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IMPLEMENTATION OF THE INTERNET OF THINGS (IOT) IN REMOTE PATIENT MONITORING SYSTEMS IN HEALTHCARE FACILITIES

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Abstract

The Internet of Things (IoT) is increasingly adopted in remote patient monitoring systems due to its ability to provide real-time physiological data, enable early detection, and enhance healthcare service quality. This study analyzes IoT implementation in Indonesian healthcare facilities using a Systematic Literature Review approach, selecting 18 high-quality articles from major scientific databases. Literature was reviewed based on methodological rigor and relevance to sensor technologies, data integration, information security, and infrastructure readiness. The findings indicate that IoT significantly improves monitoring effectiveness through automated data acquisition, reduced clinical workload, and enhanced diagnostic accuracy. However, IoT adoption in Indonesia faces challenges including limited network stability, lack of system interoperability, cybersecurity risks, low digital literacy among healthcare workers, and financial constraints. The study concludes that a phased implementation strategy, supported by infrastructure upgrades, staff training, reinforced data protection regulations, and pilot projects is essential for ensuring sustainable IoT deployment in healthcare settings. Such an approach can maximize long-term benefits and support national healthcare transformation.

Keywords : *cybersecurity, digital infrastructure, healthcare system, Internet of Things, patient monitoring.*

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1. Introduction

Advances in digital technology in recent years have brought significant changes to global healthcare systems, particularly through the use of the Internet of Things (IoT) in remote patient monitoring. IoT enables sensor devices, network connectivity, and data platforms to interact with each other to send real-time physiological information about patients to healthcare professionals without the need for patients to be present at medical facilities. This transformation has become increasingly relevant amid the growing burden on healthcare facilities, the rise of chronic diseases, and the challenge of providing equitable services across vast geographical areas. A study by Sagahyroon et al. (2017) shows that the integration of IoT into modern healthcare systems significantly improves the accuracy of physiological data collection and enables early detection of changes in patient conditions, allowing healthcare professionals to intervene more quickly. In this context, the development of remote patient monitoring (RPM) systems is not merely a technological innovation, but a strategic necessity in improving healthcare capacity.

A similar phenomenon can be seen at the global level, where IoT has been used in various care models, including the monitoring of patients with heart disease, diabetes, hypertension, respiratory failure, and other conditions that require continuous supervision. Singh (2018) explain that healthcare IoT systems enable the integration of wearable devices, medical sensors, and edge computing to provide round-the-clock clinical services, allowing healthcare professionals to detect emergencies before the patient's condition worsens. With

its ability to automatically collect physiological data, IoT supports a predictive care approach, which helps prevent costly and high-risk intensive care. This presents a significant opportunity for healthcare systems striving to achieve cost efficiencies and improve service quality amid increasing patient demands.

This situation has become even more critical following the COVID-19 pandemic, as healthcare systems worldwide face immense pressure due to a surge in patients and the need to minimize physical contact. The use of IoT devices to monitor COVID-19 patients at home has been shown to reduce the need for hospitalization and optimize hospital capacity management. Wang et al. (2021) emphasized that IoT-based monitoring systems used during the pandemic increased the efficiency of symptom monitoring and made it easier for medical personnel to conduct clinical evaluations without the risk of direct contact. In Indonesia, the pandemic has also accelerated the digital transformation of healthcare, including the expansion of telemedicine services, the use of digital health applications, and the integration of electronic medical records to improve clinical response.

However, the implementation of IoT in Indonesian healthcare facilities is still in its early stages and faces a number of challenges that differ from those in developed countries. Indonesia has significant geographical challenges, with many remote islands that are difficult to reach and have limited network infrastructure. According to Kusnanto et al. (2021), the main obstacles to the implementation of technology-based healthcare systems in Indonesia include limited internet connectivity, low interoperability between healthcare systems, and a lack of technical skills among healthcare workers in operating digital devices. This situation shows that although the potential of IoT is enormous, its success is highly dependent on the readiness of healthcare facilities to provide adequate supporting infrastructure.

