found its way into virtually all aspects including transportation, education, and healthcare systems. The Implementation of IoT has posed a major challenge to providers of healthcare services. Previous reviews have specified their approach to its applications. However, there is a need for thorough reviews to provide more insights into IoT, the challenges faced, and likely solutions for effective implementation. This article reviews different IoT monitoring systems, explores their challenges, by optimizing suitable IoT parameters for efficient healthcare delivery both for patients and healthcare workers and suggests possible solutions. It examines the idea of wearable devices in healthcare in addition addresses related security concerns, recommending proper patient education as a key measure. The integration of IoT of some integrated into systems in health can help reduce costs, improving efficiency, and boosting overall performance. This study serves as a foundation for incorporating IoT into healthcare monitoring systems.

Keywords:- *IoT, Healthcare, Security, Wearable Sensors.*

I. INTRODUCTION: THE EVOLUTION OF IOT

The Internet of Things (IoT) is a network of real-world objects or things connected with electroni cs, sensors, software, and network connectivity to collect and share data. Without human interven tion, it is a network of networked devices that can transmit data. Everything that is physical and h as sensors and network connectivity is part of the Internet of Things (IoT), which allows these de vices to communicate and collect data. (Sobhan et al., 2016; Dutta et al., 2021; Plageras & Psannis 2023). IoT, or smart healthcare, is created by merging the networks with the healthcare sector. The goals of smart healthcare are to improve people's quality of life, and increase patients' awareness of their health state around the clock (Yaseein et al., 2019). The emanation of technological advancement has brought about a drastic shift in healthcare resulting in the introduction of sensors and data science.

Internet of Things has several uses in health care , one of which includes monitoring a patient's health. By enabling real-time patient health monitoring, which gathers data as well as lower human mistake rates. Through the Internet of Things, a patient's parameters are sent over a gateway through medical devices, where it is stored and examined (Vidya et al., 2018). Recent review by Yassein et al. (2019) showed that through the integration of this technology into various functions, all industries are attempting to take advantage of its benefits. One of the leading sectors that benefited greatly from the advancement of technology and perceived its advantages was the healthcare sector.

Globally, there has been a sharp increase in IoT in Healthcare, which is the term for the digitizati on of data, namely health data, and the use of this technology in health care. One important factor in exponential rise of IoT in health has been the COVID-19 pandemic (Dash S., 2020). Innovations in medical devices, pharmaceuticals and nutraceuticals, and the human genome project are examples of healthcare technology advancements. In the practice of medicine, new techniques have been developed for mind-body medicine, evidence-based therapy throughout the continuum of care, and improved disease management (Sriram et al., 2020).

There are several devices used for navigation. These devices are majorly built to adopt the use of hardware sensors such as GPS (Global Positioning System), hosting several mobile applications. Example of such device is a fitness activity tracker usually worn by cyclers and swimmers used for the collection of health-related information such as air pressure, heart measurement values, and temperature (Garai et al., 2019). This review work focuses on the revolution of technology in healthcare via IoT, technological advancements, previous review works, various software adaptations, implementation, Challenges, Solutions, and Opportunities.

According to Abdulmalek et al., (2022), The term IoT was first used in 1999 by Kevin Ashton to refer to information on Internet which are connected to an evolving worldwide facility manner. T here has been considerable growth in the healthcare industry and it has played a significant role in employment and revenue generation (Pradan et al., 2021). IoT ensures that healthcare services are personalized in conserving each patient role numerical identification. Due to the lack of easily accessible healthcare, many health problems remain untreated in outdated health care systems. Nonetheless, widespread, inconspicuous, and effective IoT technologies have proven beneficial for cutting-edge tracking then evaluating patient data readily (Kodali et al., 2015).

Using a variety of potential applications allows for the provision of numerous medical applications, including fitness plans, wellbeing intensive care structures, quite a lot of long-lasting ailments, also remote intensive care of medical treatments then drugs at household. The main

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objectives of actuators, therapeutic facilities, devices, and investigative equipment and tools are hence IoTbased healthcare (Bhuiyan et al., 2021). A current instance of an IoT employed in health is an ingestible sensor or smart pill. Through the application of this technology, a patient's drug intake, adherence, and other important health indicators (Philip et al., 2017).

