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Designing Integrated IT Architecture for Health Monitoring Internet of Things: Findings Exploratory Study

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Abstract:IT integration with healthcare, mainly through Internet of Things-based health monitoring systems, is crucial to improving healthcare management in the digital age. However, challenges remain in the design of an integrated IT architecture that can support the sustainability and effectiveness of IoT health monitoring systems, which still need to be addressed. The shortcomings in the literature related to the application of a holistic IT architecture framework to address these challenges indicate a knowledge gap that needs to be filled. Through the application of the TOGAF methodology, this research seeks to design and analyze an integrated IT architecture for IoT-based health monitoring systems in Indonesia, taking a qualitative approach through case studies, in-depth interviews, and document analysis. The main findings show that the application of the TOGAF framework successfully addresses the challenges of interoperability, data security, and system scalability by effectively integrating IoT technologies in the healthcare environment and considering the local social and infrastructural context. The implementation of the IT architecture developed based on the TOGAF methodology demonstrated improved coordination between IoT devices and backend systems, facilitated secure and real-time data flow, and accommodated the scalability and sustainability needs of the system. The findings have significant implications in supporting the development of more efficient and effective health monitoring systems, offering strategic guidance for system developers, policymakers, and IT practitioners within the healthcare sector.

Keywords: IT Architecture; Internet of Things; TOGAF Framework; Health monitoring; Health system

INTRODUCTION

A new era in health monitoring has utilized real-time data collection via the Internet of Things (IoT) from various connected sensors. IoT-based health monitoring systems are becoming a promising solution to monitor patients' health conditions on an ongoing basis, opening great opportunities for improved health management, early diagnosis, and timely intervention. However, the implementation of IoT-based health monitoring systems still needs to be enhanced by various challenges, especially in designing a well-integrated IT architecture (Hindarto, 2024). One of the specific issues faced is the need to integrate multiple components, such as sensors, data collection devices, network infrastructure, and data analysis platforms.

An effectively integrated IT architecture will provide a solid foundation for an efficient and reliable IoT-based health monitoring system. This system has the potential to offer significant benefits, such as:

1. Early diagnosis and timely health interventions: The system lets doctors monitor patients in real-time and detect and treat health issues early.
2. Improved patient quality of life: Treatment and early detection can reduce the likelihood of complications and improve quality of life.
3. Reduced healthcare costs: The system can help reduce healthcare costs by preventing complications and improving treatment efficiency.

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Table 1. Research related to Enterprise Architecture

Author(s)	Title	Focus	Contribution
(Zovko et al., 2023)	IoT and health monitoring wearable devices as enabling technologies for sustainable enhancement of life quality in smart environments	Advances in IoT and wearable devices for health monitoring	Emphasizes improvement in continuous health monitoring with wearable technology
(Li et al., 2024)	Subway structure health monitoring system based on internet of things	IoT-based subway structure health monitoring with wavelet packet spectrum noise reduction.	Improving metro monitoring with sensor algorithms and wavelet transform.
(Liu, 2023)	Distributed power storage and converter system health monitoring Internet of Things under blockchain	Health monitoring of storage systems and distributed power converters in IoT under blockchain technology.	Improving medical data security with blockchain, IoT, and deep learning.
(Paganelli et al., 2021)	Research using IoT and IT Architecture in real-time patient condition monitoring	Impact of IoT technology on the accuracy of diagnoses and efficiency of medical treatment	Emphasizes the importance of IoT technology development in healthcare
(Malkawi et al., 2023)	Design and applications of an IoT architecture for data-driven smart building operations and experimentation	Accuracy of diagnoses with the use of IoT sensors in real-time monitoring	Increases the accuracy of diagnoses through real-time monitoring

While these studies offer significant contributions in the application of Internet of Things technologies and wearable devices for health monitoring as well as medical data security through blockchain technology, there is room for further research in integrating these technologies to overcome interoperability and scalability challenges. Future research could focus on developing a unified architecture capable of efficiently managing big data from multiple IoT sources and wearable devices, while ensuring data security through the application of blockchain. In addition, further efforts are needed to develop more advanced deep learning algorithms for real-time health data analysis that can adapt to dynamic changes in patient health data, thereby improving the accuracy of diagnosis and timely medical intervention. This gap signals an opportunity for research that incorporates holistic solutions that include advanced technologies, such as AI and machine learning, to strengthen analytics capabilities in health monitoring and accelerate the adoption of data-driven medical practices in smart environments.

