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Application of the Internet of Things (IoT) in Health: The Future of Personal Care

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ABSTRACT

The application of the Internet of Things (IoT) in healthcare has revolutionized healthcare in an unprecedented way. IoT allows devices to interconnect, collect data, and exchange information in real-time, which can improve health monitoring, diagnosis, and disease management in a more effective way. This research aims to investigate the potential application of the Internet of Things (IoT) in improving personalized healthcare. The focus is on the ability of IoT to monitor health conditions in real-time, improve early diagnosis, provide customized care, and increase the overall efficiency of the health system. This research uses a qualitative and quantitative approach by conducting a literature review on the application of IoT in healthcare, as well as analyzing data from case studies of IoT technology implementation in personal healthcare. The results of this study reveal the great potential of IoT applications in improving personal healthcare, including remote monitoring of patient conditions, data-driven disease prediction, individualized treatment customization, and cost efficiency in the healthcare system. The implementation of IoT technology also brings challenges such as data privacy, system security, and cross-platform integration that need to be overcome to maximize its benefits. The conclusion of this study is that the application of the Internet of Things (IoT) in healthcare promises a more effective and efficient future of personalized healthcare. However, technical, ethical, and security challenges need to be overcome for these applications to be successful. With an increased understanding of the benefits and risks of IoT adoption in healthcare, appropriate steps can be taken to ensure better personalized healthcare in the future.

Keywords: *Internet of Things (IoT), Health, Personalized Services*

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INTRODUCTION

Technology has revolutionized the healthcare landscape, playing an irreplaceable role in improving healthcare services, diagnosis, treatment, and disease prevention (Alamri et al., 2020). In an era where technological innovation is constantly evolving, its impact on healthcare is significant. Technological developments have enabled better data integration, allowing healthcare professionals to access patient information more quickly and accurately. Electronic medical information systems (EMIS) facilitate efficient storage, management and exchange of medical data, enabling more coordinated and personalized care. Diagnosis and treatment have been transformed by technology. Medical technologies such as medical imaging, image analysis software, and advanced equipment allow doctors to perform faster and more accurate diagnoses. Robotics and minimally invasive surgical procedures reduce patient risk and recovery time. Digital health has also improved tremendously. Health apps, wearables, and connected sensors give users real-time access to their health data, allowing them to keep up with their own health and make better decisions regarding lifestyle and treatment.

Review of Literature

1. Internet of Things (IoT)

The application of the Internet of Things (IoT) in healthcare has become an increasingly relevant and interesting topic in recent years (Dai et al., 2019). IoT technology has enabled transformation in various aspects of human life, and healthcare is no exception (Shafique et al., 2020). The rise of digitally connected devices, such as medical sensors, health tracking devices, and remote monitoring systems, has opened up new opportunities in personalized healthcare. In an era where technology is increasingly permeating our daily lives, the application of IoT in healthcare promises to profoundly change the way we monitor, diagnose, and treat health conditions (Chettri & Bera, 2020). With greater data availability and easier access, IoT brings a paradigm shift in healthcare from a reactive to a proactive approach (Ben-Daya et al., 2019). The future of personalized service in healthcare is likely to be greatly influenced by advances in IoT technology.

The Basic Concept of Internet of Things (IoT) in Healthcare is very multifaceted. The Internet of Things (IoT) refers to a network of physical devices connected via the internet, which allows them to communicate with each other and exchange data (Koroniotis et al., 2019). When this concept is applied in the context of healthcare, IoT brings great possibilities in real-time health data collection, patient condition monitoring, disease prediction, and more effective healthcare management. One of the key elements in healthcare IoT is sensor devices that can monitor various health parameters, ranging from heart rate, glucose levels, blood pressure, to physical

activity levels (Lu et al., 2020). The data collected by these sensors can be automatically analyzed or accessed by medical personnel through digital platforms to monitor patients' health conditions more efficiently. In addition, IoT also allows medical devices to be connected to the internet (Manavalan & Jayakrishna, 2019), such as pacemakers or smart insulin pumps, which can make great contributions to remote patient monitoring and therapy settings based on real-time data collected.

