

Application of Heuristic Algorithm in Medical Informatics System for Patient Data Management in Southeast Asia

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ABSTRACT

This research aims to analyze the application of heuristic algorithms in medical informatics systems for managing patient data in Southeast Asia. This research method uses qualitative research. This research data uses secondary data. Data includes scientific literature, technical reports, policy documents, and statistical data from trusted sources such as reputable journals, conferences, books, and health institutional reports. Data analysis using Nvivo 12 Plus software to identify relevant patterns and themes. This research indicates that Southeast Asian countries have begun to adopt information technology in health services. The implementation of the Electronic Medical Record (EMR) System has been used in several large hospitals in Malaysia and Thailand to integrate patient data digitally. The most prominent theme in the data findings regarding the role of heuristic algorithms in managing patient data is the importance of data security, management, optimization, efficiency, and blockchain integration in patient health services. Plus, the challenges heuristic algorithms face in healthcare include infrastructure, data fragmentation, cross-platform system integration, data security and privacy, big data analysis (big data), and potential heuristic algorithms. The significant impact is improving the efficiency, quality, and accessibility of health services. One of the main impacts is increasing operational efficiency. The implications of this research recommend that policymakers and health institutions adopt heuristic algorithms in medical informatics systems for managing patient data in hospitals to improve the quality of health services.

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1. INTRODUCTION

Advances in information technology have opened up great opportunities for the health sector, including in the Southeast Asia region, to increase service efficiency through better medical data management by utilizing medical informatics systems [1],[2]. Significant challenges are faced, such as obstacles in managing patient data, which include substantial data volumes, high levels of complexity of medical information, data privacy, and complex data security [3], [4]. The weakness of these problems will result in poor data management, which can hamper the clinical decision-making process, lengthen patient waiting times, and reduce the overall quality of health services. Solutions are needed to address these challenges quickly and effectively in Southeast Asian countries. Therefore, applying heuristic algorithms in medical informatics systems for managing patient data in Southeast Asia is very important to analyze and provide literacy insights to the public, especially as a record of improving health services in Indonesia. It is important to clean items to find important transactions in the health

sector, thereby helping streamline time and achieve the desired target focus [5].

A heuristic algorithm is a problem-solving method that uses a trial and error approach, rules of thumb, or approximations to find a good enough solution in a reasonable time [6]. This approach was chosen because it cannot be separated from the fact that Southeast Asia is one of the regions with the largest population in the world. The high level of urbanization and the health service system continues to develop, making it necessary to manage efficient patients who can access the information in real-time. However, disparities in technological infrastructure between ASEAN member countries complicate digital transformation efforts in the health sector [7]. This condition is experienced by Laos, Cambodia, and Myanmar, which still face significant challenges in terms of basic infrastructure. However, different developments in Singapore have a sophisticated medical informatics system [8].

Therefore, implementing heuristic algorithms is important to support medical informatics systems for managing patient data. This can speed up important

health service data needed effectively and efficiently. Heuristic algorithms can help speed up patient data processing, especially in handling large and complex data volumes. With a heuristic approach, the system can find a close-to-optimal solution without needing a thorough search that takes time and resources.

Case studies from several Southeast Asian countries show the great potential of applying heuristic algorithms in medical informatics systems. In Vietnam, implementing a heuristic algorithm-based system for optimizing hospital service schedules increased operational efficiency by up to 30% [9]. Thailand also demonstrated similar success with the application of genetic algorithms in electronic medical record management, speeding up data access by up to 40% [10]. However, countries like the Philippines still face significant obstacles in integrating patient data between health facilities due to limited digital infrastructure [11]. Meanwhile, in Indonesia, the application of heuristic algorithms in medical informatics systems has not been implemented optimally in large hospitals; they are still focused on integrating the Brute Force and Haversine algorithms in providing convenience to the public in BPJS health facility services, which show the closest distance [12]. Therefore, it is important to carry out this study to illustrate that although heuristic algorithms have tremendous potential, the challenges in their implementation are very dependent on local conditions [13]. This condition shows the effectiveness of heuristic algorithms in various contexts. For example, this algorithm has been applied in developed countries to optimize surgery schedules, hospital logistics, and database management [14], [15]. However, these studies have primarily focused on countries with well-established technological infrastructures, such as the United States and Germany [16].