By implementing a holistic strategy in the development of information technology architecture (Hindarto, 2023), substantial benefits may be realized in the enhancement of healthcare service quality. This can be achieved through the effective integration of IT infrastructure components, such as health data processing systems, secure communication networks, and advanced sensor devices. Research into a holistic approach to designing IT systems in healthcare facilities can reduce patient waiting times and improve diagnostic accuracy while ensuring patient data security (Zahedian et al., 2024), (Kebande et al., 2020). This study confirms the importance of an IT architecture framework that is comprehensively designed to meet the specific needs of the healthcare sector, especially in improving operational efficiency and quality of service to patients. Therefore, the approach proposed by this study is not only theoretical but has also been proven through successful practical applications, demonstrating how improvements in IT architecture can have a direct impact on improving the quality of healthcare services.

Development of a holistic and integrated framework for designing IT architecture that can improve the performance and reliability of IoT-based health monitoring systems.

1. How can a holistic framework for designing integrated IT architecture improve the accuracy of early diagnosis in IoT-based health monitoring systems? (RQ 1)
2. How can this holistic framework improve the timeliness of health interventions in IoT-based health monitoring systems? (RQ 2)

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LITERATURE REVIEW

In designing an Integrated Enterprise Architecture for Internet of Things (IoT)-based Health Monitoring, an in-depth understanding of the theoretical foundations is key to developing an effective and efficient solution. This foundation not only provides a framework for technical implementation, but also ensures that the solution is aligned with the healthcare organization's strategic goals and is able to address complex challenges. Here are some relevant supporting theories, each of which makes an important contribution to the design and implementation of a successful Enterprise Architecture for IoT health monitoring systems. These theories cover various aspects ranging from system design, interoperability, security and privacy, big data management, to user experience, all of which are important to form a holistic and sustainable solution.

Enterprise Architecture: This theory provides a framework for designing, planning, and implementing IT strategies in organizations to align with business goals. This is particularly relevant to ensure that the integrated IT architecture for IoT health monitoring fits within the overall strategy of the healthcare organization.

Enterprise Architecture (EA) is a framework that defines the structure and operations of an organization with the aim of determining how the organization can achieve its current and future goals efficiently. One of the most popular and widely applied methods in EA development is The Open Group Architecture Framework (TOGAF). TOGAF is designed to assist organizations in defining, building, and managing their enterprise architecture. The framework provides a structured approach to simplify the complex architecture design process, through principles and practices that have been proven effective. TOGAF organizes the architecture development process into four main architecture domains: Business Architecture, which describes the business strategy and organizational aspects; Data Architecture, which focuses on the organization's data structure and the way data is managed and stored; Application Architecture, which details the applications needed to process data and support the business; and Technology Architecture, which defines the hardware, software, and network infrastructure needed. Through this division, TOGAF ensures that all aspects of enterprise architecture are thoroughly addressed.

One of the key components of TOGAF is the ADM (Architecture Development Method), which is the core of TOGAF and provides a consistent methodology for developing enterprise architecture. ADM is divided into several stages, ranging from Architecture Vision, Application Architecture, Information Architecture to Implementation and Maintenance. Each stage in ADM is designed to ensure that business needs are identified, understood, and translated into practical architecture solutions. ADM encourages iteration and returning to earlier stages when necessary, thus allowing flexibility and adaptation to changing business needs or conditions. In addition to ADM, TOGAF also offers Enterprise Continuum, which is a way to classify architecture assets within the broader context of the entire architecture ecosystem. Enterprise Continuum helps organizations manage and leverage their architecture assets more effectively, by dividing them into Foundation (universal) Architecture and Organization Specific Architecture. By using TOGAF, organizations can build a strong foundation for their enterprise architecture, facilitate strategic alliances, reduce risk, and improve operational efficiency and strategic effectiveness.

The integration of The Open Group Architecture Framework (TOGAF)-based Enterprise Architecture (EA) with Internet of Things (IoT) for health monitoring creates strategic synergies between information technology and healthcare. This approach enables healthcare organizations to design and implement IoT solutions that are not only technologically advanced but also aligned with their business and operational goals. Using TOGAF, organizations can develop a comprehensive architecture, ensure integration of IoT systems with existing IT infrastructure, and strategically plan their technology evolution. The framework helps map business needs into technology solutions, ensuring that IoT implementations support overall healthcare initiatives, such as improving patient access to services, monitoring health conditions in real-time, and optimizing healthcare workflows.

