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Revolutionizing Healthcare: The Impact and Future of the Internet of Things (IoT) in the Health Sector

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Abstract

Internet of things (IoT), a modern technology, is introducing various devices and systems in the health care setting by allowing sharing of information among them in real time. This paper seeks to examine the remarkable effect that IoT has brought in the healthcare sector, especially in remote monitoring of patients, smart clothes and wearable technologies, remote consulting, and hospital administration. The main benefits of applying IoT solutions include the enhancement of the patient care, increasing efficacy and costs savings in healthcare. concerns with protection of data, issues of compatibility and issues of the law. In this article, the author has given a detailed description of IoT in healthcare encompassing the current use cases and advantages and disadvantages of IoT systems in this domain along with examples from the literature. It also brings out emerging concepts and advancement that can shape the future of IoT in health such as Artificial Intelligence, big data analysis and 5G network. Ethical and legal perimeters to IoT in the healthcare systems are also provided. Ideas on how to surmount the challenges that hinder the use of IoT have been provided in the paper before concluding by embracing IoT as a technology that holds the promise of drastically changing future systems of global health.

Keywords: IoT, Healthcare, Internet, Remote

1. Introduction

The usage of IoT in healthcare has an increased opportunity to improve patients' outcomes and the processes that surround them as it would be less costly (Abouzakhar et al., 2017). From health focused wearable electronics that monitor biometrics such as body temperature, pulse and blood pressure to smart hospitals managing multiple processes and patient data, IoT is revolutionizing healthcare through faster and better ways to observe patient status. Internet of Things technology is quickly finding its place in the global health care

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industry since IT can help in improving clinical decision-making services, monitoring patient remotely and assist in early detection of diseases.

It is against this backdrop of global population aging, escalating healthcare costs, and rising incidence of chronic diseases that the potential of IoT to deliver higher and more accessible standards of care has been felt than ever before (Abouzakhar et al., 2017). With the help of IoT, patients in other settings other than the mentioned healthcare system components like hospital can be closely supervised and the expected right and timely intervention achieved. However, IoT technologies improve the working efficiency of the health care facilities since they reduce complex processes into automated and optimal use of resources. Nevertheless, there are some issues that are Data privacy concern, Legal concern, concerns with reference to privacy, and concerns with reference to compatibility with other systems considering IoT in health care sector.

1.1. Objectives and Scope of the Article

Quite simple, the main aim of this article is to give readers a clear understanding about the position and contribution of IoT in healthcare industry. As part of the current research in the field of IoT, this paper focuses on a description of how IoT is being implemented in the healthcare industry to support patients' needs and improve the functioning of health care facilities as well as for solving existing problems. Therefore, this article provides certain application examples such as remote patient monitoring, smart wearable devices, and IoT-based hospital systems with particular focus on how these innovations are used in improving, the provision of healthcare as well as lowering its costs.

Further, this article presents the issues that have limited the widespread of IoT adoption such as issues of security, privacy, and regulatory issues. It is also a goal of the paper to identify other evolving technologies of the IoT together with how AI, big data, and the 5G technology is expected to take the healthcare industry even further. Last, the article presents the ethical and legal issues concerning IoT and the relative advantages and disadvantages for the modern healthcare system.

1.2. Structure of the Paper

This article is structured as follows: In section 2, the concept of Internet of Things is introduced, preliminary concepts are presented, and its architecture in healthcare is explained. Section 3 present some of the use cases of IoT in health sector such as remote health monitoring, wearables, and health facility information systems. Section four deals with the advantages of using IoT in the health facility to deliver quality results on the care of patients as well as creating efficiency and cutting cost. The main issues and research questions addressed in the paper are presented in Section 5, where the focus is Issues and barriers to IoT adoption including security and privacy concerns, as well as interoperability. Section 6 provides specific examples and real-life applications of IoT in healthcare, which demonstrate how these technologies are being successfully deployed. In section 7, possible developments of IoT in the healthcare domain are discussed based on existing possibilities and future technologies and trends. Section 8 debates on the concerns of ethical and legal issues of considering and employing IoT in healthcare. In the last and final Section 9, summary of recommendation for the overcoming of

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the challenges as well as utilizing the giant of IoT in healthcare are outlined.