The role of MIoT a crucial role since broadband Internet and electronic apps have proven to be key components of healthcare (Bolhasani et al., 2021). As practical tools for medical applications, body-wearing sensors are gaining popularity. Devices for aptness, consciousness of events, and individual health are among the many uses for which they are being sold. (Azzawi et al., 2016; Sharma et al., 2022) but because there are so many illnesses and disabilities, it is essential to have continuous patient monitoring to provide timely medical care. The use of Wearable Sensor Networks, WSNs in the health sector, and patient intensive care is consequently a critical use of smart wearable expertise (Junaid et al., 2022).

Hospital patient monitoring methods now in use take a lot of time. Improvements in the communication protocols of IoT systems allow for the design of research prototypes aimed at immediate patient monitoring. The prototype will support in direct communication between doctors and patients (Yeole et al., 2016). Internet of Things can be used to continuously monitor health metrics including blood pressure, blood sugar, and body temperature by using remote sensors. The IoT is a framework made up primarily of devices that measure profitability. A backend structure records the prosperity parameters of the patients remotely (Trayush et al., 2021). The development of smart healthcare facilities and hospitals is also made possible by IoT through the introduction of smart beds, intelligent drug dispensers, and asset tracking systems are examples of connected gadgets that can maximize productivity, raise patient safety, and better utilize resources (Sharma et al., 2022).

IoT represents highly promising paradigm for communication, whereby all smart items encountered in daily life are seamlessly integrated into the Internet due to their advanced computer and communication capabilities. There are new security risks associated with this prospect for Internet of Things applications (Yeh 2016). The number of elderly people and patients in need of health monitoring has increased due to the recent significant increase in life expectancy and decrease in reproduction. As a result, it is anticipated that hospitalization and patient care costs will rise globally (Shen et al., 2020).