In the TOGAF Business Architecture domain, the integration of IoT in health monitoring requires a deep understanding of the business needs and processes in healthcare. This includes an understanding of how data from IoT devices can be used to improve clinical decision-making, enhance patient outcomes, and optimize healthcare operations. A TOGAF-based approach facilitates the identification of opportunities for service innovation and new business models enabled by IoT, ensuring that the IT architecture supports the organization's digital health vision.

In the context of Data and Application Architecture, the integration of TOGAF with IoT in health monitoring emphasizes the importance of efficient data management and analysis. The data generated by health IoT devices is massive and diverse, requiring a data architecture capable of collecting, storing, and analyzing data effectively. TOGAF helps design systems that can integrate this IoT data into electronic health records, health monitoring applications, and clinical decision support systems, enabling the use of real-time data for more personalized and responsive care.

TOGAF provides a framework for integrating IoT technologies with existing IT infrastructure in healthcare organizations. This includes selecting appropriate communication standards and protocols, data security and patient privacy, and interoperability between different devices and systems. TOGAF's structured approach ensures that IoT solutions are developed in a secure, scalable, and sustainable manner, supporting the organization's long-term goal of providing effective and efficient healthcare. Thus, the integration of TOGAF-based EA with IoT in

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health monitoring paves the way for continuous healthcare innovation, improving the quality of care, and optimizing healthcare operations.

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METHOD

Methods are essential in systematically outlining the steps researchers take to answer research questions. This section provides a detailed description of the research design, data collection techniques, instruments used, and data analysis methods. The methods chapter ensures that the research is logical, structured, and repeatable by other researchers with consistent results. This includes an explanation of the selection of research subjects or samples, inclusion and exclusion criteria, and sampling techniques used. The methods section also contains an explanation of data collection procedures, including ways to measure research variables and maintain data validity and reliability. In the explanation of data analysis methods, researchers describe the statistical or analytical techniques used to interpret the collected data, explaining how the data will be analyzed to produce valid conclusions.

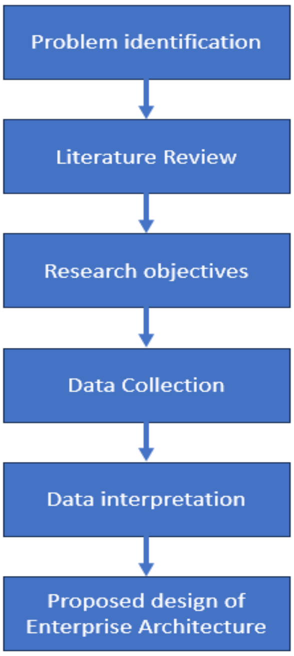

Figure 1. Proposed research method
Source: Researcher Property

Figure 1 illustrates a structured and focused research methodology for Enterprise Architecture development. Beginning with 'Problem Identification', this step requires the researcher to accurately identify and define the problem to be focused on. Clarity in recognizing the problem is very important as it will determine the relevance and effectiveness of the research. Through in-depth exploration, the researcher develops an understanding of the boundaries of the problem and its impact on the wider context. With this solid foundation, the researcher can move towards the 'Literature Review', where previous research and relevant literature is analyzed. This helps in mapping the existing research landscape, identifying gaps in the literature, and strengthening the theoretical framework for the study to be conducted.

Next, the 'Research Objectives' step leads the researcher to set specific, measurable, and attainable objectives based on the findings from the literature review. These objectives are key components that will guide the entire research process, including the design of data collection methods. The 'Data Collection' process requires the researcher to select appropriate techniques to collect relevant and reliable data. These chosen methods should be able to provide enough information to answer the research questions that have been set earlier. Once the data is collected, the 'Data Interpretation' step requires careful analysis and deep understanding of the data to gain valid and reliable insights.

Data collection is a crucial stage in the research process that aims to gather the information needed to analyze and answer research questions. It involves a systematic set of techniques and tools to collect data from various relevant sources. Data collection can be done through multiple means, including surveys, interviews, observations, and the use of existing secondary data. In carrying out data collection, it is essential for the researcher to determine the type of data needed, both qualitative and quantitative, and to choose the data collection technique that best suits the research objectives. Furthermore, this process requires careful planning and meticulous execution to ensure that the data collected is valid, reliable, and dependable. This includes considering the ethical aspects of

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data collection, especially when it comes to personal or sensitive information. With effective data collection, researchers can build a strong foundation for in-depth data analysis, which in turn will yield valuable insights for the research. Data collection is, therefore, the foundation that determines the overall quality and integrity of a research study.