2. Overview of the Internet of Things (IoT)

The IoT is gradually being adopted as a key element of today's technology environments providing a new complex where physical objects, sensors and systems are connected with each other providing real-time data exchange. In healthcare for instance, IoT offers a way of linking many health devices, monitoring systems, patient management systems as well as hospital management systems resulting in enhanced and efficient patient care and efficient decision making (Abouzakhar et al., 2017). Before we go any further into understanding how IoT is implemented in healthcare, it would be helpful to know the basic definition of IoT and the defining characteristics of IoT systems, as well as how it was developed and how its architecture is implemented in health care today.

2.1. Defining IoT and Its Key Components

IoT therefore stands for the integration of numerous physical objects in the world starting from the mundane to the most complex technical processes that are conventionally connected through sensors, software and other technology (Alansari et al., 2018). These devices are interconnected and they take advantage of the internet in disseminating information in a way that these devices can gather information and share the information among them without necessarily having to undergo human-human or human-computer interaction.

Key components of IoT include:

- Sensors and Actuators: These devices gather information on their surroundings (e.g., temperature, pulse rate, blood pressure) and execute or elicit particular actions depending on specific conditions.
- Connectivity: IoT refers to interconnected devices that employed Wi-Fi, Bluetooth, cellular and other methods of communicating with other devices or systems.
- Data Processing: IoT end devices apply cloud or edge computing to process the gathered information, gained perception, and perform actions in response to circumstances within milliseconds.
- User Interfaces: This part helps to enable the communicating the results from the IoT devices with the patients through apps, dashboard, or notifications from the health care professionals.

In healthcare, these components combine to create a complex system of appliances for enhancing and facilitating the effectiveness of medical staff in evaluating the state of patients and organizational efficiency of a healthcare facility.

2.2. History and Evolution of IoT

The idea of IoT was first conceived in the late 20th century when the possibility of embedding sensors and actuators into most objects was firs. In the early 1980s the RFID technology was introduced into the market, which was a breakthrough in the development of IoT as it made things mobile and able to communicate without wires (Alansari et al., 2018). The 'Internet of Things' concept was hardly mentioned by the late 1990s and was

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only officially named thus by Ashton, who predicted that the Web would have objects connected.

Coming to the technological breakthroughs of early 2000, remarkable involutions like usage of wireless networks, smart devices, and better media storage & data processing system took place. Such advancements set the stage for more IoT environment as is in present days. Starting with the use of smart wearable appliances and remote monitoring in healthcare, IoT started receiving attention in the 2010s.

Since this time, use of IoT in healthcare has rapidly expanded due to the developments in cloud computing technologies, big data processing and AI. Many healthcare organizations are starting to see possibilities of IoT in enhancing the quality of care, decreasing the spending, and optimizing the deliverance of care (Alansari et al., 2018). Currently, there is an application of IoT in healthcare by monitoring patients and their illness, improving diagnose as well as helping to give right treatment to the patients.

2.3. IoT Architecture in Healthcare Systems

Healthcare IoT mainly concerns a layered model to link devices, data sources, and networks to facilitate the entire healthcare execution. The architecture typically follows a three-layer model: At the application level the classes are Perception Layer, Network Layer and Application Layer.

Figure 1: System Architecture

2.3.1. Perception layer:

This is the base level where physical things, such as devices, sensors and actuators, are located (Amaraweera & Halgamuge, 2019). In healthcare, these devices include wearable sensors, smart medical devices and monitors: vital signs such as heart rate, glucose, blood pressure. This layer is accurate to data acquisition and elementary signal conditioning.

2.3.2. Network layer:

In the network layer, transfer takes place between the devices and central systems of the network. The collected

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data gathered from sensory devices in the Perception Layer transmits the data through several classes of communication that may comprise Wireless Fidelity, Bluetooth, Zigbee, or cellular connection (Amaraweera & Halgamuge, 2019). This layer also involves switches that control access using different devices to outside networks, other servers in a hospital or cloud solutions.

2.3.1. Application layer:

The Application Layer is about how to analyze the data received from IoT devices, or in other words, about how to use it. In healthcare this layer involves, administrative healthcare systems, electronic records system, and remote patient monitoring boards (Amaraweera & Halgamuge, 2019). Other technologies such as, data analysis, and artificial intelligence algorithms may also be used in this layer in supporting the health care staff including in prognosis, early diagnosis, recommendation on treatment plans.