In contrast, research on the application of heuristic algorithms in developing countries in Southeast Asia is still minimal. Studies such as that conducted by [17], demonstrate the effectiveness of heuristic algorithms for large-scale optimization. However, these studies do not consider developing countries' specific challenges, such as infrastructure and budget constraints. Heuristic algorithms have the potential to manage patient data, but the study did not accommodate specific regional constraints [18]. According to the ASEAN report in 2023, the problem faced in Southeast Asia is that around 20% of health facilities still rely on manual systems to manage medical data [19]. This causes delays in access to information, which has the potential to hinder clinical decision-making. In addition, data from the World Health Organization (WHO) shows that errors in patient data management account for up to 15% of cases of delayed diagnosis in developing countries, including Southeast Asia [20]. Innovative solutions to these challenges are

increasingly urgent, with the population reaching more than 339 million people by 2023 [21].

This gap opens up opportunities for more comprehensive and contextual research. Although previous studies have proven the effectiveness of heuristic algorithms, no research has specifically examined their application in the Southeast Asian context. Therefore, this study aims to analyze the application of heuristic algorithms in managing patient data in Southeast Asia using secondary data, which includes scientific literature, technical reports, policy documents, and statistical data from trusted sources such as academic journals, conference articles, books, and Health institution reports. The data analysis process uses Nvivo 12 Plus software to identify the benefits, challenges, and obstacles in implementing the algorithms, as well as provide evidence-based recommendations to improve the efficiency of patient data management systems in Southeast Asia in health services in hospitals.

The implications of this research enrich the literature on the application of heuristic algorithms in medical informatics, especially in the Southeast Asia region. Plus, it can guide policymakers and health institutions in adopting heuristic algorithm-based solutions for managing patient data. Furthermore, social implications encourage improvements in the quality of health services for the community, which can support efforts to achieve sustainable development goals in the health sector. Therefore, exploring the application of heuristic algorithms through secondary data analysis with an analysis approach using Nvivo 12 Plus is important. The novelty of this research lies in its efforts to answer previous research gaps and offer contextual solutions for the Southeast Asia region.

2. MATERIALS AND METHOD

This research method uses qualitative research with a descriptive approach. The research data used is secondary data. Secondary data is supported by scientific literature, technical reports, policy documents, statistical data, and health institutional reports [22]. To ensure that the data collected is relevant and up-to-date, data searches were carried out on scientific databases such as Scopus and Google Scholar, taking into account relevant research and priority publications within the last 10 years. Data sources were selected by considering inclusion criteria, which included relevance to the topics of heuristic algorithms, medical informatics, and patient data management in Southeast Asian countries. The process for selecting sample data focused on the five selected countries: Thailand, Malaysia, the Philippines, Vietnam, and Indonesia. The reason for choosing these five countries is because of the Health Index in Southeast Asia reported by the World Health Organization (WHO) in 2024; these five countries have experienced a decline in

the health index, so it is interesting to analyze [23]. More details can be seen in Figure 1, Health Index in Southeast Asia in 2024 below.

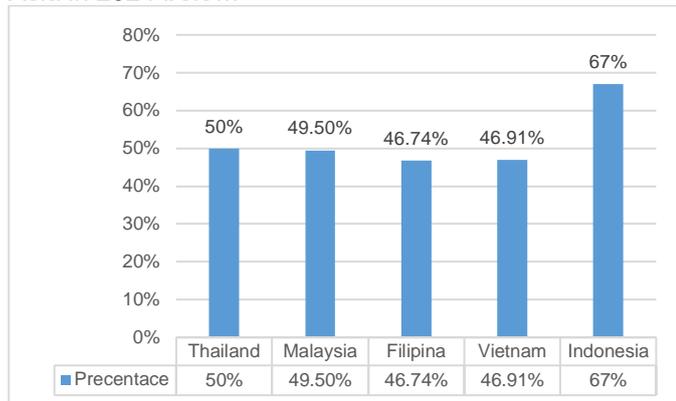


Figure 1. Health Index in Southeast Asia in 2024. (Source: WHO, 2024).

Figure 1 above shows the health index in five Southeast Asian countries, namely Indonesia, Thailand, Malaysia, the Philippines, and Vietnam, with a decreasing trend from 67% in Indonesia, 51% in Thailand, to below 50% in Malaysia (49.5%), Philippines (46.74%), and Vietnam (46.91%). The lower index in most of these countries reflects significant health system management challenges, including managing large and complex patient data, service efficiency, and the need for data security. This decline underscores the urgency to find innovative solutions to improve health services' quality. In this context, the application of heuristic algorithms in medical informatics systems for patient data management becomes very relevant because these algorithms can help optimize medical data management, speed up the analysis of disease patterns, and increase the responsiveness of health systems to patient needs [24], [25].