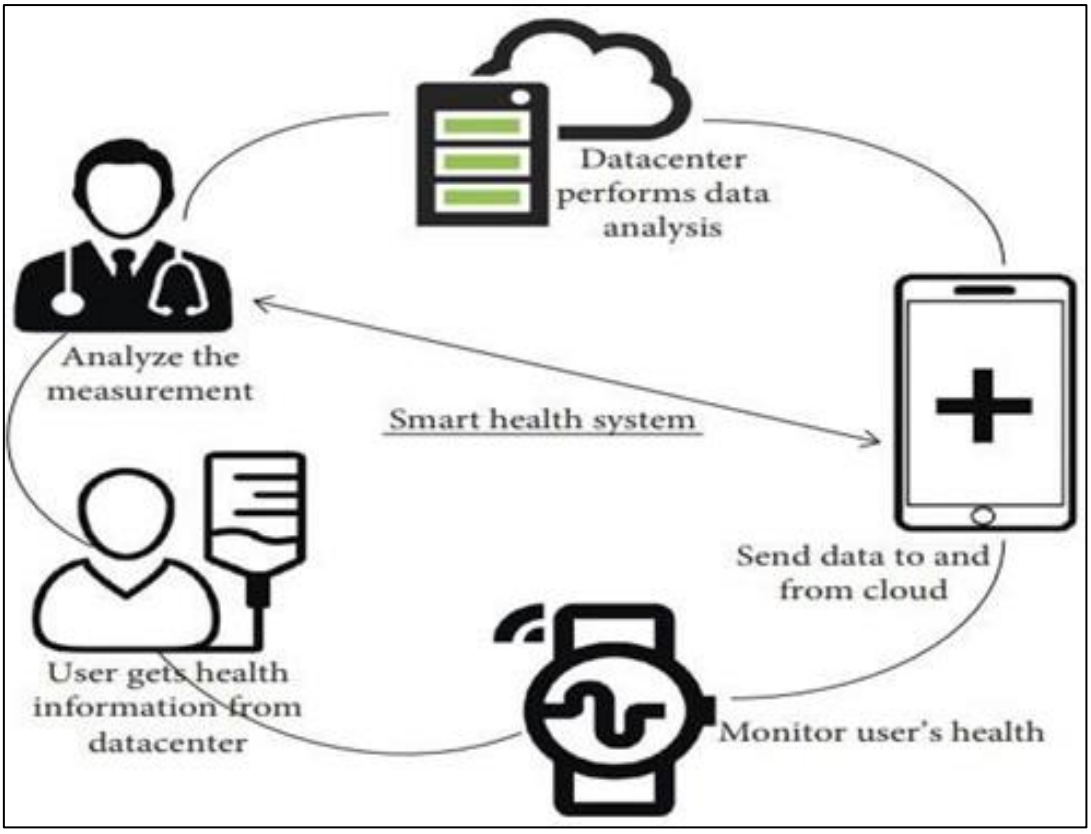

Fig 1: Diagram Illustrating How IoT is Being used in Healthcare Source: Nazir et al., 2019

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Yin et al. (2016) explained that IoT for health paradigm has advanced steadily consisting of three key mechanisms. They include; Things, Server, then Master. Physicians, nurses, as well as anyone with been granted explicit access end-user devices connect to the system (such as smartphones, PCs, or tablets) are included in the master group. The focal point of the whole healthcare system is Sever. It is in charge of creating prescriptions, managing databases, analyzing data, building subsystems, and maintaining knowledge bases. The term "things" refers to any physical object linked via WAN, multi-media technologies, or SMS, including patients and human resources. In a similar vein, mobile computing supports the Internet of Things by means of apps, mobile phone services, and healthcare systems. By providing a range of features like portability, IP connectivity, low power consumption, and security, electronic health advances IoT (Nazir et al., 2019).

However, user control, data visualization, and authentication are all handled by the majority of IoT systems' user interfaces, which serve as a dashboard for medical providers. Maintaining the quality-of-service matrices which include cost, availability, dependability, security, and privacy of information sharing is the primary consideration while designing an IoT device. Several countries have executed novel policies also technologies toward optimizing employability of IoT in health systems (Pradhan et al., 2021).

II. TECHNOLOGICAL ADVANCEMENTS IN HEALTHCARE

The COVID-19 surge witnessed enormously a considerable amount of attention globally, leading the governments of different countries to embrace technology in the health sector. Many affected and non-affected individuals were responsible for monitoring their health status via various devices.

Robust logistics solutions that employ robots to transport food supplies and other goods improve online purchasing because in-person delivery isn't virus-proof. In place of the consumers picking for themselves with their hands, nations like China and the US have introduced contactless delivery systems, in which the customer's ordered goods are delivered elite style to the designated areas. Ageing and continuous population expansion affect healthcare demands and necessitate the development of new, more cutting-edge scientific solutions, even while increasing expense of health treatment has a substantial negative influence on people's lives (even more so in the case of chronic conditions) (Renu 2021; Aceto et al., 2018).

Technology facilitates remote working by enabling the use of virtual private networks, voice Inte rnet rules, Zoom or virtual meetings, and facial recognition software that allows an individual to appear behind a simulated background. In addition to stopping the coronavirus from spreading, re mote work has offered staff autonomy within the organization and avoided numerous unnecessary meeting hours. Although technology has made remote work more convenient, there are still sev eral challenges for employers and staff. (Renu 2021).

Today's healthcare is more expensive than ever in many circumstances, and the majority of patients need to stay in hospitals while receiving treatment. These difficulties may be partially addressed by using equipment that allows for patient monitoring from a distance. IoT technologies lower healthcare expenses and enable the treatment of health issues before they worsen by instantly gathering patient health data and providing it to caregivers (Aghdam et al., 2020). Dental diseases of all kinds are commonplace throughout the world. The most recent oral health survey in China revealed that a startling 94% of the population has various dental issues. In light of this, this issue might be solved by the Smart system for Health-IoT of teeth, which is built on mobile terminals, deep learning, and smart hardware (Bolhasani et al., 2021).