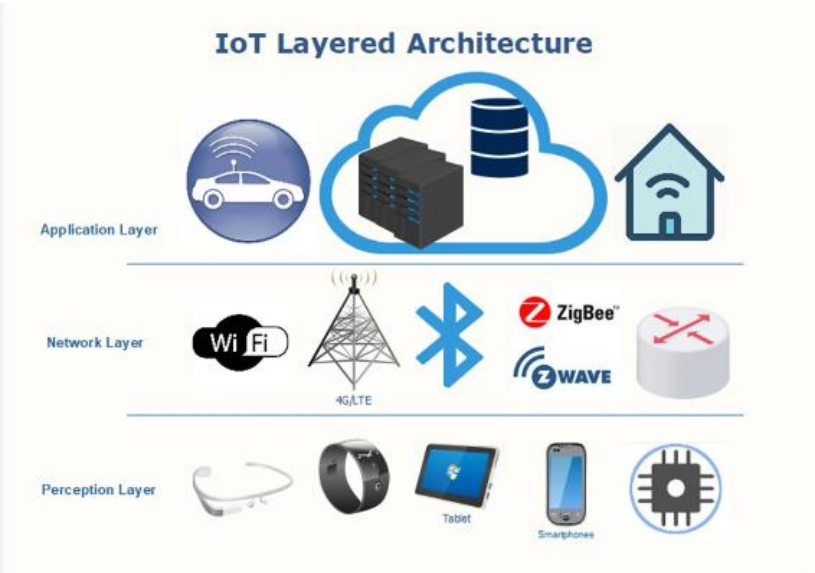

Figure 2: IoT Layered Architecture

When these components are integrated, then IoT systems in Health care aim at enhancing the accuracy of the captured information, improving the connectivity between the devices, as well as producing valuable information relevant to the physicians. This architecture allows for the effective convergence of patient, clinician, and medical device to create an environment of efficiency within the larger sphere of disease control and management.

3. Applications of IoT in the Health Sector

Due to the impact offered by IoT technology, the health care industry has developed a number of varieties of

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solutions that can help to change the approach to patients' treatment, the functioning of hospitals, and the processing of health information (Jha et al., 2021). From tele-monitoring the patient to optimizing its internal processes and optimizing supply chain of drugs IoT is disrupting the healthcare sector at various tiers. So, this section focuses on the key IoT applications that are defining the dynamics of change affecting healthcare services.

3.1. Remote Patient Monitoring (RPM)

Remote Patient Monitoring (RPM) is a leading use of IoT in the healthcare industry; the solution facilitates checking of patients' vitals through the transfer of data via the internet by healthcare providers without necessarily having contact with the patient (Javaid et al., 2022). RPM systems are based on IoT connected wearable devices ranging from sensors worn on the patient's body, blood pressure cuff, glucometer among others that capture the patient's vital signs and relay the information to the caregivers.

In this we find out that this technology is most suited to chronic diseases such as diabetes, heart diseases, hypertensions and others because constant checkup is useful in early detection of the complications that arise (Javaid et al., 2022). RPM also eliminates the issue of patients who need constant follow-up since they get more comfort from the device. In the view of healthcare providers, RPM holds the potential for constant monitoring, acquisition of timely data and, subsequently, improved decision-making, timely interferences and the development of individualized care plans.

For example, through RPM, a doctor sees that his patient has changed the rate in the beating of the heart or even a new abnormality in the rate of blood pressure and can address it before getting worse. Also, the data collected can be mapped into EHRs where there would be proper care given to the patient though in the long run there will be complete record of their health information.

3.2. Smart Wearables and Health Sensors

Some of the more familiar IoT devices which are used to keep an eye and record various signs including physical activity, pulse rate, and sleep include the fitness bands and the health monitors. Smart-watch, health bands, and wearable ECG monitors give immediate, accurate, and personal health information to the patient to enable them self-manage their health.