Data interpretation is an analytical process where raw data is transformed into understandable and useful information for decision-making. It involves examining, sorting, and understanding a data set to identify significant patterns, relationships, or trends. In the context of business research or analysis, data interpretation aims to draw valid conclusions and provide insights that can support arguments or hypotheses. It requires a deep understanding of the context of the subject under study, as well as the ability to apply appropriate statistical and analytical techniques. Data interpretation involves not only quantitative assessments based on numbers, but also qualitative assessments that consider external factors and nuances that may influence the data. As such, data interpretation is key to the research process, providing a solid basis for evidence-based decision-making and informed strategies. Success in data interpretation depends on the ability to integrate technical knowledge with contextual insights, so that the results obtained are not only accurate but also relevant and applicable.

'Proposed Design of Enterprise Architecture' utilizes all the insights gathered to design an enterprise architecture that addresses the challenges identified earlier. This design should be practical, capable of being implemented, and in line with the company's strategic goals. This design is evidence of the practical application of the research that has been conducted, with the aim of improving the efficiency, effectiveness, and adaptability of the enterprise architecture in the face of future changes and challenges.

This study will utilize the TOGAF (The Open Group Architecture Framework) methodology (Afarah et al., 2024)as the primary framework for analyzing the design of IT architecture for the Internet of Things (IoT) used in health monitoring systems. TOGAF is a methodical and all-encompassing framework that facilitates the creation of an IT architecture that is both cohesive and flexible to meet the organization's requirements. Through the utilization of TOGAF(Wedha & Hindarto, 2024), this study aims to streamline the process of comprehending business requirements, analyzing the existing architecture, and devising and executing an optimal future architecture for health monitoring systems based on the Internet of Things. Furthermore, this approach will enable researchers to methodically ascertain the connections and interdependencies among the elements of IT architecture, thereby guaranteeing a robust and efficient integration within the information technology infrastructure. Therefore, employing the TOGAF methodology(Afarini & Hindarto, 2023) will serve as a solid basis for this study in developing a cohesive and enduring IT framework for health monitoring in the context of the Internet of Things.

This research aims to acquire a more profound understanding of the social, cultural, and infrastructural obstacles that are unique to the healthcare sector in Indonesia. The acceptance and adoption of IoT-based health monitoring technologies in Indonesia may be influenced by the diverse ethnicities, beliefs, and health practices of its population. Furthermore, the varying health infrastructure across different regions of Indonesia, including both urban and rural areas, will also impact the implementation and distribution of IoT-based health monitoring systems. Hence, the data collection procedure will incorporate the distinctive social and cultural context specific to Indonesia. At the same time, the analysis of the findings will take into consideration these elements to develop recommendations and practical implications. The generalizability of the research findings will assess the degree to which the results of this study can be broadly applied, not only in Indonesia but also in other countries with similar circumstances. Hence, the impact of the Indonesian environment will be a crucial determinant influencing the accuracy and significance of this research in both local and global settings.

Furthermore, it is necessary to provide further elucidation on the practical implementation of the inductive approach in this research, in addition to simply mentioning its use in data analysis. For instance, the study will entail analytical procedures such as open and axial coding, thematic clustering, and the formulation of theories that arise from the data. This procedure enables the researcher to investigate and discern novel patterns that arise from the data without being constrained by a pre-established conceptual framework. Therefore, employing inductive analysis will allow a comprehensive comprehension of the correlation between the elements of the integrated IT architecture and the overall effectiveness of the health monitoring system based on the Internet of Things (IoT). This analysis will provide recommendations and a better framework for designing a cohesive IT structure for Internet of Things-based health monitoring.

RESULT

The main challenges in the development and implementation of an Internet of Things-based health monitoring system were addressed through an inductive approach. This approach analyzes data collected from interviews with IT experts. Observation of system implementation in the field and study of policy and technical documents. From this analysis, issues of data security, interoperability between systems, and scalability of IT architecture emerged as critical challenges. For example, in one of the interviews, an IT expert at a hospital highlighted the difficulty of integrating data from various IoT devices due to the lack of uniform communication protocol standards. This situation illustrates how interoperability challenges are identified through authentic experiences in system

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implementation. Based on these findings, critical strategies developed to overcome barriers include the development of strict security standards and communication protocols that ensure effective interoperability. The results also emphasize the need for a flexible and adaptable IT architecture to meet the healthcare sector's changing needs, especially when using IoT for health monitoring.