The research data analysis process simplifies data coding using the NVivo 12 application. The collected data is organized in a digital format, such as a PDF or text document, for import into Nvivo 12 Plus qualitative analysis software. The reason for using NVivo 12 Plus software in data analysis is that it can code and visualize data automatically [26]. Nvivo software is also used to do this *query* text and generate data visualizations, such as *word clouds* and cluster analysis, to find patterns and relationships between themes. The coding results are then processed thematically to identify the main patterns and themes relevant to the research focus [27]. The final results of this research will be presented in the form of visualizations such as *word clouds*, thematic diagrams, and relationship matrices between themes, which are equipped with descriptions of in-depth analysis. The main findings from this research will provide insight into the effectiveness of implementing heuristic algorithms in medical informatics systems and offer practical recommendations for managing patient data, especially in Southeast Asian countries. Plus, this process strengthens research results and ensures that the findings can

significantly contribute to the development of science and practice in medical informatics.

3. RESULTS

A. Application of Heuristic Algorithms in Patient Data Management

Applying heuristic algorithms in patient data management has provided significant results in overcoming the challenges of medical data complexity, especially in big data analysis, process optimization, and data-based decision-making [28]. One prominent application is the use of genetic algorithms to analyze disease patterns. This algorithm allows the identification of certain disease risks based on genetic and environmental data, such as detecting the risk of heart disease or diabetes. By leveraging the ability of genetic algorithms to generate optimal solutions from large data sets, medical institutions can design more targeted prevention programs, thereby increasing the effectiveness of treatment and reducing long-term treatment costs [29], [30]. However, implementing this algorithm requires adequate resources, including standardized data and strong technological infrastructure support [31].

In addition, heuristic algorithms such as simulated annealing and tabu search have been successfully used to optimize medical schedules, including doctor schedules and operating room allocations [32]. The application of this algorithm can increase hospital operational efficiency by reducing patient waiting time by up to 20% [33]. Simulated annealing works by exploring various possible solutions to find the best settings, while tabu search helps avoid less efficient solutions by considering medical personnel preferences and facility capacity [34]. These two algorithms provide flexible solutions to logistical problems in healthcare, although challenges such as parameter setting and the need for experts still need to be overcome for broader implementation [35].

Grouping patient data is also one of the main successes of heuristic algorithms, with the K-Means Clustering algorithm used to group patients based on diagnosis [36], [37]. This technique allows healthcare providers to identify patients with similar medical needs, facilitating more specific service planning [38]. For example, patients with chronic conditions such as diabetes or hypertension can be grouped to receive coordinated care that improves efficiency and quality of care. However, implementation of these algorithms is often hampered by fragmented and inconsistent data, especially in developing countries [39]. Applying heuristic algorithms in patient data management has shown promising results in various aspects of healthcare. The analyzed case studies reveal that these algorithms can overcome complex medical data management challenges, especially in big data analysis, process optimization, and data-driven decision-making. Some main applications of heuristic algorithms in patient data

management include disease pattern analysis, medical schedule optimization, and patient data clustering [40]. The author generally identified heuristic algorithm patterns in managing patient data, visualized in the following word cloud analysis.

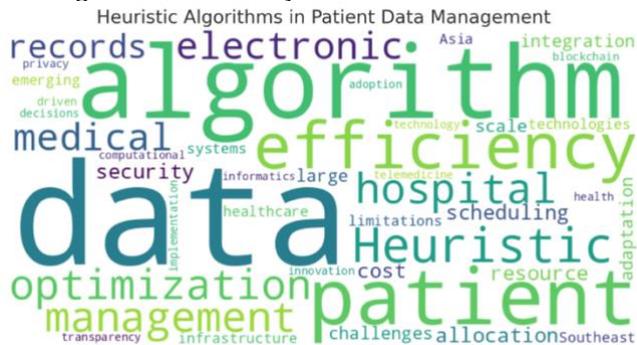


Figure 2. Wordcloud Analysis. Source: (Data Processed by Author, 2024)

Figure 2 shows that the main terms are relevant to the role of heuristic algorithms in patient data management. The most prominent terms, such as heuristic algorithms and patient data, highlight the importance of these algorithms in managing patient information efficiently. One of the main benefits is optimization, which increases efficiency in data management, as seen in the application of electronic medical records (EMR) for digitization and integration of patient data [41]. In addition, data security and integration aspects emphasize the need to protect patient privacy while ensuring information integration across systems. Technologies such as blockchain and telemedicine are emerging as enabling innovations that expand data security and health access, especially in remote areas [42].