In the healthcare lineup, these wearables are not only confined to tracking of fitness but are used for medical purpose. For example, continuous glucose monitoring (CGM) devices are used by diabetes patients during the day to closely monitor their glucose levels and trigger alarms to the patient, the patient's doctor or any other health care attendant for any abnormalities. Likewise, self-monitoring asthma inhalers may be employed to monitor when the medication was used, as well as analyze environmental stimuli that may cause worsening of the disease.

The information gathered by these wearables is stored on cloud interfaces or mobile applications that act as a portal where the data may be interpreted and scrutinized by caregivers. It makes personal care possible by giving doctors an opportunity to administer treatment based on real-time information. Moreover, health sensors

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can be incorporated into garments or even into the human body in which it provides precise monitoring technologies for acutely ill patients.

3.3. IoT in Hospital Management and Operations

Also, in the aspect of hospital management and functionality, IoT is slowly bringing positive changes by increasing the efficiency as well as reducing the cost of managing a health facility (Hassan et al., 2021). In transitions and processes to be made in hospitals, smart IoT devices are utilized for managing both patients and equipment. For instance, real-time location systems (RTLS) for IoT that deals with management of the items and tracking of motion of patients, staff and instruments in the hospital reduces on time waiting.

IoT applications are also employed to learn conditions within hospitals to promote the best environment for patients (Hassan et al., 2021). For instance, smart systems in particular can monitor the levels of temperature or humidity in the operational theatre or any other areas that are closed off from the rest of the training area regarding the standards of hygiene and safety. Further, sensors of IoT are used for monitoring the inventory of important health care items including drugs, surgical tools, and, PPEs to make sure the same is replenished when it's low.

3.4. Smart Medication Systems and Drug Delivery

Smart medication system and use of IoT in medication delivery hold a lot of promise for patients, as patient's health is closely tied to the quality of the drug delivery system. Smart pill boxes, which are part of IoT, can also inform patients when to take their medicine and if a dose was omitted, inform the medical personnel or caregivers (Darshan & Anandakumar, 2015). This is especially helpful in patients with chronic diseases or elder patients who may find it difficult to consistently take their drugs.

In more complex uses implantable drug delivery devices that are linked to an IoT interface transmitting data can deliver medication into the target area as per the information passed to the system (Darshan & Anandakumar, 2015). For example, such systems can control the patient's physiological state and provide insulin or painkiller medication at the exact moment it would be most effective, minimizing the side-effects. It is possible to set these devices to dispense specific therapeutic regimens and adjust the amount or frequency of the drug delivered depending on the values found in the readings taken by the patient.

3.5. Telemedicine and Virtual Healthcare

Besides healthcare, telemedicine and virtual healthcare services have emerged and expanded during and post COVID 19 pandemics, IoT has a significant contribution in improving these services. Smart electronics also enable doctors to track patient's conditions and even consult with them through video calls while simultaneously observing actual health parameters from the wearables or even home monitoring systems. This capability helps healthcare professionals attend to patients who often have limited access to healthcare centers which are usually located in remote or areas with low population densities.

Telemedicine together with IoT devices enhances constant follow-up with patients with surgical cases or

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chronic diseases that do not require inpatient hospital visits (Dalal et al., 2020). For instance, a patient with a heart problem can wear a connected ECG which sends data to the doctor, who can fine-tune the treatment likely without the need for an office visit. Further, the IoT devices in these virtual health care systems can monitor rehabilitation of patients; devices record progress and send it to physiotherapist or rehabilitation specialists.

The administered model of care enhances patient compliance, contracts the load on hospitals, and optimizes the consumption of the limited health care resources. It also avails an efficient method, through which, healthcare services can be reached out to communities especially those in rural or, areas of poor physical health infrastructure.

4. Benefits of IoT in Healthcare

There is a lot that can be achieved by incorporating IoT in healthcare these includes; Improved quality of patients' care, efficiency in delivering of health care services, and handling of health care systems (Poongodi et al., 2019). New technologies are beneficial not only in terms of increasing efficiency by eliminating intermediaries but also for gaining additional information in the sphere of IoT in healthcare. This section provides further details of the following opportunities that the IoT comprise to the healthcare sector.