The application of IoT in healthcare involves not only medical devices, but also includes hospital management systems, electronic medical records, as well as personal health applications that can connect patients with medical personnel or support systems directly (Tao et al., 2019). This entire ecosystem is working together to create more integrated, responsive, and personalized healthcare for each individual. IoT deployment has also changed the way we look at disease prevention efforts (Ali et al., 2019). For example, in daily routines, health tracking devices such as fitness bands or smartwatches have enabled users to continuously monitor physical activity levels, sleep quality and even physiological parameters. This data can be used to provide more personalized and real-time information about the user's health condition, as well as encourage healthy behavior by providing relevant feedback. In the medical field, the use of connected medical devices, such as smart insulin pumps or pregnancy monitors, allows patients to integrate health monitoring into their daily lives without interrupting their activities. The data collected by these devices can provide valuable information for medical personnel to design more appropriate and effective treatment plans. In addition, IoT also brings a great impact in hospital management and the overall health system (Cheng et al., 2019). Connected hospital management system allows patient information, examination schedules (Dwivedi et al., 2019), and drug supplies to be controlled more efficiently, while connected electronic medical records enable faster access to clinical information needed for medical decision-making.

Some key aspects of the application of IoT in healthcare are, first, IoT enables real-time health data collection (Al-Garadi et al., 2020). Connected devices such as sensors and tracking devices can continuously monitor health parameters such as heart rate, blood glucose level, or blood pressure, providing more accurate and in-depth data about an individual's health condition. This provides opportunities for early disease detection and more targeted healthcare services. Secondly, the use of IoT in remote patient monitoring has opened the door for more flexible healthcare. (Mohamad Noor & Hassan, 2019). Patients with chronic conditions can be monitored remotely through wearables or connected medical devices, allowing doctors to monitor the patient's condition on a regular basis without the patient having to be present in person at the healthcare facility. This can improve chronic disease management and reduce emergency room visits. In addition, IoT also enables the development of preventive health tracking devices (Ayaz et al., 2019). For example, devices that measure physical activity levels, sleep quality, or nutritional intake can help individuals to actively manage their health. With the information gathered by these devices,

individuals can make healthier lifestyle changes, prevent diseases, and improve overall well-being.

2. Health

Health is a state of physical, mental, and social well-being, not just the absence of disease or infirmity. It includes physical fitness, mental balance, and positive social interactions (Dash et al., 2019). Health also involves a person's ability to function on a daily basis without significant physical or mental impairment (Ahmad et al., 2016). Staying healthy is not just about medical treatment, but also includes a healthy lifestyle, a good diet, regular physical activity, stress management and positive social relationships (Esteva et al., 2019). Health is a valuable asset that affects one's overall quality of life. The importance of maintaining good health cannot be overlooked. Health is a valuable asset that affects one's overall quality of life. Staying healthy plays a role in ensuring that one can live with full potential, productivity and happiness. The following is a discussion on the importance of staying healthy which includes its positive impact on daily life, social relationships, productivity and overall well-being.

The importance of staying healthy is not just about keeping your body healthy, it is also about maintaining your mental and emotional state (Bull et al., 2020). Good health contributes to higher productivity, emotional stability, and overall happiness. Good health also allows one to live a life with more freedom and independence. In a social context, maintaining good health also plays an important role. Good health allows one to establish positive social relationships with others (Greco et al., 2020). Maintaining good health allows one to engage in social activities, contribute to society in meaningful ways, and build healthy relationships with family, friends and coworkers. This also has implications for one's psychological aspects, which in turn affects overall well-being. Another aspect of the importance of staying healthy is in increasing productivity. A good physical and mental state allows one to work efficiently, focused and productively (Mulyasari et al., 2023). Good health also has an effect on endurance, which in turn allows one to be present at work, complete tasks well, and achieve set goals.