Technically, IoT in patient monitoring relies on sensors and wearable devices to measure physiological variables such as blood pressure, oxygen saturation, body temperature, heart rate, and physical activity. The data is then transmitted via the internet to a server or cloud platform to be analyzed and monitored by healthcare personnel. Feng et al. (2020) explain that one of the main advantages of IoT is its ability to maintain continuous, real-time physiological monitoring with a high degree of reliability, thereby improving the accuracy of diagnoses and clinical decisions. The implementation of such systems is particularly relevant in Indonesian healthcare facilities, especially regional hospitals, community health centers, and clinics, which often experience a shortage of medical personnel but have a high patient load.

Data security issues are a crucial aspect in the implementation of IoT for health monitoring. Medical data is highly sensitive and protected by strict health regulations. However, the use of internet connectivity in IoT systems makes data vulnerable to security threats such as interception, data manipulation, or illegal access. Roman et al. (2013) emphasize that IoT devices in the health sector are at great risk of man-in-the-middle attacks, unauthorized access, and data modification if they are not protected by encryption and multi-layered authentication. With the enactment of the Personal Data Protection Law (PDP Law) in Indonesia, health facilities are now required to ensure that all patient data sent via IoT is stored and managed securely.

In addition to security, system interoperability is also a critical factor that determines the success of IoT implementation in healthcare facilities. Many hospitals in Indonesia still use internal information systems that are incompatible with one another. This makes it difficult to integrate IoT data into the national electronic medical records. Mavrogiorgou et al. (2019) state that interoperability is a key prerequisite for IoT integration because without uniform data standards, clinical information becomes fragmented, hindering medical decision-making. Inter-platform disconnectivity makes it difficult for healthcare professionals to make optimal use of IoT data.

In addition to improving diagnostic effectiveness, IoT also provides significant benefits in terms of operational efficiency. Remote monitoring systems can reduce the burden of hospitalization, decrease healthcare worker fatigue, and allow medical staff to monitor more patients without having to perform routine direct examinations. Chen et al. (2019) showed

that the use of a remote physiological monitoring system in intensive care units can reduce clinical incidents and improve resource efficiency. In Indonesia, where the distribution of healthcare workers is still uneven, IoT can help optimize the utilization of medical personnel in areas with a shortage of health professionals.

The application of IoT is also useful in monitoring the elderly, pregnant women, post-operative patients, and patients with limited mobility. Kumar et al. (2018) reported that an IoT system for monitoring post-operative patients can accelerate the detection of complications, reduce the rate of repeat hospital visits, and improve the patient experience during recovery. With Indonesia's elderly population projected to increase, the need for remote monitoring technology is predicted to grow.

Despite these benefits, previous studies still point to a number of gaps that need to be clarified. First, international studies such as Sagahyroon et al.'s article titled “The Internet of Things and e-Health: remote patients monitoring.” (2017) provide strong evidence of the clinical benefits of IoT, but this study used a sample of healthcare facilities in the Middle East, whose technological infrastructure differs significantly from that of Indonesia. Second, the study by Wang et al. entitled “. Integrating digital technologies and public health to fight Covid-19 pandemic: key technologies, applications, challenges and outlook of digital healthcare” (2021) highlights the effectiveness of IoT in pandemic conditions, but the study focuses more on clinical workflows and does not provide implementation guidelines for health facilities with low infrastructure capabilities such as community health centers (Puskesmas). Third, the study by Kusnanto et al. in “Challenges in Implementing Digital Health in Indonesia” (2021) discusses the barriers to the adoption of health technology in Indonesia, but does not examine in depth the IoT architecture model suitable for remote patient monitoring. Fourth, the research by Feng et al. in “Towards Energy-Efficient Framework for IoT Big Data Healthcare Solutions.” (2020), which focuses on the technical performance of sensors and networks, does not discuss the capacity of health facilities to adopt these devices. These research gaps indicate that there has not been a comprehensive analysis linking the technical, operational, and regulatory aspects of IoT in the context of Indonesian health facilities.