4.1. Improved Patient Outcomes and Care Quality

Due to the proliferation of IoT, connectivity and supervision of patient's health conditions become possible continuously and remotely (Radwan & Farouk, 2021). For instance, in the application of IoT wearables healthcare, one of the usability cases of IoT RPM systems is to assess patients' overall health and their primary signs. It means surveillance of diseases at an early stage and getting treatment as early as possible, and thus reducing the likelihood of developing complications and admission. In facilitating the patients' care, IoT makes it also possible to find solutions based on the patients' individual data giving quality care in general.

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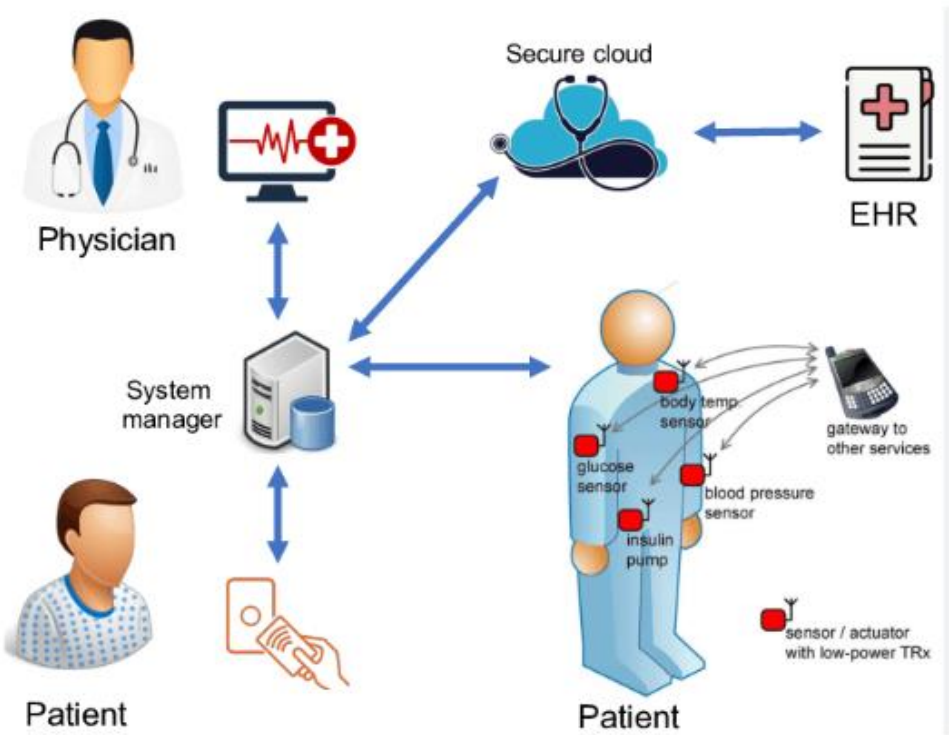

Figure 3: Importance of IoT in Healthcare

4.2. Enhanced Efficiency in Hospital Operations

IoT results in improvement of the health facility's operational productivity through automation of activities, efficiency in resource utilization and effective organization of duties (Radwan & Farouk, 2021). For example, in hospitals, RTLS used for location determination aids in identifying the movement of patients, staff, and medical equipment with the purpose of efficiently managing resources with reference to minimizing lag time. Furthermore, actual IoT enabled predictive maintenance provides that equipment such as, those used in the medical field, are always available since IoT can predict equipment failure before it occurs. This minimizes settler interaction with patient handling and also improves the overall reliability of treatment in general healthcare systems.

4.3. Reduced Healthcare Costs

In many ways, IoT plays an important role in cutting healthcare costs through increased efficiency and remote care (Radwan & Farouk, 2021). Remote patient monitoring enables the patients to be controlled from their homes this helping to minimize hospitalization and lengthy hospitalization once admitted. Moreover, a great

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deal of efficiency in hospital administration is made possible with the help of IoT-driven automation. In addition, patient monitoring with the help of predictive analysis and real-time monitoring decreases further tests and operations, emergency measures as well as costs for both sides, the healthcare facilities and the patients.

4.4. Real-Time Data and Predictive Analytics in Healthcare

Another important advantage of IoT is real time and predicting factors in the field of healthcare. IoT devices are always generating immense amounts of data that can be interrogated for patterns (Radwan & Farouk, 2021). This timely analysis allows healthcare practitioners to make better and informed choices before crafting patient treatment plans. IoT data in structures of the predictive analytics tools can also predict follow-up needs for care, enhance the treatment process and controllability, and minimize episodes of unhealthy outcomes or complications, enhancing patients' experiences and organizational execution.