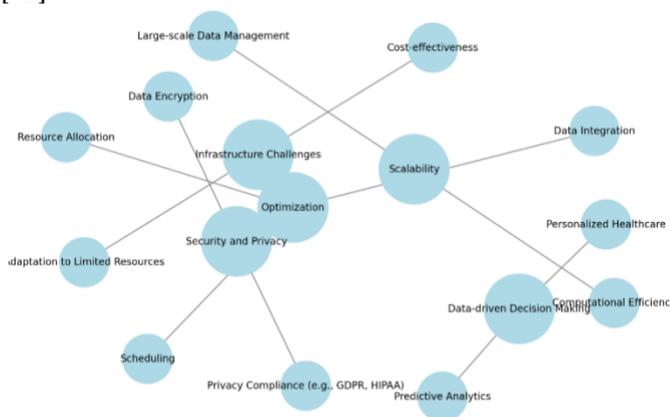


Figure 3. Hierarchical Themes: Role of Heuristic Algorithms in Patient Data Management. Source: (Data Processed by Author, 2024)

This algorithm also helps in resource allocation and cost-efficiency, which optimizes the use of health resources more cost-effectively. However, infrastructure limitations and the need for data transparency remain significant obstacles, especially in areas with limited infrastructure. Overall, this word cloud reflects the

strategic role of heuristic algorithms in supporting the digital transformation of healthcare through efficiency, security, and technological innovation. In addition, this research was analyzed more deeply in a noded manner related to heuristic algorithms to determine the connection between important themes, as in Figure 3.

Figure 3 shows that heuristic algorithms have played a significant role in managing patient data, especially in optimizing resources and increasing the efficiency of health management. One of the main aspects of this algorithm is its ability to solve complex problems such as resource allocation, schedule optimization, and digital integration of patient data, as seen in the implementation of Electronic Medical Records (EMR) in several large hospitals. This technology, widely used in developed countries, efficiently collects and processes patient data. However, challenges such as implementation costs and the need for training of health personnel remain significant barriers, especially in developing countries [43]. Apart from that, data security and privacy are also significant concerns in managing patient data. Blockchain technology to ensure data transparency and security has begun to be adopted in several countries, such as the Philippines. However, it is still in its early stages [44]. Blockchain offers a solution to overcome challenges related to data leakage, but its implementation is hampered by uneven digital infrastructure and society's trust in this technology [45].

Plus, advances in telemedicine technology have also significantly contributed to increasing access to health services, especially in remote areas. Heuristic algorithms support these systems, enabling better allocation of healthcare resources [46]. Countries such as Thailand and Indonesia have shown significant growth in the use of telemedicine, although challenges such as limited internet access and inadequate regulations remain major obstacles [47]. Previous literature also highlights that although heuristic algorithms have proven effective globally, their application in developing countries, particularly Southeast Asia, is minimal. Many studies focus on countries with advanced technological infrastructure, while specific challenges such as infrastructure and budget limitations have not been fully accommodated. Research conducted by Huang et al. (2023) shows the potential of heuristic algorithms in handling large-scale data, but implementation in developing countries requires approaches tailored to local needs [48].

Thus, heuristic algorithms not only provide practical solutions for patient data management but also pave the way for innovations in the field of health technology. However, successful implementation depends on overcoming infrastructure challenges, increasing health workers' technological literacy, and integrating new technologies such as blockchain and telemedicine. Further research is needed to develop more comprehensive and contextual solutions for developing countries in Southeast Asia [49].

Challenges in Implementation

The application of technology in health services, including heuristic algorithms, has opened up tremendous opportunities to improve the efficiency and quality of patient data management. However, this innovation is not free from challenges that can hamper its implementation and sustainability, especially in Southeast Asia. Data fragmentation, limited technological infrastructure, and threats to data security and privacy are often the main obstacles [50]. These problems slow the adoption of advanced technologies and reduce the effectiveness of medical informatics systems in providing solutions to healthcare challenges. These challenges reflect the

complexity of implementing heuristic algorithms in environments that are not yet fully ready to support advanced technologies. Infrastructure gaps, inadequate system integration, and increasing cybersecurity risks indicate the need for a comprehensive strategy to support adopting these technologies [51]. By understanding and overcoming these obstacles, heuristic algorithms can be maximized to support health service transformation and provide tangible benefits to society. More clearly, you can see the results of the data analysis visualization regarding the challenges faced in implementing the heuristic algorithm as in Figure 4 below.