Good health is also key to enjoying old age with a better quality of life. By maintaining good health from an early age, there is a lower chance of chronic diseases common in old age such as heart disease, diabetes and osteoporosis (Rajpurkar et al., 2022). As such, maintaining good health is a long-term investment to ensure a good quality of life in the future. Health care also plays an important role in ensuring a good economic survival. Health care costs can be a heavy financial burden for a person or family in the event of an illness or health condition that requires intensive care. By taking care of one's health early on, the risk of developing chronic diseases can be minimized, which in turn can reduce overall healthcare costs (Mesko & Győrffy, 2019). In addition to the physical and psychological benefits, staying healthy is also important in establishing a healthy lifestyle. Healthy living habits such as a balanced diet, regular exercise, stress management and adequate sleep are key to

maintaining overall health. By living a healthy lifestyle, one can reduce the risk of developing various diseases and health conditions that can potentially affect quality of life.

In a global context, good health also affects the sustainability of the environment (Janz & Becker, 1984). When individuals and society as a whole are healthy, they are more likely to care about their surroundings and contribute to environmental conservation efforts. This can have a positive impact on the sustainability of the earth we live on. Furthermore, the importance of staying healthy is also linked to the development of stronger and more productive communities. Good health enables society to develop as a whole, economically, educationally and socially. Individuals who are physically and mentally healthy tend to be able to contribute more to community development, advance the economy, and create a more stable social environment (Qiu et al., 2020). From these various perspectives, it can be concluded that maintaining health is not only an individual problem, but also a collective responsibility related to the welfare of society as a whole. The importance of maintaining health reaches various aspects of life, both in terms of physical, mental, social, economic, and environmental aspects. Therefore, attention to health needs to be given as a whole, both from individuals and the government, health institutions, and society at large. Thus, maintaining health is the key to creating a more prosperous, productive, and sustainable society.

3. **Personalized Services**.

Personalized services are services that are individualized and tailored to each person's unique needs, preferences, and characteristics. The form of personalized services may vary from sector to sector, but at its core, personalized services aim to provide a more focused and customized experience for each individual. In the healthcare sector, personalized service refers to healthcare that is tailored to a patient's specific needs. This includes not only diagnosis and treatment that is individually adapted, but It is also a holistic approach to patient health, considering factors such as genetic background, lifestyle, and patient preferences. From a technology perspective, personalized service has begun to expand into the digital realm. For example, e-commerce platforms use algorithms to recommend products to consumers based on their shopping history, personal interests, and other online behaviors. This aims to provide a more personalized and customized shopping experience. In general, personalized service reflects an emphasis on individuality and the unique needs of each person. In an era where personalization is increasingly valued, personalized service has become an important strategy for companies to build strong relationships with customers, while meeting consumer expectations for relevant and customized experiences.

There are several opinions of previous research. The first research according to Achmad Solechan et al., (2022), with the research title Business Opportunities in the Application of Industrial Internet of Thing (IIoT). The results of his research state that business opportunities from the utilization of the Industrial Internet of Things (IIoT).

IoT can be implemented in various fields of modern economy, for example: health, environment, defense, quality control, transportation, logistics, clean water, building/construction, industrial/manufacturing production, energy sources, agriculture and plantations. The second research according to Ratna, (2020), with the research title Internet Of Things (IoT) Based Health Monitoring System. The results of his research state that an Android-based application that can monitor HR, HRV and ST values for patients who must always be under the supervision of a doctor. The third research according to Megawati, (2021), with the research title Development of Internet of Things Technology Systems that Need to be Developed by Indonesia. The results of his research state that the low number of studies that have been conducted by Indonesian researchers, the average national research related to the development of IoT does not exceed 10% of the overall research that has been reviewed.

RESEARCH METHODOLOGY

In conducting a literature review on the establishment of the Internet of Things (IoT) in healthcare, both qualitative and quantitative research can be used to gather information and develop a comprehensive understanding of the topic. Qualitative research methods can be used to gain a deep understanding of how the use of IoT in healthcare affects individuals, organizations, and society as a whole. Qualitative approaches may include in-depth interviews with healthcare professionals, patients, and other stakeholders to understand experiences, perceptions, and expectations regarding the establishment of IoT in healthcare. Direct observations can also be made to understand how IoT technologies are implemented and used in the healthcare environment. In qualitative research, data analysis is conducted using an inductive approach, which allows researchers to identify patterns, themes, and frameworks that emerge from the data (Bauer & Scheim, 2019). Qualitative research methods may also involve text analysis of relevant articles, reports, and documents to understand theoretical and practical views related to the establishment of IoT in healthcare (Yomeldi, 2020). The advantages of qualitative research methods are the ability to explore the complexity and context of the use of IoT in healthcare, and provide deep insights into its impact on individuals and society. However, the limitations of this method are subjectivity in data interpretation and difficulty in generalizing the results.