5. Challenges and Barriers to IoT Adoption in Healthcare

The extensive benefits of using IoT in healthcare notwithstanding, IoT-based care delivery has faced a number of challenges and obstacles (Rath & Pattanayak, 2019). These are anything from data protection issues to connectivity issues, among them; all of which has to be overcome to harness the full benefits of IoT in reformation of healthcare systems. The following section discusses the most significant factors that negatively influence IoT implementation in the healthcare domain.

5.1. Data Security and Privacy Concerns

Probably one of the most profound challenges that have faced the implementation of IoT in the healthcare sector is security. IoT devices further acquire and forward large amounts of sensitive personalized information related to health, and any adverse breach in securing IoT devices can lead to significant repercussions within the ambit of users and medical facilities (Rejeb et al., 2023). The frequency of cyber-attacks on healthcare facilities has risen, courtesy of hackable aspects of IoT health care institutions. Privacy of PHI calls for effective security features like; encryption, secure authentication procedures and constant system upgrades. Nonetheless, IoT is employed in a vast number of capabilities; the application in healthcare is a good example, and because there is a variety of devices and platforms, the ecosystem is a little hard to secure in its entirety. The protection of the patient data is still an important issue and a challenge to both, healthcare organizations as well as IoT designers.

5.2. Integration with Existing Healthcare Systems

The fourth issue is the interoperability of IoT technology with currently utilized healthcare systems. Traditional medical records and well-established health care operational systems such as Electronic Health Records (EHR) systems, hospital information systems, diagnostic structures, etc., are quite often not compatible with the newer IoT devices. For effectiveness in the exchange of information between IoT devices and healthcare workers, integration between these systems is vital (Salama et al., 2023). Though this can be well attained, it needs lots of

capital investments in facilities, software, and human resource personnel with specialist skills in these frontages. This could mean that two systems are incompatible, leaving valuable information in silos which is not shared with the individuals who need it to make decisions within the healthcare organizations. It becomes imperative for the healthcare institutions to find a way of implementing the IoT solutions in a way that they will not affect the normal working of the institution or the quality of patients being handled.

5.3. Regulatory and Compliance Issues

Internet of Things IoT faces several challenges in the health care industry since the health care industry is strictly regulated and compliance with the following legislation is a massive challenge; For instance, the legislation governing the handling of patient's information in the United States is HIPAA (Health Insurance Portability and Accountability Act) and the legislation governing the same in the European region is GDPR (General Data Protection Regulation) (Tallapragada et al., 2022) . A large number of patients' data pass through IoT devices, and as a result, the privacy and security standards that govern the use of IoT devices in healthcare organizations regulate the privacy of the patient's data. Managing these regulations is not easy since most IoT solutions deal with several vendors, cloud, and service providers. All these entities have legal necessities to observe the laws and standard, making the adoption of IoT in healthcare more cumbersome. A failure to meet such regulations leads to heavy fines financially and loss of reputation for any healthcare organization hence discouraging adoption of IoT.

5.4. Technical Challenges (Interoperability, Connectivity, etc.)

Other barriers include; Technical barriers in the form of interoperability and connectivity problems are also a big setback to actually realizing the IoT in healthcare. Such IoT devices are built by different companies and do not all use the same corresponding protocol of network connectivity to join the IoT infrastructure. For example, getting a wearable glucose monitor interface with hospital management software and EHR can be a difficult task (Usak et al., 2020). Also, due to unsatisfactory internet access in some regions or district, resource-scarce zones, restricted internet access may hamper IoT devices to provide healthcare solutions to the target customers. Since IoT devises rely on Internet connectivity to transmit real-time data, any disruption to this option exposes patient's lives to perilous consequences. Solving these technical issues is possible only with joint cooperation, all stakeholders of the healthcare system: providers, technology suppliers, and policymakers, who need to set the same requirements for connections.