Since technological advancements have increased access to treatments and diagnostics, particular ly in high-income nations, they are frequently cited as one of the primary causes of the surge in health expenditures. Numerous other variables that are used to explain the growth in healthcare expenses are also causally driven by technology. For example, we can reasonably deduce that new technologies that improve health outcomes also contribute to increases in life expectancy and decreases in mortality and that GDP growth is correlated with technology as the primary driver of productivity (Marino 2019). It could be difficult for patients from particular locations or with severe injuries to get to the hospital. As a result, individuals can consult with their doctors via video conferencing to enhance their health and conserve time and resources. Through this technology, patients can document their medical conditions on their phones (Abdulmalek et al., 2022).

According to Shen et al., (2020), technology for health monitoring can lower hospital stays, doctor workloads, consultation times, waiting lists, and overall healthcare expenses. Sharma et al., (2022) further explained the introduction of wearable technology also known as wearables describes a variety of portable, intelligent devices as well as wirelessly communicative systems that are integrated into clothing, accessories, and equipment that assess or evaluate one or more health metrics related to the wearer. Abdulmalek et al., (2022) reviewed a developed wearable sensor equipment which can track and evaluate patient behavior. An Internet of Things device that gauges social distance could help keep a COVID-19 patient healthy.

To supervise and control patients' circumstances quickly, smart technology and advanced tools such as wearable and smart wireless sensors have allowed patients to obtain their vital signs promptly and have continuing evaluations of them significantly increased in popularity (Junaid et al., 2022; Majid et al., 2022). Wearable expertise, including cameras, machine constructions, and exhibitions, makes up three components (Alekya et al., 2020).

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The Internet's expansion and success since the early 1990s have spurred the development of Infor mation and Communication Technologies (ICTs), which have greatly enhanced the effectiveness, efficiency, accessibility, and quality of all procedures associated with healthcare. Consequently, t he concept of "e-health," which is commonly understood to refer to the application of ICTs in the healthcare industry, has gained widespread acceptance (Aceto et al., 2018). The incorporation of artificial intelligence (AI) into healthcare systems to improve the accuracy and effectiveness of m edical interventions is transforming the field of medical technology. These technologies are highly helpful for increasing exam quickness and accuracy (Nadella et al., 2023).

III. IOT IN HEALTHCARE

Majid et al., (2022) explained that the engineering field known as the IoT is focused on creating thousands of tiny, physically linked objects that could cooperate to achieve a single goal stating clearly that Industry 4.0 depends solely on IoT. Li et al., (2024) concluded that apart from enhancing patient wellbeing, IoT has the abilities to significantly lower health costs through process optimization, automation of repetitive operations, and a reduction in the necessity of costly interventions.

The next big development that will significantly alter how businesses function is IoT technology. In the following years, Plageras & Psannis (2023) anticipated that there would be a wide range of linked devices, including positioned apps and activities they would carry out, that would increase quickly. Alekya et al., (2020) emphasized the primary advantage of IoT in the health sector is less maintenance load, which is closely followed by a higher likelihood of receiving healthcare. It was envisaged that the development of cloud health services would be made possible by the integration of individual and online healthcare networks, as well as by mobile information and general technology-killing applications. Bolhasani et al., (2021) proposed deep learning and technical taxonomy theories and concepts. Then, by an analysis of related research, significant deep learning applications for IoT in the medical sciences and health care are shown. It also studies the most recent studies and evaluation ns on various IoT and deep learning applications in the fields of medicine and healthcare.