On the other hand, quantitative research methods can be used to collect empirical data related to the use of IoT in healthcare, such as its adoption rate, effectiveness, efficiency, and impact on clinical outcomes and disease management. Quantitative research can involve surveys, experiments, and secondary data analysis to measure variables related to IoT penetration in healthcare. In quantitative research, data analysis is conducted using a deductive approach, where hypotheses are tested and variables are measured quantitatively. This research method can also utilize statistical techniques to test relationships between variables and make generalizations to a wider population. The advantages of quantitative research methods are its ability to provide strong empirical evidence related to the penetration and effects of IoT in

healthcare, as well as allowing generalization of results to larger populations. However, the limitations of this method This is due to a lack of in-depth understanding of the context, processes, and experiences of the individuals involved. In conducting a literature review on IoT adoption in healthcare, a combined approach of qualitative and quantitative research methods can provide a comprehensive understanding. Qualitative research can be used to explore the perspectives, experiences, and context of IoT use in healthcare, while quantitative research can provide empirical evidence related to its adoption, effectiveness, and impact on health outcomes. Through the integration of these two methods, researchers can combine the advantages of each approach, as well as overcome the limitations of each. Thus, the literature review on IoT deployment in healthcare can provide a comprehensive and in-depth understanding, as well as strong empirical evidence related to the use of this technology in improving healthcare. In integrating these two methods, researchers can use triangulation, which is the process of comparing and confirming findings from both approaches to strengthen the validity of the research results. In addition, researchers can also adopt a mixed methods approach that simultaneously utilizes qualitative and quantitative approaches to gain a richer and holistic understanding of IoT deployment in healthcare.

RESULT AND DISCUSSION

IoT in healthcare combines sensors, devices, information systems, and infrastructure to form a connected healthcare environment. This allows medical devices and users to communicate directly, collect real-time health data, and enable more effective patient monitoring. For example, wearable devices connected to the internet can collect heart rate data, activity levels, or even measure blood sugar levels continuously. The application of IoT in healthcare has several goals. 1). Better Patient Monitoring. IoT enables continuous monitoring of patients remotely. The data collected by IoT devices helps doctors to monitor patient conditions more effectively, make earlier diagnoses, and respond more quickly to changes in conditions. 2). Chronic Disease Management. Patients with chronic conditions such as diabetes or heart disease can benefit from better monitoring through IoT devices. It helps in disease management by providing timely information and provide appropriate maintenance recommendations. 3). Telemedicine. The use of IoT enables remote medical consultation and examination of patients without having to be physically present on-site. This enables easier access to healthcare for individuals who live in remote areas or have limited mobility. 4). Drug Development and Clinical Research: IoT enables the collection of big data coming from various sources for use in medical research and drug development. This helps researchers understand a patient's response to a particular therapy and identify patterns that may have been missed. 5). Healthcare Infrastructure Management: In hospitals and other healthcare facilities, IoT helps in efficient management of drug stocks, medical equipment, and resource utilization. This can reduce wastage and improve operational efficiency. Finally, as health

education and awareness. The use of IoT devices can also help in improving public health literacy by providing information on healthy lifestyles, providing recommendations, and monitoring general health.