5.5. Patient and Healthcare Professional Acceptance

Another factor that may be problematic is the acceptance of IoT technologies by patients and care givers. Some patients may be hesitant to use IoT devices due to privacy issue, or lack of tech-savvy or due to idea of monitoring checking throughout the process. Otherwise, the healthcare professionals themselves may shy away from adopting IoT, with or without proper knowledge or trust in the technologies in question. When it comes to these challenges, awareness and education are critical in both the patient and health care provider (Usak et al.,

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2020). This transformation will increase the expectations of the healthcare professionals regarding their competency to manage IoT devices, assess the data collected, and work with the data results. Patients too require to be educated about the benefits of IoT in helping manage their health and getting to know their information is safe and secure. Thus, the widespread acceptance of IoT is critical not only for expanding the IoT's utilization in healthcare but also for achieving the technology's best possible outcome.

6. Case Studies and Real-World Examples of IoT in Healthcare

The integration of IoT technology in the health sector has already shown its potential assets across numerous practice scenarios (Salama et al., 2023). These case studies that range from chronic disease management through to enhancing emergency services prove that IoT is revolutionizing the healthcare sector.

6.1. IoT for Chronic Disease Management

One of the more promising niches within the infrastructure of IoT is the application of smart solutions in the treatment of chronic diseases including diabetes, heart diseases, and hypertension, and among others. For example, the company Medtronic has developed an IoT-based CGM system aimed at diagnosing diabetes patients. This device constantly tracks the glucose level within the body, sending the data to a smartphone companion application where the patient and the doctor will get notified of a dangerous level (Salama et al., 2023). It also assists in halting the worsening of other complications with the diseases and is useful in enhancing the management of the diseases in the future.

6.2. IoT in Emergency Care and Critical Monitoring

It is also transforming urgent response and critical observation as well. Some of the ways that IoT devices are applied in most hospitals include tracking patients in intensive care, usually ICCs. An example is the integration in a smart manner of sensors in Intensive Care Units to record constantly the patient's physical state (Salama et al., 2023). These devices can determine when there is a sign of decline and notify the healthcare professionals withing no time hence giving a way forward. Furthermore, IoT devices used in the ambulance will be capable of forwarding real-time patient information to Emergency care units for informed management on arrival.

6.3. Success Stories from Global Healthcare Systems

The integration of IoT in healthcare has already been fashioned by some countries such as Singapore and the United States (Salama et al., 2023). For example, the Singapore was the first to engage internet connected devices where Singapore General Hospital uses IoT to locate medical equipment in real time and also manage patient flows. Further, Cleveland Clinic has adopted the use of IoT to keep track of the patients for purposes of

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improving patient care and reducing readmissions.

7. The Future of IoT in the Health Sector

With regards to the trend, it became clear that IoT is only going to increase its importance to the healthcare industry, which will be brought about by improvements in the newest technologies and the move in the direction of preventive and stratified care (Radwan & Farouk, 2021). This section focuses on illumining several trends that the society will experience in future concerning IoT in healthcare.

7.1. Emerging Technologies and Trends (AI, Big Data, 5G)

IoT is set to be significantly benefited from the integration of, Artificial Intelligence (AI), Big Data and 5G technology. Through A.I, IoT can process large amount of data generated by connected device which leads to improve diagnostics, treatment and prognosis (Radwan & Farouk, 2021). Healthcare practitioners will be able to examine data across large patient populations and identify the kind of patterns that will inform public health strategies. On the other hand, 5G networks will offer sufficient speed and low latency that are relevant for real-time IoT services like tele-surgery and sharp HD telemedicine.

7.2. Predictive and Preventative Healthcare through IoT

Further on, IoT will be a key driver to change healthcare from a reactive to a proactive and predictive make-up. Soon IoT devices, integrated with AI and analytics will allow for constant monitoring of patients' conditions, possible problems in their condition can be spotted in advance (Radwan & Farouk, 2021). For instance, smart clothing may capture instances of heart disease or loss of balance, which could be a sign of an oncoming stroke, before that disease or condition would need an emergency health response. This approach, therefore, will not only enhance better health among patients but also reduce future expensive hospitalizations.

7.3. The Role of IoT in Precision Medicine and Personalized Care

IoT will also feature prominently in the creation of smart healthcare and particularly precision and personalized medicine (Radwan & Farouk, 2021). IoT devices will track the Personal Health Indicators of every individual, and thus ensure that treatments administered are right for each patient. This will bestow precise dosing, individualized treatments, and better patient compliance, thus increasing the efficacy of the present and future healthcare.