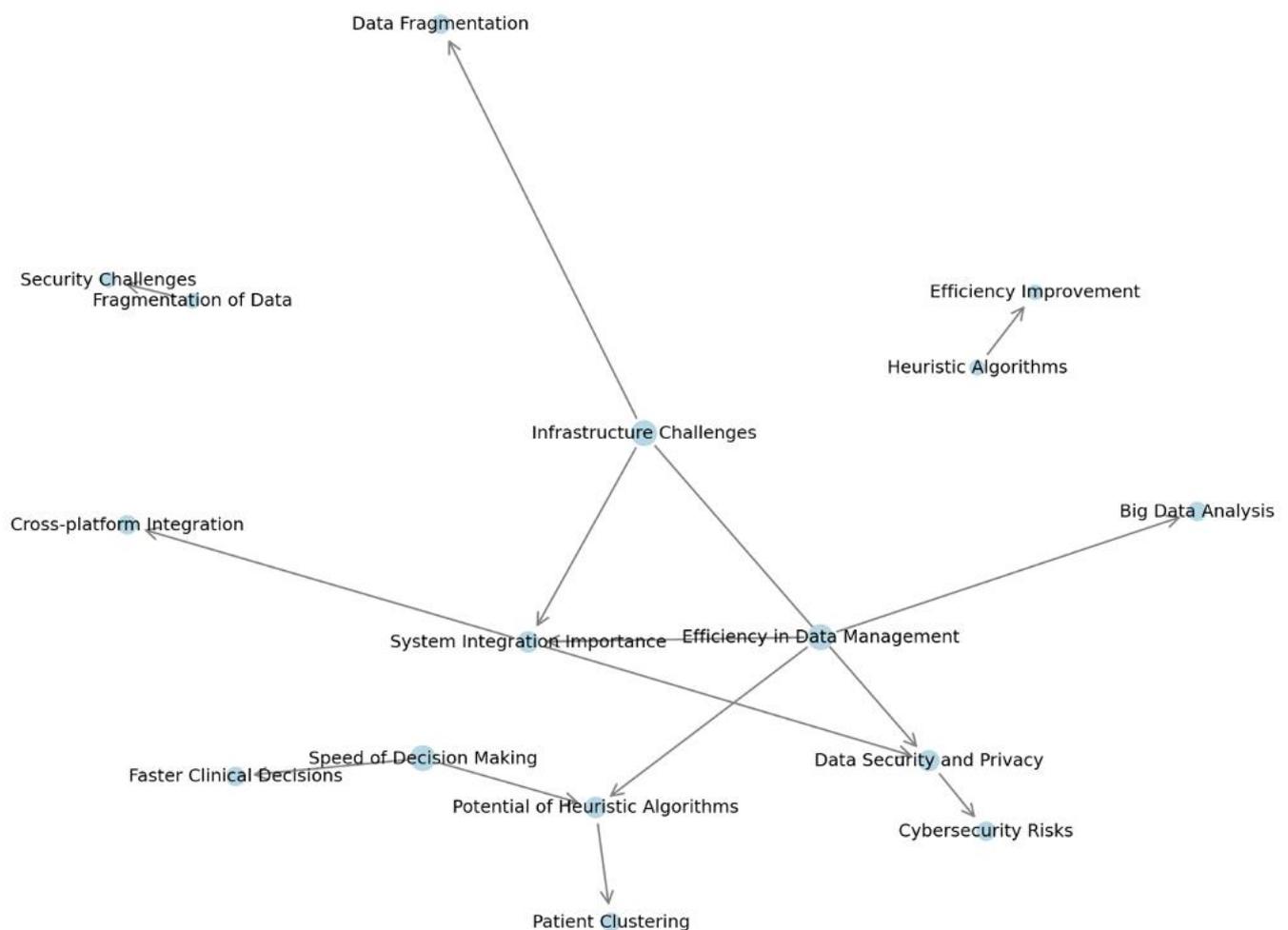


Figure 4. Heuristic Algorithms in Healthcare. Source: (Data Processed by Author, 2024)

Figure 4 shows the relationships between concepts relevant to applying heuristic algorithms in health services, as generated from analysis using the software *Nvivo*. Some key nodes and hubs identified include infrastructure challenges, data fragmentation, cross-platform system integration, data security and privacy, big data analytics (*big data*), and potential heuristic algorithms. These relationships reflect the dynamics between challenges and opportunities in adopting

heuristic algorithms to improve the efficiency and quality of health services [52]. One of the fundamental challenges identified is data fragmentation, where patient data is often spread across multiple institutions without an integrated system. This hampers real-time data accessibility and slows down the analysis processes required for clinical decision-making. This fragmentation is also closely linked to security challenges, as data spread across multiple platforms increases the risk of

information leaks and cyberattacks. Non-integrated systems create gaps in the protection of patient data, which is a critical issue in the context of healthcare modernization [53].