The application of the Internet of Things (IoT) in healthcare has brought about a transformation in managing, monitoring, and treating health. IoT refers to a network of physical devices that are connected online, enabling the exchange of data and information between these devices. In healthcare, IoT has had a tremendous impact. The application of IoT in healthcare is constantly evolving and continues to provide new innovations that enable more personalized, efficient, and affordable care for many people. In the application of IoT in the world of health and the various types and opportunities that can be felt from its use. 1. Wearable Devices. These types of devices are sensors worn on the body, such as smart bracelets, watches, skin patches, or smart clothing. They are used to track heart rate, oxygen levels, physical activity, and sleep. Opportunities include early disease detection, stress management, and increased physical activity. Furthermore, the use of sensors to monitor conditions such as diabetes (glucose levels) or heart conditions continuously. 2. Connected Medical Devices. This type of device is a medical device that is connected to the internet, such as a connected insulin pump or digital ECG device. It provides medical data directly to doctors or electronic medical record (EMR) systems. This can improve patient monitoring in critical situations and enable faster diagnosis. Then in a hospital setting, these devices can monitor medication dosage or patient response in real-time. 3. Smart Hospitals and Health Infrastructure. This type is a sensor and connected system in a hospital environment. The way it is used is sensors to monitor drug stocks, medical equipment, or patient needs. Furthermore, maintaining patient security and safety, for example, the use of RFID technology in patient bracelets to avoid loss or theft. 4. Telemedicine and Remote Consultation. This type is a connected communication platform that enables remote medical consultations. Its use allows patients to communicate with doctors without having to come to the office or hospital, reducing costs and improving healthcare accessibility. Then Remote Monitoring: Through sensors or IoT devices, doctors can remotely monitor a patient's condition and provide necessary treatment. 5. Household Health. This type is health-related connected household devices, such as smart scales, smart fridges, or IoT devices for the surrounding environment. Applications include smart scales to monitor weight and body composition, smart fridges to store and monitor healthy food intake. Healthy Environment: Use of sensors to monitor indoor air quality, temperature, or humidity that can affect health.

NO	Questions	Answer	Value
1	Can the trend of using IoT support decision making and information quickly and precisely?	Yes, the use of IoT can support decision making and information quickly and precisely.	80%
2	How is the IoT implementation	That is, by identifying	60%

	technique that can support every decision making based on IoT?	models/techniques related to analytical data that support the decision-making process in IoT.	
	Is the application of IoT in the future world of benefits in the world of health in the current era of digitalization?	Yes, there are many benefits that arise in the application of IoT in the world of health such as helping to improve public health literacy by providing information about healthy lifestyles, providing recommendations, and monitoring health in general.	75%
	Does the application of IoT in the world of health help improve the quality of health in the future?		60%
	Can the application of IoT guarantee personal health in the future?	Yes, it is very helpful because IoT has a fast response system in its use.	50%

Table 1: Research Questions and Answers Provided by their us

The application of IoT in healthcare brings great opportunities. The first of these opportunities is disease prevention and management. Through continuous and real-time monitoring, IoT enables early identification of diseases or changes in a patient's condition, allowing for faster and more appropriate interventions. Secondly, improved access and efficiency. Telemedicine and wearables enable easier and more affordable access to healthcare for individuals, especially in hard-to-reach areas. Third innovation in care with data collected from IoT devices, we can develop more personalized and targeted care, reducing unnecessary risks and costs of treatment. Fourth, health infrastructure improvement. IoT can improve hospital management, ensuring sufficient drug stock, efficient use of equipment, and patient safety. Fifth, health education and awareness. IoT devices can also be used for public health education, providing information on healthy lifestyles or monitoring general health conditions. The application of IoT in healthcare opens up great opportunities to improve the quality of healthcare, reduce costs, and provide more personalized care.

NO	**Paramenter**	Devenisi	**Code**
	Privacy	Ensures that the system complies with privacy policies and	P
	Non-repudiation	allows users to control their personal data.	NR
	Auditability	The ability of the system to confirm the existence or absence of an action.	AU