The novelty of this study lies in the development of an integrative analysis of IoT implementation for remote patient monitoring, specifically contextualized to Indonesian healthcare facilities that face infrastructure limitations, varying digital capabilities, and regulatory challenges. This study brings together technical, clinical, data security, organizational readiness, and healthcare system challenges perspectives into a single evaluative framework. Thus, the objectives of this study are to evaluate empirical evidence on the effectiveness and challenges of IoT implementation in remote patient monitoring, identify relevant barriers and opportunities for Indonesian healthcare facilities, and formulate an implementation model that can be applied gradually and sustainably.

2. Method

This study uses a Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize scientific evidence regarding the implementation of the Internet of Things (IoT) in remote patient monitoring systems in healthcare facilities. SLR was chosen because it provides a rigorous and transparent analytical structure for tracing and assessing the contributions of previous research. In line with Snyder's (2019) view, SLR allows researchers to map knowledge development, find patterns of findings, and identify research gaps that have not been adequately addressed. The literature search was conducted through the Scopus, PubMed, IEEE Xplore, ScienceDirect, and SpringerLink databases using a combination of the keywords “Internet of Things,” “remote patient monitoring,” “IoT healthcare,” “telemedicine IoT systems,” and “connected health devices.” Each article found was then selected based on topic relevance, methodological quality, and its contribution to the study of IoT implementation in the context of healthcare facilities.

Literature selection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which includes four stages: identification, screening,

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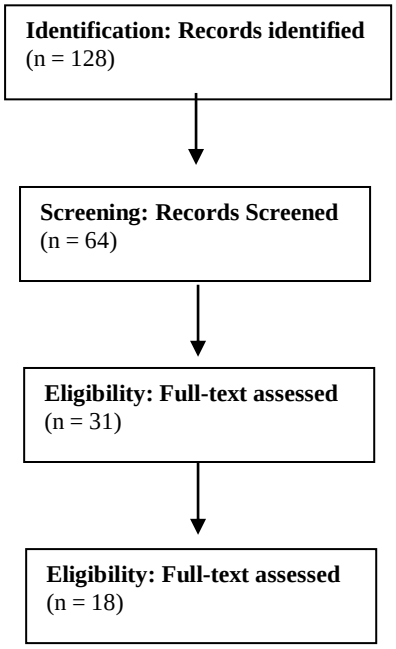
eligibility assessment, and final selection. Inclusion criteria included articles in English or Indonesian, published within the last ten years, available in full-text, and discussing IoT applications for patient monitoring from both technical and clinical operational perspectives. Articles focusing on non-medical IoT, pure network protocols without clinical relevance, or IoT devices for household use were excluded from the analysis. All articles that passed the screening stage were assessed for quality through critical appraisal as recommended by Tranfield et al. (2003) to ensure the validity of the findings and the reliability of the methodology.



3. Results and Discussion

The Role of the Internet of Things in Improving the Effectiveness of Remote Patient Monitoring in Healthcare Facilities

The implementation of the Internet of Things in remote patient monitoring has brought about fundamental changes to the way healthcare facilities conduct clinical monitoring of patients, especially those who require continuous monitoring. This change is not merely a technological transformation, but also an operational one, as traditional monitoring systems that rely on face-to-face examinations are gradually being replaced by smart sensors, real-time connectivity, and automatic data integration that allow healthcare professionals to obtain patient physiological information at any time. IoT enables the continuous collection of data such as heart rate, blood pressure, oxygen saturation, body temperature, sleep patterns, and physical activity, providing a more comprehensive picture of a patient's condition than periodic examinations. According to Valsalan et al. (2020), IoT improves the effectiveness of health monitoring by providing non-stop access to patient data, thereby minimizing blind spots in the clinical journey that often occur in manual monitoring systems. In the Indonesian context, where healthcare workers often have a high patient-to-staff ratio, real-time monitoring can reduce the possibility of delays in medical intervention and improve the quality of care, especially for patients with chronic diseases.