In addition to data fragmentation, limited technological infrastructure is a significant obstacle, especially in Vietnam and Cambodia [54]. Inadequate infrastructure, including limited internet connectivity and lack of sophisticated hardware, hinders the adoption of more advanced medical informatics technologies. To overcome this challenge, massive investment is required to develop supporting infrastructure, including cross-platform integration systems that enable data collaboration between institutions. This is the key to increasing the efficiency and effectiveness of patient data management.

Amidst these challenges, heuristic algorithms show great potential as innovative solutions in medical data management. These algorithms can group patient data based on diagnosis or disease risk, allowing healthcare providers to provide more personalized and coordinated care [55]. In addition, heuristic algorithms such as *simulated annealing* and *tabu search* can speed up clinical decision-making, such as surgery scheduling and medical resource allocation, which has been proven to increase operational efficiency by up to 20%. This relationship shows that heuristic algorithms cannot only overcome significant data challenges but also provide solutions to improve the speed and accuracy of decision-making in healthcare [3]. However, data security and privacy issues must be prioritized to maximize the benefits of heuristic algorithms. Solutions such as blockchain technology can help create more secure and transparent systems, protecting patient data from external threats while ensuring the integrity of information. Heuristic algorithms can catalyze healthcare transformation by overcoming data fragmentation, infrastructure limitations, and cybersecurity, especially in Southeast Asia, which faces significant challenges in managing health systems. An integrated and collaborative approach between governments, health institutions, and technology developers is key to achieving this goal.

Impact of Implementing Technology and Algorithms

The application of information technology (IT) and heuristic algorithms in managing patient data has revolutionized healthcare services by significantly enhancing efficiency, quality, and accessibility. These advancements have transformed how hospitals and healthcare institutions operate, leading to better patient outcomes and streamlined processes. One of the most notable impacts of incorporating heuristic algorithms into healthcare systems is the marked increase in operational efficiency. Hospitals that utilize heuristic algorithms, such as simulated annealing and tabu search, report efficiency improvements of up to 30% in managing medical data [56]. With incredible speed and accuracy, these algorithms facilitate key tasks like medical schedule management, resource allocation, and patient data

analysis. As a result, patient waiting times are reduced, and the utilization of medical resources is optimized. Efficient scheduling ensures that healthcare providers can attend to more patients without compromising the quality of care. In contrast, effective resource allocation ensures that critical medical equipment and personnel are available where they are most needed. Beyond operational efficiency, integrating IT and heuristic algorithms has significantly improved the quality of healthcare services. Information systems, including electronic medical records (EMR), have become integral to modern healthcare. Data clustering algorithms, such as K-Means Clustering, have enhanced diagnostic accuracy and clinical decision-making processes [57]. With data that is well-organized and easily accessible, physicians can base their decisions on comprehensive patient histories and clinical evidence. This leads to more accurate diagnoses and personalized treatment plans, ultimately improving patient care outcomes. For example, clustering patient data can reveal patterns related to disease progression or treatment effectiveness, allowing healthcare providers to tailor interventions more precisely. Improved decision-making reduces the likelihood of medical errors and ensures patients receive the most appropriate care based on their unique needs.

Accessibility of patient data is another critical benefit brought about by adopting digital technology in healthcare. Real-time access to patient data is essential, especially in emergencies or when managing complex cases. Digital platforms enable healthcare providers to retrieve medical information quickly, eliminating the need for time-consuming manual processes. This immediate access allows for faster emergency response, potentially saving lives in critical situations. Additionally, digital systems facilitate seamless collaboration among healthcare professionals across different institutions. For instance, specialists can consult on cases remotely, accessing relevant patient information without physical barriers. This level of accessibility ensures continuity of care, especially for patients requiring multidisciplinary treatment. Moreover, heuristic algorithms contribute to predictive analytics in healthcare. By analyzing historical patient data, these algorithms can predict future health trends, enabling proactive patient care management. Predictive insights help identify high-risk patients, plan preventive interventions, and optimize treatment plans, further enhancing healthcare delivery. The application of such technologies supports the shift toward personalized medicine, where treatments are tailored to individual genetic profiles and lifestyle factors. The significance of analyzing the application of heuristic algorithms in healthcare is evident from the positive outcomes reported in various studies. These algorithms not only streamline operational processes but also enhance the overall quality and accessibility of healthcare services. The detailed results of how heuristic algorithms impact healthcare management are summarized in Table 1 below, illustrating the substantial benefits of these technological advancements.