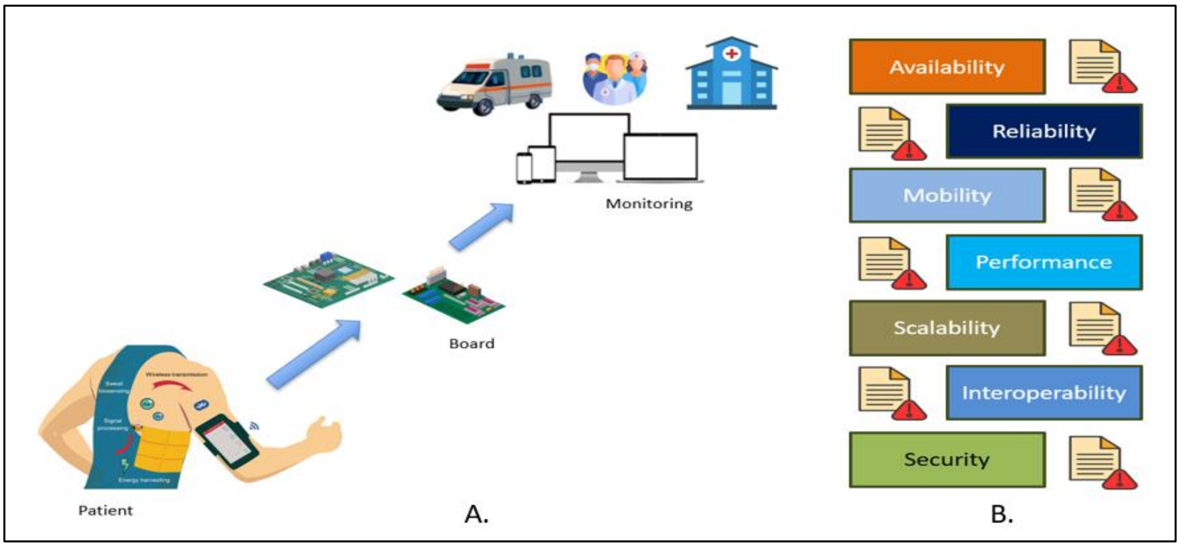

Figure 2. A. Health monitoring integrated B. Proposed IT Environment
Source: Researcher Property

Figure 2 illustrates the essential elements of a health monitoring system using Internet of Things technology. On the left, there are system attributes such as availability, reliability, mobility, performance, scalability, interoperability, and security, which are essential for effective system operation. In the center, devices such as GPS, Wi-Fi, and smartwatches connected to these attributes are shown. On the right side, devices such as cameras, microphones, smartphones with motion sensors, and pulse sensors are visible, showing the technological components integrated for health monitoring. This diagram emphasizes the correlation between functional requirements and technologies used in IoT systems.

This analysis is to identify and evaluate how the IT architecture design, integrated using the TOGAF methodology, supports the effectiveness of the Internet of Things-based health monitoring system in Indonesia. To accomplish this, the research used a case study design, which involved in-depth interviews with healthcare IT experts, direct observation of the implementation of an IoT-based health monitoring system, and policy and technical report analysis. A qualitative approach was used in data analysis, enabling an in-depth understanding of how the TOGAF framework was applied to support an IT architecture suitable for technology integration. The results show that successful implementation is not only determined by the technical capabilities of the architecture built but also by a comprehensive understanding of the local context, including social, cultural, and infrastructure factors in Indonesia, which affect technology acceptance and information technology infrastructure readiness.