A classification of healthcare monitoring sensors is provided by Abdulmalek et al.'s (2022) analysis of wearable and wireless sensor-based Internet of Things monitoring systems. Their work further analyzed difficulties and unresolved problems with healthcare privacy, security, and quality of service. The research paper provided a detailed overview of IoT-driven medical surveillance solutions to ensure scientists, academics, and upcoming scholars can quickly identify a road map for comprehending the state-of-the-art healthcare monitoring systems and quickly develop improvements and fixes for such crucial applications. Philip et al., (2017) examines the most recent IoT health system applications and technologies, as well as the underlying and operational architectures. The report delves into the primary concerns and obstacles encountered by them, yielding fresh perspectives and avenues for IoT research.

Nazir et al., (2019) in an organized literature review methodology investigated how mobile computing supports IoT applications in the health sector, advances IoT research in the present and future, adds confidentiality and safety to health IoT policies, and impacts IoT in the health sector. Moreover, the study intends to look at how mobile computing affects IoT in health settings and smart hospitals, taking into account our systematic literature review protocol.

Espinosa et al., (2021) employed a mixed methodology, including a review of the literature and examination of how the Sustainable Development Goals may affect the usage of smart structures and the IoT and addressed the following queries:

- Do IoT applications perform a key function in enhancing both environment then public health?
- Are there studies and case studies that have been conducted in cities or territories that show h ow beneficial Internet of Things applications (IoT) are for public health?
- Which goals and metrics for sustainable development can be evaluated in the applications and projects that are examined?

Al-rawashdeh et al., 2022 identifies and examines the factors that prompt healthcare providers to implement the application of IoT and the influence of it’s in the COVID-19 era. Some of the factors include facilitating conditions, costs and environmental factors.

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Table 1. Summary of Previous Review Works on IoT

References	Title of Article	Objectives and Input	Techniques	Characteristics	IoT and WSN Architect	Limitations and Future Work
Majid et al., 2022	Applications of Wireless Sensor Networks and Internet of Things Frameworks in the Industry Revolution 4.0: A Systematic Literature Review	To automate Industry 4.0, investigate innovative methods and research laying a solid	Creating research questions based on filtered data and solutions. foundation with SLR techniques	The data can be assessed	IoT and WSN	Problems with wireless network coverage regions were not addressed in the review work, and there were no practical answers offered to the issues that now exist in this field.
Li et al., 2024	A review of IoT applications in healthcare	Adoption of the Internet of Things with an emphasis on particular sensor types and communication networks	Employed secure algorithms for data security through MediBlock combining Blockchain and IoT	Optimization strategies, applications, and challenges of IoT in healthcare	IoT	Anonymization and DE identification to protect patient's privacy through implementation of robust authentication and access control
Plageras and Psannis 2023	IoT-based health and emotion care system	Installation of a Smart Health Care room in a local network consisting of sensors and actuators	Emotion care System application to gain interoperability and authenticate patients	Data analysis through algorithms	IoT and WSN	Adoption of Mobile Cloud Computing
Abdulmalek et al., 2022	IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review	Adoption of the Internet of Things with an emphasis particular sensor types and communication networks	Systematic review of recent studies through the exploration of wireless and wearable sensors	Healthcare systems automation	IoT and WSN	Analysis and evaluation of disease based parameters need to be addressed
Bolhasani et al., 2021	Deep learning applications for IoT in healthcare: A systematic review	Proposition of deep learning and technical taxonomy	Deep learning applications through ana lysis of related works	Digital imaging, IoT Electronic Health Record (HER) data	IoT	Alleviation of varying Challenges and potentials for optimizing QoS parameters needs to be addressed
Nazir et al.,2019	Internet of Things for Healthcare Using Effects of Mobile Computing: A Systematic Literature Review	Systematic Literature Review on how mobile computing assists IoT applications in healthcare	Mobile computing in IoT healthcare systems and smart hospital	User-friendly interfaces to record data	IoT	More analysis and quality assessment required