Table 1. Impact of health IT and heuristic algorithms in some countries in Southeast Asia. Source: (Data Processed by Author, 2024)

Category	Indicator	Value	Relevance
Operational Efficiency	Increase in data management efficiency	35%	Hospitals using heuristic algorithms in Vietnam
Data Access Speed	Average time to access patient records	< 3 seconds	Blockchain-enabled EMR systems in Singapore
Cost Reduction	Reduction in operational costs	20%	Cost savings from resource optimization in Thailand
Diagnostic Accuracy	Increase in diagnostic accuracy	98%	Enhanced diagnostic systems in Malaysia
Decision-Making Time Reduction	Reduction in clinical decision-making time	25% faster	Heuristic-enabled emergency response systems in the Philippines
Operational Time Savings	Reduction in data processing time	50% faster	Telemedicine platforms in Indonesia
Patient Coverage in Remote Areas	Percentage of patients reached in remote areas	90%	Improved healthcare reach in Laos and Myanmar
Staff Training Time Reduction	Reduction in staff training hours	30% reduction	Automated training systems in Brunei

Table 2 above shows that heuristic algorithms in medical informatics systems for managing patient data in Southeast Asia have significantly impacted information technology and health service systems. One is increasing hospital operational efficiency by up to 35% in Vietnam, thanks to data management optimization. Meanwhile, the blockchain integrated into the EMR system in Singapore provides easy access to real-time patient data in less than 3 seconds. In addition, heuristic algorithms have optimized Thailand, resulting in operational cost reductions of up to 20%, which shows the technology's great potential for increasing financial efficiency. Meanwhile, in Malaysia, the implementation of the diagnostic system has been realized in a sophisticated manner and has increased accuracy to 98% to support more precise clinical decision-making.

Clinical decision-making time was also reduced by up to 25% faster in the Philippines through the implementation of heuristic algorithms in the emergency response system. This technology also plays an important role in expanding the reach of health services, as seen in Indonesia, Laos, and Myanmar, where patient coverage in remote areas reached 90% via telemedicine. Additionally, with an automation-based training system, Brunei recorded a 30% reduction in staff training time. This data confirms that information technology and heuristic algorithms not only speed up operational processes but also provide tangible benefits in efficiency, accessibility, and quality of health services in various countries in Southeast Asia. Overall, the impact of applying information technology and heuristic algorithms in medical informatics systems for patient data

management in Southeast Asia shows excellent potential to revolutionize health services. By improving operational efficiency, service quality, and data accessibility, this technology can help overcome key challenges in health systems, especially in regions such as Southeast Asia, which face limited resources and infrastructure [58]. However, the sustainability of this impact requires support in the form of technology investment, workforce training, and strengthening data integration systems so that the application of heuristic algorithms in medical informatics systems for managing patient data in Southeast Asia can be maximized in its implementation throughout hospital health services.

Implementation of Information Technology in Health Services

Information technology has become one of the main pillars in transforming modern health services. In Southeast Asia, the application of this technology is increasingly recognized as a solution to overcome complex challenges, such as limited access to health services, fragmentation of patient data, and the need for operational efficiency in medical facilities [59]. Although the level of adoption of information technology varies among countries in the region, various initiatives have begun to improve the quality of health services and make it easier to manage patient data. This report reviews several significant steps that have been taken in maximizing the implementation of heuristic algorithms in health services, including implementing an electronic medical record (EMR) system, using blockchain technology, and integrating telemedicine [60]. Each of these innovations addresses specific needs, from managing patient data

Table 2. Implementation of Information Technology in Healthcare in Southeast Asian countries