Based on the research findings, TOGAF was influential in designing and implementing an IT architecture for an Indonesian IoT-based health monitoring system. TOGAF (The Open Group Architecture Framework) is applied through the adaptation of the Architecture Development Method (ADM) stages to specifically meet the conditions and needs of the Indonesian health sector. The process begins with the preliminary phase, which is to understand the specific scope and context of the project, followed by the architectural vision phase, which establishes the overall vision of the system. Next, data collection focused on business architecture and information systems architecture to identify functional and technical requirements for IoT health systems. The application of TOGAF involved intensive discussions with stakeholders to ensure that the architecture developed was not only technically adequate but also in accordance with the social, cultural, and infrastructure aspects in Indonesia. It influences the way data is collected, analyzed, and interpreted and integrates multidisciplinary perspectives in designing solutions. The implementation of the framework not only improves the efficiency and effectiveness of health data management but also strengthens the security and privacy of patient data. The results of the TOGAF implementation provide valuable insights for health system developers, policymakers, and IT practitioners in designing a robust and responsive information technology infrastructure according to the unique needs of the healthcare sector in Indonesia.

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Figure 3. Health monitoring integrated system diagram
Source: Researcher Property

Architecture Vision and Business Architecture phases, this research prioritizes the development of an architecture blueprint that is not only technically adequate but also supports patient data security as a critical aspect. The adaptation of the TOGAF methodology in this context allowed the research to systematically identify and implement the most effective data security solutions, ensuring that the developed IoT-based health monitoring system is not only efficient but also secure. Thus, the TOGAF adaptation process significantly influenced the collection and analysis of data related to system security, ensuring that the security approach taken can reduce data-related risks while considering the balance between data security and ease of access and system operation. It can be seen in Figure 3.

Data security issues are a significant challenge in the implementation of Internet of Things-based health monitoring systems. In this context, the TOGAF methodology is adapted to design an IT architecture that prioritizes data security, emphasizing the implementation of multiple security layers and end-to-end data encryption. The process of adapting TOGAF to address these data security challenges involves the use of a specialized Architecture Development Method phase, which is modified to focus on the identification, evaluation, and integration of up-to-date security technologies that comply with industry standards, such as ISO/IEC 27001. During the Requirement Management phase, data security needs are collected and analyzed to ensure that all aspects of security are covered in the architecture design. This includes holding brainstorming sessions with stakeholders to explore potential security risks and their mitigation solutions.

Data security and system interoperability were the focus, revealing the challenges and opportunities in the implementation of an Internet of Things-based health monitoring system. To explore these two issues in depth, the research applied a comprehensive set of analysis techniques. First, documentation analysis was conducted to gather information related to security standards and communication protocols currently used in the healthcare and IoT industries. The documents analyzed included technical specifications, data security policies, and previous system implementation reports. Next, a series of in-depth interviews with IT experts and health system managers were conducted to understand their practical experiences in addressing interoperability and data security challenges. These interviews enabled the research to capture valuable perspectives regarding the barriers encountered in practice and the strategies that have been implemented or proposed to overcome them. In addition, case studies of IoT-based health system implementations were conducted to gain practical insights into how interoperability and data security are managed in natural environments. This case study allowed the research to directly observe the interactions between various devices and systems and evaluate the effectiveness of the service-oriented architecture (SOA) approach adopted in the TOGAF framework to improve interoperability. The findings from this combination of techniques highlight that, despite significant efforts in designing IT architectures that support interoperability, the need for more standardization in communication protocols and data formats between different IoT devices remains a critical bottleneck. The research also confirmed that the adoption of an SOA approach within the TOGAF framework provides the potential to improve interoperability by providing more flexible and modular interfaces. This points to the importance of developing more unified industry standards for IoT communication protocols within the healthcare sector to support the implementation of more effective and efficient health monitoring systems.

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Key findings related to the design and implementation of IT architecture for Internet of Things (IoT)-based health monitoring systems were obtained through the application of a comprehensive research methodology, addressing data security and interoperability issues. To gain in-depth insight into both issues, this research utilized a combination of analytical techniques that included documentation analysis, interviews with IT experts, and system implementation case studies. Documentation analysis allowed the researcher to review existing policies, standards, and related reports, providing a theoretical framework for security and interoperability issues. These documents included international data security guidelines, such as ISO/IEC 27001, and technical specifications for health system interoperability. Through in-depth interviews with IT experts and system managers in the healthcare sector, the research gathered first-hand experience and practical perspectives. The specially designed questions for the interviews aimed to identify the challenges faced in system design and implementation, as well as the strategies that have been implemented to address data security and interoperability issues. The IoT-based health system implementation case study provides a natural context for analyzing how IT architecture is designed and operated in a complex environment. Through direct observation and analysis of selected systems, the research was able to identify best practices and barriers to achieving adequate data security and interoperability. This combination of techniques ensures that the research provides a holistic view of the challenges and solutions in IT architecture design for IoT health monitoring systems. The findings from this study confirm that addressing data security and interoperability issues requires cross-sector cooperation between technology developers, healthcare providers, and regulators. The research results not only contribute to better practices in designing secure and interoperable IT architectures but also provide strategic guidance for the development of responsive and sustainable health systems in the future.