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Bhuiyan et al., 2021	Internet of Things (IoT): A review of its enabling technologies in healthcare applications, standards protocols, security and market opportun ities	Review and analysis of existing research gaps for sustainable IoT healthcare development	Survey through filtering mechanism on journals and conference databases	Development of apps and security models	IoT	Proposition of a top-level architecture of IoT system using blockchain
Alekya et al., 2020	IoT-based Smart Healthcare Monitoring Systems: A Literature Review	Incorporation of IoT into complex healthcare procedures	Creation Mobile Healthcare Management System (HMS)	Development of IoT app	IoT and WSN	Further work on safety issues in different implementation phases
A-rawashdeh et al., 2022	IoT Adoption Application for Smart Healthcare: A Systematic Review	IoT applications such as wearable devices, monitoring devices, rehabilitation devices, and smart home	Introduction of IoT applications	Adoption of Systematic Literature Review method	IoT	Creation of a framework for enhancing IoT in healthcare and the challenge remains the inability to achieve a sustainable socio ecological transition

IV. EMANATING CHALLENGES IN IOT

There are several obstacles and restrictions associated with IoT implementation in healthcare that need to be properly considered. These include worries about safety and confidentiality of information, problems with interoperability, and the requirement for uniform rules and standards. IoT-based devices have occasionally been unable to deliver dependable and efficient solutions due to security and response times. This might also be due to unlimited available resources to prevent attack (Li et al., 2024; Lederman et al., 2021; Chang et al., 2019). Medical records are converted into digital files and saved in the cloud, where hackers can readily access them through electronic health records. Hackers could gain access to sensitive medical data through a cloud server securit y flaw. This causes problems with user identification, data protection laws, data ownership, and health information misuse (Abdulmalek et al., 2022).

A paramount challenge of swallowing an electrical sensor might not be appealing to most patients. Raising consciousness regarding the pill's safety is very necessary. Finally, the medication ought to be accessible to all demographics and reasonably priced. Fixing a price for ingestible medicines is therefore a significant problem (Philip et al., 2017). IoT devices have very low processing speeds and few processing functions, which makes them weak. We require strict real-time data transfer in the healthcare system since even a small delay could result in a deadly scenario. However, since heterogeneous devices are used in IoT-based healthcare systems, it will be difficult to design a multiprotocol network with a topological structure, cryptographic methods, and a security mod el for numerous devices that will satisfy everyone's needs in an IoT-driven healthcare system within the framework of computing on mobile devices (Nazir et al., 2019).

Systemic failures could result from software bugs, hardware flaws, power outages, or environmental threats. The premise behind most IoT system surveys is that there aren't many current issues interfering with IoT system functionality. Yet, because IoT sensors and equipment are dispersed across several regions and are infrequently protected, external dangers like power f ailures or environmental hazards grow more likely to affect this system. (Aghdam et al., 2020).

V. POSSIBLE SOLUTIONS TO THESE PROBLEMS

A major approach to the problem of IoT is Fog Computing Architecture. Chang et al., (2019) figured out this as encompassing an extensive range of gadgets and networks. All things consider ed, it is a conceptual architecture that covers every scenario for expanding the frontend IoT devices are located at the far edge, which is connected to the cloud via the IoT edge netw ork,

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intermediate network nodes, and the geo-distributed data center.

Modern buildings that balance energy use and efficiency must be designed and implemented with sensors and other equipment that support people's safety and health. Likewise, University professionals working in the technology and engineering fields need to be taught to prioritize sustainability and people in all of their project designs (Espinosa et al., 2021).

VI. CONCLUSIONS

Automation of healthcare using various devices including IoT has brought about the possibilities of achieving an improvement in healthcare delivery such as reducing cost and increasing efficiency and performance. This study would provide a platform for future research to integrate IoT into healthcare monitoring systems through various reference resources. Various IoT monitoring systems have been reviewed, delving deep into their challenges and possible solutions. It also provides an understanding of Utilizing wearable devices in healthcare systems and how security issues can be tackled accordingly. Appropriate sensitization of patients is therefore recommended.

Table 2 Glossary

IoT	Internet of Things
EHR	Electronic Health Record
QoS	Quality of Service
MIoT	Medical Internet of Things
IoTh	Internet of Things in Healthcare
SMS	Short Message Service
WSN	Wireless Sensor Network

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