One of the most significant benefits of IoT-based monitoring systems is their ability to detect changes in clinical conditions early. With 24/7 monitoring, IoT sensors can identify downward trends in conditions before patients feel symptoms or they are detected through manual examinations. This function is particularly relevant for patients with heart disease, respiratory failure, or diabetes, where small fluctuations in physiological parameters can lead to serious complications. Elhoseny et al. (2018) emphasize that analytics-based IoT systems

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are capable of providing early warnings through automatic calculation of abnormal patterns, enabling healthcare professionals to take action before conditions become critical. This mechanism not only improves patient safety but also reduces the risk of sudden hospitalizations and emergency visits that can burden healthcare facilities, especially in areas with limited hospitals and doctors.

The effectiveness of IoT is also evident in the integration of sensors, network connectivity, and analytics platforms. Data collected by wearable sensors or medical devices is not only stored but also automatically analyzed and visualized to help healthcare professionals understand the patient's condition comprehensively. According to Hosseinzadeh et al. (2021), the success of IoT-based health monitoring systems depends on analytical algorithms that are capable of filtering relevant data and detecting anomalies without causing false alarms that disrupt the workflow of healthcare professionals. The reliability of these analytics is particularly important in Indonesian healthcare facilities, which are still limited in terms of human resources, so that technology can help reduce the administrative burden and increase the focus of medical personnel on clinical decision-making.

In addition to improving clinical effectiveness, IoT also supports operational efficiency. Remote monitoring systems reduce the need for healthcare workers to perform routine checks that are not always urgent, allowing them to allocate their time to patients with acute needs. Chen et al. (2019) showed that the use of remote physiological monitoring systems in ICUs can reduce clinical incidents by up to 20% and improve resource allocation, as doctors and nurses do not need to perform manual checks on stable patients on a regular basis. A similar effect can occur in Indonesia, especially in community health centers and regional hospitals that often face a shortage of healthcare workers. The uneven distribution of medical personnel makes IoT a strategic technology for accelerating the equal distribution of access to healthcare services without adding to the excessive workload.

The implementation of IoT also affects the pattern of communication between patients and healthcare workers. IoT allows patients to remain under supervision without having to visit a healthcare facility, thereby reducing transportation costs and waiting times. According to Rahman et al. (2021), patients with IoT-based monitoring show higher satisfaction levels because they feel safer and more monitored without having to be under direct physical supervision in a hospital. In the Indonesian context, this is particularly relevant because many patients live far from hospitals or face mobility limitations. With remote monitoring, hospitals can expand their service coverage to patients in remote areas without having to build additional physical facilities.

IoT integration also indirectly improves the quality of clinical decision-making. Medical personnel do not only rely on intuition or patient reports, but have objective data collected with high-precision methods. This reduces the subjectivity of assessments and improves diagnostic accuracy. According to Kumar et al. (2018), doctors who utilize IoT data in post-operative monitoring are able to detect complications two to three days faster than conventional methods. Thus, IoT plays a role in accelerating the patient recovery process and reducing the number of readmissions that often burden health facilities.

However, the effectiveness of IoT is highly dependent on sensor reliability and network quality. IoT systems can only provide maximum benefits if the collected data is accurate and processed in a timely manner. In areas with unstable internet networks, sensor data can be delayed or lost. This shows that the success of IoT depends not only on the devices, but also on the readiness of the digital infrastructure. According to Shah et al. (2016), the reliability of IoT sensors in healthcare must be maintained through redundancy technology, self-checking systems, and error correction algorithms so that the data received by healthcare workers remains valid. Indonesian healthcare facilities with varying internet network quality need to consider this aspect before fully adopting IoT systems.

Beyond technical aspects, the implementation of IoT in patient monitoring also raises ethical and privacy concerns. Patient health data is highly sensitive and must be protected with strong security protocols. Roman et al. (2013) emphasize that IoT is vulnerable to

attacks such as data interception, medical information manipulation, and identity theft if not equipped with a layered security system. New regulations such as the Personal Data Protection Law (PDP Law) tighten the obligations of healthcare facilities in maintaining the confidentiality of medical data sent through IoT networks. Therefore, IoT implementation must ensure that encryption systems, device authentication, and access control are consistently applied.