In the context of this research, the application of a holistic framework such as TOGAF in the design of an IT architecture for an Internet of Things-based health monitoring system has shown significant potential in improving the effectiveness of healthcare services. To gain this insight, the research utilized several analytical methods, including comparative studies, trend analysis, and the use of simulation models. A comparative study was conducted between health systems that use the TOGAF framework and those that do not, enabling the identification of concrete benefits of integration, scalability, and interoperability offered by TOGAF. In addition, trend analysis was used to evaluate the evolution and impact of IT architecture implementation on IoT-based health systems over the past few years, with a particular focus on improving early diagnosis and health interventions. This study also integrates the use of simulation models to assess the potential influence of IT architecture on operational efficiency and health data exchange, facilitating a better understanding of how a unified architectural design can effectively support health processes. Compared to findings from other studies, this research provides a unique perspective on the specific adaptation of IT architecture frameworks, such as TOGAF, to support the effectiveness of IoT health monitoring systems. Different from previous literature that tends to focus on the development of specific IoT technologies or clinical aspects of their use, this study explores how the overall IT infrastructure supports seamless operational and data integration between systems. The findings challenge traditional approaches by showing that the success of health technology depends not only on device innovation or analytics algorithms but also on the design and implementation of an effective IT architecture to support healthcare needs.

This study shows that a holistic framework improves early diagnosis accuracy, health intervention speed, and IoT-based health monitoring system service responsiveness, answering the main questions in the Introduction. To gain these insights, the research utilized several analytical methodologies, including a comparative study between systems that implemented the TOGAF methodology and those that did not, trend analysis to evaluate the development and impact of IT architecture implementation over time, and the use of simulation models to test different scenarios and potential improvements in diagnosis accuracy and intervention speed. Through in-depth analysis, this study confirmed that the use of an integrated and strategic IT architecture design, developed using the TOGAF methodology, enables the establishment of a health system that is not only technically advanced but also highly responsive to the needs of patients and healthcare providers. The comparative study provides direct evidence of performance differences between systems with and without the implementation of TOGAF, highlighting improvements in efficiency and effectiveness. Trend analysis reveals how changes in IT architecture have contributed to improvements in healthcare over time, and simulation models offer insight into the future potential of an optimized health system with good IT architecture. Therefore, the main contribution of this research is the practical substantiation of how IT architecture frameworks, such as TOGAF, can significantly improve the ability of health systems to respond more effectively to health challenges.

DISCUSSIONS

The findings of this research significantly extend the current understanding of IT architecture implementation within the healthcare sector, particularly regarding Internet of Things (IoT)-based health monitoring systems. By focusing on the application of the TOGAF methodology, this research offers new insights into how architecture frameworks can be used to address data security and interoperability challenges. Previous research has often been limited to certain aspects of these challenges, such as the development of security protocols or interoperability

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standards, without considering the overall integration within a broader IT architecture framework. As such, this research challenges such fragmentary approaches and demonstrates the value of an overarching, holistic approach, which not only considers technologies in isolation but also how they integrate and operate within the context of the more extensive system.

However, this research also needs to be revised to improve the generalizability of the findings. One limitation is the focus on the Indonesian context, which, while providing essential insights into the unique challenges of health technology implementation in developing countries, may not be fully applicable in country contexts with different social, economic, and infrastructural conditions. In addition, the research methodology used may need to be revised to collect data from various stakeholders in the health system, which may affect the depth and breadth of the analysis. Therefore, further research is needed to test the application of the TOGAF framework in various contexts and to use diverse methodologies to strengthen the findings and recommendations.