	Accountability	Ability to monitor all processes	AC
	Availability	in the system	A

Table 2: IoT usage needs and safety

The application of the Internet of Things (IoT) in healthcare has become an increasingly hot and promising topic. IoT refers to a network of physical devices that are connected via the internet and can collect and exchange data. In the context of healthcare, IoT has brought great changes in the provision of health services, especially in the form of personalized services. The application of IoT in healthcare has changed personalized services, provided benefits to individuals, and looked at the future perspectives of the application of IoT in the provision of personalized healthcare. The first is IoT-based personal health monitoring. IoT has changed the way we monitor our own health. Internet-connected devices, such as smartwatches, activity tracking devices, and other health sensors, have enabled individuals to actively monitor their health parameters around the clock. For example, smartwatches are equipped with heart rate sensors that constantly monitor the user's heart rate. This data can provide valuable insights into cardiac activity throughout the day, help individuals monitor their health conditions, and provide early alarms in case of detection Problems. Second, chronic disease management. For individuals with chronic diseases, the application of IoT in healthcare has brought significant advances in the management of their health conditions. For example, a blood sugar monitoring device connected to a smartphone allows users to real-time monitor and manage their blood sugar levels. This data can also be instantly shared with their medical team, enabling faster and more appropriate interventions. Third, remote healthcare. The application of IoT has enabled more efficient and effective remote healthcare. Through telemedicine and health apps connected to IoT devices, individuals can consult with healthcare professionals from anywhere at any time. This has a positive impact especially for individuals who live in remote areas or are hard to reach by traditional healthcare services. Fourth is stress monitoring and mental well-being. IoT has also changed the way we monitor our mental health. Technologies such as brainwave sensors connected to smartphone apps can help individuals monitor their stress levels and brain activity. This data can be used to identify stress patterns and provide recommendations to reduce stress, improve mental well-being and achieve peace of mind.

The application of IoT in healthcare is still in its infancy, but its potential to transform personalized care in the future is huge. 1. Further Personalization in Healthcare. With more data collected from IoT devices, we can expect more personalized healthcare tailored to each individual. Intelligent algorithms can be used to analyze continuous health data and provide more precise and personalized recommendations. 2. Integration of Health Data from Multiple Sources. In the future, we can expect to see greater integration between health data from various sources, including electronic medical records, personal health monitoring data, and genetic data. This will provide a more holistic view of health and help medical teams make better decisions. 3. Development of Smarter IoT Devices. See developments in the design of smarter and more integrated IoT devices. For example, health devices that can monitor various health parameters simultaneously and provide more comprehensive

recommendations based on the collected data. 4. Focus on More Comprehensive Remote Monitoring Health

The application of IoT in personal health brings challenges in its implementation. Some of the key challenges include 1. Concerns over Data Privacy and Security. With the amount of personal health data collected by IoT devices, concerns over data privacy and security are important. It is important for healthcare providers and IoT device manufacturers to have strong and transparent security systems in place to protect individual health data. 2. Integration and Standardization. Integration of data from different devices and sources is a challenge in the application of IoT in healthcare. Standardization in health data collection, storage, and exchange will be key to ensure good interoperability and prevent "siloed" data. 3. Access and Technology Literacy Gaps. The biggest challenge in implementing IoT in healthcare is the access and technology literacy gap. Some individuals may not have easy access to IoT devices or may not have enough knowledge to utilize them to their full potential.

CONCLUSION

Based on the results and discussion above, it can be concluded that the application of the Internet of Things (IoT) in healthcare promises a more effective and efficient future of personalized healthcare. However, technical, ethical, and security challenges need to be overcome for these applications to be successful. With an increased understanding of the benefits and risks of IoT deployment in healthcare, appropriate steps can be taken to ensure better personalized healthcare in the future. The application of IoT in healthcare brings great opportunities. These opportunities can be in the form of firstly disease prevention and management, enabling early identification of diseases or changes in a patient's condition, enabling faster and more appropriate interventions. Second, increasing access and efficiency. In addition, the application of IoT can develop more personalized and targeted care, reducing unnecessary risks and costs of treatment. Fourth, health infrastructure improvement, IoT can improve hospital management, ensuring sufficient drug stocks, efficient use of equipment, and patient safety. IoT devices can also be utilized for public health education, providing information about healthy lifestyles or monitoring general health conditions. The application of IoT in healthcare opens up great opportunities to improve the quality of healthcare, reduce costs, and provide more personalized care. However, challenges such as data security, standardization, and system integration remain in focus to ensure that these developments provide maximum benefits to society as a whole.

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