In addition to security challenges, interoperability is an important issue. Healthcare facilities in Indonesia use a variety of information systems that are not always compatible with each other. This hinders the integration of IoT data into electronic medical records. Mavrogiorgou et al. (2019) note that interoperability is a key requirement for optimizing the benefits of IoT. Without uniform data standards, clinical information tends to be fragmented and cannot be used effectively by healthcare professionals. Therefore, the implementation of IoT must be followed by the implementation of interoperability standards such as HL7 or FHIR so that data can move between systems without obstacles.

The increased effectiveness of IoT can also be seen from the perspective of continuous care. Remote monitoring systems enable the transition of care from hospitals to patients' homes, thereby improving service continuity. According to Lee et al. (2020), patients with IoT monitoring show higher compliance with treatment plans because they can view their own health data and receive automatic notifications in case of significant changes. This is highly relevant to Indonesia's need to develop community-based health services and encourage active patient participation in maintaining their health.

Overall, the analysis in this subchapter shows that IoT plays an important role in improving the effectiveness of remote patient monitoring in terms of clinical, operational, and communication aspects between patients and healthcare providers. IoT not only helps with early detection and speeds up medical response, but also supports resource efficiency and improves patient comfort. Thus, IoT is a strategic technology that can strengthen the capacity of Indonesia's healthcare services to face future challenges.

Challenges of Implementing IoT in Remote Patient Monitoring Systems and Their Impact on Service Reliability

The implementation of the Internet of Things in remote patient monitoring provides a great opportunity for healthcare transformation, but there are a number of technical, operational, and regulatory challenges that need to be analyzed in depth for the implementation to be effective. One of the main challenges is network stability and connectivity quality as a crucial factors considering that IoT is highly dependent on real-time data transmission. In many regions of Indonesia, internet access is not yet evenly distributed, so sensor data can be delayed or interrupted, reducing the reliability of the monitoring system. According to Woo et al. (2018), healthcare IoT systems can only function optimally when they have stable connectivity with low latency, as data delays can potentially hinder early detection and reduce the effectiveness of clinical decision-making. These limitations create clinical risks for patients who require continuous monitoring, especially in areas with suboptimal digital infrastructure.

In addition to network issues, device energy efficiency is also an important challenge in the use of IoT in healthcare facilities. Many IoT devices, especially wearable sensors, rely on batteries with limited capacity. When sensors have to work 24 hours a day, energy consumption increases and devices can run out of power without being noticed by either patients or healthcare workers. This can lead to data gaps that endanger patient safety. Feng et al. (2020) emphasize that high energy consumption in health sensors is a major obstacle to IoT implementation, requiring energy management algorithms and device designs that can extend battery life. In Indonesian healthcare facilities that are not yet familiar with IoT-based monitoring devices, the risk of sudden device failure can reduce healthcare workers' confidence in the reliability of the system.

Cybersecurity is also a fundamental issue that cannot be separated from IoT implementation. Patient monitoring systems generate sensitive medical data that must be

protected from hacking, eavesdropping, and manipulation. IoT has vulnerabilities in the form of inter-device connectivity, network protocols, and cloud data storage, all of which can be targets for attacks. According to Diaz et al. (2022), medical IoT devices are one of the most vulnerable categories of technology because they are often designed to maximize clinical function but lack layered security systems. Attacks on these devices can cause patient data to be leaked or altered, which not only poses a privacy risk but also a serious clinical risk if the incorrect data is used as the basis for medical decisions. The implementation of IoT in Indonesian healthcare facilities must adhere to strict security standards, especially since the enactment of the Personal Data Protection Law.