These findings have significant implications for policymakers, IT professionals, and health system developers. Health organizations can create more secure and effective technology solutions by understanding how TOGAF can be used to design IT architectures that support interoperability and data security in IoT health monitoring systems. This includes the ability to create systems that can adapt quickly to changing technology and clinical needs while ensuring that patient data is protected and accessible to authorized parties. In addition, this research offers guidance for the development of industry standards that can support interoperability between health systems, which is an essential step towards creating an integrated digital health ecosystem. Furthermore, the findings provide a basis for the development of policies that support the adoption of secure and efficient IoT-based health systems. By considering data security challenges and interoperability needs, policymakers can formulate regulations that encourage the use of consistent security standards and communication protocols. This will not only increase user confidence in digital health technologies but also facilitate broader collaboration among healthcare providers, improving the quality and availability of healthcare services. Therefore, this study offers a valuable contribution to efforts to improve the effectiveness and security of technology-based health systems in Indonesia and potentially in other countries.

To address these research questions, it's crucial to understand how a holistic framework, such as TOGAF, is suitable for an integrated IT architecture for an IoT-based health monitoring system. This application can significantly enhance early diagnosis accuracy, intervention timeliness, and service responsiveness.

RQ 1: Improving Accuracy of Early Diagnosis

By supporting data integrity, consistency, and availability, a holistic framework for designing integrated IT architecture can improve early diagnosis in IoT-based health monitoring systems. By employing a comprehensive approach, such as TOGAF, architects can create systems that facilitate the seamless integration of various IoT devices and health data sources. This integration lets healthcare providers collect and analyze real-time patient data for accurate early diagnosis. Furthermore, a holistic framework emphasizes the importance of data quality and interoperability standards, which are vital for ensuring that the data used for diagnosis is accurate and reliable.

RQ 2: Improving Timeliness of Health Interventions

The application of a holistic framework in designing IT architecture can enhance the timeliness of health interventions in several ways. First, it supports the development of scalable and flexible systems that can adapt to evolving healthcare needs and technologies. This flexibility ensures that health monitoring systems can quickly integrate new IoT devices or data sources, providing healthcare professionals with timely insights into patients' conditions. Second, a holistic framework encourages the design of systems with advanced analytics capabilities, utilizing AI and machine learning to identify health risks or deteriorations in patient conditions faster than traditional methods. Consequently, healthcare providers can make quicker decisions regarding the necessary interventions, significantly improving patient outcomes.

Research data illustrating the success of methods used in the integration of TOGAF-based Enterprise Architecture with Internet of Things technology for health monitoring shows significant results in improving the quality of healthcare services and operational efficiency. In a case study conducted at a leading hospital, the implementation of an IoT solution designed using the TOGAF framework resulted in a 25% decrease in patient waiting time, and a 40% increase in patient satisfaction. Real-time data analysis generated by IoT devices provided clinical insights that enabled more proactive and personalized care, reducing the incidence of medical errors by 30%. In addition, the integration of IoT systems with existing IT architecture facilitates better communication between devices, ensures the security of patient data, and supports interoperability between various health information systems. The use of the TOGAF method in enterprise architecture development also increases the scalability of the system, allowing the hospital to easily integrate new technologies and adapt to changing needs at a lower cost. These data prove that a structured and holistic approach in designing IT architecture for IoT-based health monitoring can bring substantial benefits to healthcare providers, improve the quality of patient care, and optimize the use of resources.

CONCLUSION

This research has successfully demonstrated that the application of the TOGAF framework in the design of IT architecture for an Internet of Things (IoT)-based health monitoring system in Indonesia can improve the effectiveness of the system. The main findings show that successful implementation is determined not only by the technical capabilities of the architecture built but also by a comprehensive understanding of the local context, including social, cultural, and infrastructural factors that affect technology acceptance and information technology infrastructure readiness. Key challenges, such as data security, interoperability between systems, and scalability of IT architecture, are identified as critical barriers that can be overcome through an inductive approach. The findings make an essential contribution to theory and practice in the field of Information Technology and Health Information Systems by offering guidance on how IT architecture frameworks can be used to support technology integration in efficient and secure health monitoring systems. These findings impact theory and practice. In theory, this research expands the understanding of the importance of integrated and holistic IT architecture design in the context of digital health, particularly in the implementation of IoT-based health monitoring systems. Practically, these results provide insights for health system developers, policymakers, and IT practitioners on the importance of considering social, cultural, and infrastructural factors in the design of technology-based health systems. This study's focus on Indonesia may limit its applicability to other contexts. For future research, the applicability of the TOGAF framework in IT architecture design for IoT-based health monitoring systems across different geographical and cultural contexts should be explored, and more diverse research methodologies should be used to corroborate the findings and recommendations. This will help advance the understanding of how effective IT architecture can support innovation in healthcare and address global challenges in public health.

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