8. Ethical and Legal Considerations

The adoption of IoT in the healthcare sector is one, which poses many ethical and legal issues. Since IoT devices obtain and forward patient's identifiable data, unprecedented importance is given to such issues as privacy, consent, and ownership. This section looks at the rights and wrongs of IoT in healthcare.

8.1. Ethical Implications of IoT in Healthcare

The major ethical issues of IoT in health care are respect to patient's, self-determination, privacy, and trust. Opportunities of using IoT Devices in Healthcare; Initiatives and objective uses of IoT devices in healthcare but with increasing reportage and avenues of connected fridges, door sensors and even babies' nappies generating and reporting vast amounts of personal data the question that lies in the minds of many is; what is being done with my data? If not controlled, telemonitoring of patients by wearing devices may lead to encroachment on the privacy of the patients (El-Khoury & Arikan, 2021). Moreover, the subject depends on the IoT technology, meaning also that the doctor's relation to the patient is less personal and based only on data. Stewardship of technology and ethical considerations regarding patients; right to dignity and self-determination is a big challenge.

8.2. Legal Frameworks Governing IoT in Healthcare

IoT legal standards in healthcare differ from country to country, yet their common goal is to protect patient information. For instance, IoT devices applied to healthcare in The United States of America has to conform to HIPAA standards which govern patient data (El-Khoury & Arikan, 2021). In Europe, for instance, the regulation of how personal data, including data from IoT devices, is processed and stored is regulated by the General Data Protection Regulation (GDPR). These regulations involve the healthcare facilities and the IoT creators to have high standards of security failure to meet them they are subject to the law.

8.3. Patient Consent and Data Ownership

The data collected from the patients have to inform them of the ways in which the data will be acquired, processed and managed, and must seek their permission before sharing data. Also, issues related to data ownership of the IoT devices surface; whether it belongs to the patients or the providers (Van der wees et al., 2022). It can therefore be noted that that there exist areas that still lack a clear policy regarding the ownership of the data collected by the patient through IoT devices to protect the rights of the patients as well as to overweight the benefits of IoT usage.

9. Conclusion

The Internet of Things (IoT) is revolutionizing the healthcare industry with a myriad of opportunities availing themselves for a great disruptive change, but these come with some daunting questions. This final section presents findings and implications of the study, affords recommendations for further research, and outlines policy implications to guide the management of sustainable water supply in the context of climate change.

9.1. Summary of Key Findings

In adoption of IoT in healthcare, many benefits have been witnessed including rise in health clients' outcomes, increased efficiency in the health facility and possible cut down in costs. Remote patient monitoring, smart wearables, and telemedicine are amongst the IoT applications that are already the cornerstone of today's

healthcare. But there has been challenges that have hindered its full growth such as security challenges, integration issues and compliance challenges (Van der wees et al., 2022). The major challenges still persisting are ethical and legal capacity and limitation such as consent from the patient, and ownership of the data collected.

9.2. Recommendations for Future Research and Policy

For the next research on the application of IoT in healthcare to be effective, it should consider the following areas of research Data security in IoT, integration of IoT devices with both the current systems in place and regulation of the technology to cater for the ever-advancing development of IoT in healthcare (Van der wees et al., 2022). In particular, future studies should investigate guidelines for patient consent as well as data ownership besides enhancing collaboration between the healthcare sector, the technologically sector, and the government. Secondly, the exploratory studies concerning the impact of IoT that has been done to advance the personalized medicine and impact or lack of it to lower the health care inequality among the population will help in a detailed understanding of the social perspective of the innovation.

9.3. The Long-Term Impact of IoT on Global Health Systems

In the long run, IoT is going to transform world health care by increasing ability to forecast illnesses, making precision medicine a reality and increasing health care access especially in the developing world. As IoT technologies mature and further and weave themselves into the fabric of the comprehensive global health care environment, they stand to gain from real-time data, treatment options customized for the individual patient, and better systems of delivery of care (Van der wees et al., 2022). Finally, through connected technologies, associated with IoT, it is possible to solve some of the key issues in Healthcare, and change the system of providing care on a global scale.

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