In addition to technical challenges, data interoperability remains a significant obstacle to the implementation of IoT in healthcare facilities. Indonesia has a highly diverse healthcare information system, ranging from local hospital applications, different community health center systems in each region, to electronic medical records that are not yet fully standardized. This lack of connectivity hinders the ability of IoT to provide maximum benefits. According to Rahmani et al. (2018), interoperability is an absolute requirement for IoT so that devices, sensors, and data platforms can work in an integrated ecosystem; otherwise, data becomes fragmented and difficult to use for clinical decision-making. Without proper integration, IoT only adds new devices without improving service effectiveness.

To provide a structural overview of the various challenges in technical, operational, and security aspects that impact the implementation of IoT in healthcare facilities, the following table has been compiled as a conceptual summary based on scientific evidence. This table aims to clarify the relationship between the technical aspects of IoT and its implications for the reliability of healthcare services.

Challenge Category	Description	Impact on Healthcare Delivery
Network Reliability	Limited bandwidth, unstable internet connectivity, latency issues	Delayed physiological data, reduced early warning accuracy
Device Energy Constraints	Wearable and sensor devices with limited battery capacity	Data gaps, device malfunction, reduced monitoring continuity
Data Interoperability	Incompatible health information systems and lack of data standardization	Fragmented clinical data, hindered clinical decision-making
Cybersecurity Risks	Vulnerability to hacking, data interception, and unauthorized access	Threats to patient privacy, compromised clinical safety
Infrastructure Readiness	Variability in healthcare facility digital capabilities	Uneven implementation, inconsistent service quality

The table shows that the challenges of IoT are not only related to devices or sensors, but also include infrastructure readiness, security, and health system integration. These factors are interrelated: unstable networks cause data disconnections, devices with low batteries disrupt monitoring continuity, and a lack of interoperability makes data unable to be integrated with electronic medical records. These overlapping challenges indicate that IoT implementation must be carried out holistically in order for its impact on service reliability to be truly significant.

In addition to technical barriers, there are also operational challenges related to the adaptation of healthcare workers. The use of IoT devices requires medical personnel to understand how sensors work, read data dashboards, and respond to automatic alerts according to clinical protocols. However, the digital literacy of healthcare workers in Indonesia still varies. Research by Mackert et al. (2016) shows that healthcare workers who are unfamiliar with digital technology have difficulty operating IoT-based patient monitoring

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systems, especially in managing real-time data and interpreting physiological trends. This can reduce the effectiveness of the system, even if the devices are working optimally from a technical standpoint. Therefore, IoT implementation must be accompanied by intensive training and regular technical assistance.

Another challenge arises in the aspect of change management. Healthcare facilities that are accustomed to manual recording systems or conventional monitoring often find it difficult to adapt to sensor-based service models and digital dashboards. Farahani et al. (2018) emphasize that organizational resistance and a lack of digital leadership can be major obstacles to IoT adoption. Hospitals and health centers may face internal barriers, such as concerns about increased workloads due to the use of new systems, or uncertainty about the division of responsibilities in managing IoT data.

Implementation costs are also an important issue. IoT implementation requires a significant initial investment, including the purchase of sensor devices, network systems, data storage servers, and analytics software. In addition, operational costs such as maintenance, device updates, and network security must also be taken into account. Selvaraj & Sundaravaradhan et al. (2020) found that small-scale health facilities face greater financial barriers to adopting IoT than large hospitals. This condition is relevant in Indonesia, where most primary healthcare facilities have limited budgets. Finally, technology sustainability is a crucial aspect. IoT systems that are not regularly updated will be vulnerable to device failure, security risks, and incompatibility with the latest clinical systems.

Acampora et al., (2017) emphasizes that IoT sustainability is determined by firmware updates, sensor maintenance, and device lifecycle management. Without a clear sustainability strategy, healthcare facilities may experience a decline in system performance over time even if the initial implementation goes well. This subchapter's analysis shows that the challenges of IoT implementation are multidimensional and affect the reliability of remote patient monitoring services.

Therefore, implementation strategies must consider network readiness, device design, cybersecurity, data interoperability, healthcare workers' digital literacy, and technological continuity. By thoroughly understanding these challenges, healthcare facilities can design stronger, more adaptive, and sustainable implementation models.

Feasible and Sustainable IoT Implementation Strategies for Healthcare Facilities in Indonesia

The implementation of the Internet of Things in remote patient monitoring systems requires a strategy that considers not only technological readiness but also the institutional context, regulations, and human resource capabilities in Indonesian healthcare facilities. Successful IoT implementation cannot be achieved instantly, as this technology requires fundamental changes in how healthcare workers operate, how patient data is managed, and how healthcare facilities organize digital-based service flows. In the context of a developing country such as Indonesia, the right implementation strategy must take into account infrastructure limitations, variations in digital capacity between facilities, and the need for regulatory adaptations that support a secure digital environment. According to Binci et al. (2022), the adoption of IoT in the health sector can only be successful if it is done gradually through a phased implementation approach that allows health facilities to learn, adapt, and improve their capabilities with minimal risk.

The initial stage of the implementation strategy must begin with an assessment of the digital infrastructure readiness of each healthcare facility. This assessment includes internet network stability, server capacity, integration capabilities with electronic medical records, and the availability of supporting devices such as routers capable of processing sensor data. Research by Yusif et al. (2017) shows that the success of IoT is highly dependent on baseline infrastructure readiness, which includes network capabilities and adequate communication devices. Indonesian healthcare facilities, especially community health centers and small clinics, tend to have limited digital infrastructure and require gradual improvements before they can fully integrate IoT devices.

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Therefore, the implementation strategy must prioritize the improvement of basic infrastructure that can support remote monitoring systems. After mapping infrastructure readiness, the next step is to determine the IoT architecture model that best suits the needs of the healthcare facility. Not all facilities require highly complex IoT technology. Large hospitals may require cloud-based IoT architecture and edge computing integration to process big data, while primary healthcare facilities can start with simple sensor devices connected to a local dashboard.

According to Patel et al. (2021), the selection of IoT architecture must consider the scale of the facility, the number of patients being monitored, and the complexity of the medical services provided. By adjusting the level of technological complexity to the needs of the facility, IoT implementation becomes more efficient and sustainable, and does not overburden the resources of healthcare facilities.

In addition to architecture selection, the success of IoT implementation is also greatly influenced by the quality of healthcare worker training. IoT changes the way medical personnel receive, process, and interpret patient data. Therefore, the digital literacy capacity of healthcare workers must be improved so that they are able to operate devices and data dashboards effectively. Research by Sinha (2024) emphasizes that continuous digital training is a central component in the success of IoT-based health monitoring systems, especially in developing countries with significant variations in technological capabilities. In Indonesia, training for healthcare personnel must include understanding sensor data interpretation, response protocols when automatic alerts occur, and security procedures for handling sensitive medical data.

Data security and patient privacy are critical aspects that must be prepared from the early stages of implementation. IoT systems generate large volumes of sensitive medical data that must be protected with strict security protocols. IoT implementations that do not consider security aspects can open up opportunities for cyberattacks that threaten patient safety. According to Rauscher & Bauer et al. (2018), IoT requires a layered security approach that includes data encryption, device authentication, intrusion detection systems, and incident recovery procedures. In the Indonesian context, all of these procedures must be in line with the Personal Data Protection Law (PDP Law), which stipulates that patient data must not be leaked or manipulated during the data exchange process through IoT devices. The IoT implementation strategy must include periodic security audits and risk mitigation procedures in the event of a cyber threat.

In addition to security, the IoT implementation strategy must consider interoperability with the national health information system. Healthcare facilities use different applications, and IoT integration is only effective if data can be seamlessly exchanged with electronic medical records. Research by Jabbar et al. (2020) shows that IoT interoperability in healthcare can be strengthened through the use of international data standards such as HL7 FHIR so that devices from different vendors can work in a single service ecosystem. Indonesian healthcare facilities need to adopt these interoperability standards so that IoT data is not fragmented, which can hinder the diagnostic process and reduce the reliability of the monitoring system.

The implementation of IoT must also be accompanied by effective change management at the organizational level. Healthcare facilities must prepare an organizational structure that supports the integration of IoT with daily clinical workflows. According to Mourtzis et al. (2021), the implementation of new technologies such as IoT often fails not because the devices do not work, but because staff do not understand how the technology should be used in service flows. Therefore, it is necessary to conduct socialization, re-map workflows, and develop clear SOPs to ensure that IoT is not just an additional tool, but a tool that is truly integrated into clinical operations.

The cost of implementing IoT is a real challenge that requires realistic and sustainable budgeting strategies. IoT requires initial investments in sensor devices, networks, data storage servers, and analytics systems, all of which can be a financial burden for small healthcare facilities. Mashudi et al. (2021) state that IoT financing strategies must combine

initial investments with long-term operational cost models to ensure system sustainability. In Indonesia, healthcare facilities can begin implementation gradually, for example by monitoring high-risk patients first before expanding coverage to other patient groups.

Another important strategy is to conduct a pilot project before full implementation. Pilot projects allow healthcare facilities to test devices, evaluate system reliability, identify technical obstacles, and measure limited clinical benefits before making a large investment. According to Solangi et al. (2017), pilot projects are the best approach to IoT implementation in the healthcare sector because they provide empirical data on the effectiveness of technology in specific contexts.

Indonesian healthcare facilities can choose specific service units such as non-communicable disease clinics, elderly care, or chronic inpatient wards to test IoT systems. From a long-term effectiveness perspective, the sustainability of technology is an aspect that should not be overlooked. IoT systems are vulnerable to device obsolescence, new cyberattacks, and changes in network protocols.

Therefore, IoT implementation must include a plan for device updates and ongoing maintenance. Research by Khan et al. (2022) shows that IoT sustainability is largely determined by the ability of healthcare facilities to perform lifecycle management, which includes firmware updates, periodic sensor checks, and replacement of devices that are no longer compatible with the latest security standards.

Overall, a feasible and sustainable IoT implementation strategy for Indonesian healthcare facilities must combine infrastructure readiness, healthcare worker training, data security, interoperability, organizational change management, realistic financing, and long-term maintenance. By implementing this strategy gradually and measurably, Indonesian healthcare facilities can harness the full potential of IoT to improve the quality of remote patient monitoring, accelerate clinical response, and expand access to quality healthcare services without being limited by distance and the physical capacity of facilities.

4. Conclusions and Suggestions

Analysis of the implementation of the Internet of Things in remote patient monitoring systems shows that this technology has great potential to improve the quality of healthcare services, accelerate clinical response, and expand access to real-time physiological monitoring. IoT enables healthcare professionals to continuously monitor patient conditions through sensors that automatically collect vital data, allowing for faster and more accurate early detection of changes in clinical conditions. In addition to clinical benefits, IoT also reduces the operational burden on healthcare facilities by reducing the need for manual examinations and improving the efficiency of healthcare personnel allocation at various service levels. However, this effectiveness can only be achieved if the IoT system is supported by a stable network infrastructure, good data integration, and security procedures that comply with data protection regulations.

On the other hand, technical and institutional challenges indicate that IoT implementation cannot be done instantly. Healthcare facilities face obstacles in the form of limited digital infrastructure, varying levels of technological literacy among healthcare personnel, system interoperability issues, data security risks, and significant financial constraints. Therefore, the implementation strategy must be carried out in stages through infrastructure readiness improvements, the development of technology architecture models that are appropriate for the capacity of the facility, training of healthcare personnel, and the formulation of strict data security procedures.

Pilot projects in specific service units can help healthcare facilities assess the effectiveness of IoT before expanding implementation to all service areas. Overall, the successful implementation of IoT in remote patient monitoring depends heavily on organizational readiness, policy support, and the ability of healthcare facilities to manage technological change in a sustainable manner.

Healthcare facilities in Indonesia need to adopt an integrative approach that combines technical, clinical, and regulatory aspects so that this digital transformation provides long-

term benefits. With the right strategy, IoT has the potential to become an important foundation for the Indonesian healthcare system in building more responsive, efficient, and affordable services.

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