IT Initiative	Country	Implementation	Challenge
Electronic Medical Records (EMR)	Malaysia, Thailand, Singapore, Vietnam	Malaysia and Thailand have implemented EMR in major hospitals. Singapore has integrated EMR nationwide through the <i>National Electronic Health Record (NEHR)</i> . In Vietnam, EMR adoption has started in urban hospitals.	High implementation costs, lack of training for healthcare personnel, and limited infrastructure in Vietnam.
Blockchain for Health Data	Philippines, Singapore, Indonesia	The Philippines uses blockchain for patient data security. Singapore integrates blockchain for managing patient data across institutions. Indonesia is piloting blockchain in several clinics to improve medical record transparency.	Uneven technology infrastructure in the Philippines and Indonesia; low public trust in the technology.
Telemedicine	Thailand, Indonesia, Myanmar, Laos	Thailand and Indonesia are leaders in telemedicine adoption. Myanmar utilizes platforms like <i>Doctor on Call</i> for rural areas. Laos has developed basic telemedicine using SMS and mobile	Uneven internet access, lack of digital devices, and minimal regulations in Myanmar and Laos.
AI in Diagnostics	Singapore, Vietnam	Singapore uses AI for radiology analysis and disease prediction. Vietnam has begun adopting AI to support diagnostics in major hospitals like Bach Mai Hospital.	Lack of local AI experts in Vietnam and regulations for AI in the healthcare sector.
Hospital Management Systems	Malaysia, Philippines, Cambodia	Malaysia operates IT-based systems like the <i>Total Hospital Information System (THIS)</i> . The Philippines introduced similar systems in major hospitals. Cambodia has begun piloting IT systems in primary healthcare facilities.	Difficulties in integrating data across facilities, and a lack of trained personnel, especially in Cambodia.
Mobile Health Applications	Indonesia, Thailand, Brunei	Indonesia's <i>HaloDoc</i> and <i>Alodokter</i> are popular for health consultation services. Thailand has similar apps focused on mental health. Brunei launched <i>BruHealth</i> , a national app for public health management.	Limited digital literacy in rural communities and underdeveloped data privacy regulations.

digitally to increasing the transparency and security of medical information. However, although these efforts show promising results, challenges such as infrastructure, funding, and regulations still need to be overcome. In this context, it is important to understand the implementation

Table 2 shows that the analysis results show that Southeast Asian countries have begun to adopt information technology in health services, although with varying levels of progress between countries. The application of this technology is an important step to increase the efficiency and accessibility of health services in regions that have complex geographic and demographic challenges. Several prominent initiatives identified in this study reflect efforts to integrate information technology into health systems to overcome operational barriers and improve the quality of care. One of the main initiatives is the implementation of an Electronic Medical Record (EMR) System [61]. In countries such as Malaysia and Thailand, EMR has been used in several large hospitals to integrate patient data digitally [62]. This system allows doctors and health workers to access patient data in real-time, thereby increasing the efficiency of medical decision-making. However, EMR adoption is still limited to certain institutions, huge hospitals in major cities, due to implementation costs, lack of infrastructure, and training barriers for health workers [63].

Additionally, the study noted the use of blockchain technology in the Philippines to increase transparency and security of patient data. This technology enables

of information technology in health services as part of a strategy to improve health quality in Southeast Asia. Some of the literature in Table 2 has been presented for comparison with previous research to highlight its significance and contribution to this field.

decentralized data storage, preventing unauthorized modification and increasing trust in medical information management [64]. Although blockchain implementation is still early, it shows great potential in addressing data security issues that are a significant concern in the health sector. On the other hand, the integration of telemedicine technology has shown significant growth in Thailand and Indonesia [47]. Telemedicine is used to expand access to health services, especially in remote areas that are difficult to reach by physical health facilities. With telemedicine, patients can consult with doctors via digital platforms, reducing health access disparities [65]. Although telemedicine adoption continues to increase, challenges such as internet connectivity, device limitations, and regulations remain barriers that need to be overcome for wider adoption. Overall, the implementation of information technology in healthcare in Southeast Asia is growing rapidly despite facing various technical and non-technical challenges [66]. These steps highlight the commitment of countries in Southeast Asia to integrate digital technology into their health systems to improve efficiency, transparency, and accessibility of services for the public. So, these results are significant in encouraging and maximizing the application of heuristic

algorithms in medical informatics systems for managing patient data in Southeast Asia [67].

4. DISCUSSION

A. Medical Informatics: Technology Trends and Innovations

Medical informatics is a branch of science that integrates information technology with health sciences to manage, analyze, and utilize medical information efficiently [68], [69]. This discipline includes developing, implementing, and evaluating systems such as electronic medical records (EMR) and hospital management systems that support decision-making in healthcare [70]. Medical informatics needs to focus on policy, ethical, and social aspects related to the use of information technology in the health sector [25]. In the modern healthcare system, medical informatics is important in improving efficiency through data integration, accelerating clinical decision-making processes, and supporting data-driven research for better health policies [1]. Significant challenges are faced in Southeast Asia, such as data fragmentation, lack of technological infrastructure, and limited expertise.

On the other hand, there are also threats related to data security and limited funding and policy support [71]. Therefore, medical informatics supported by innovative algorithms, such as heuristic algorithms, has excellent potential to improve the efficiency of health systems [27]. Therefore, heuristic algorithm technology can help overcome infrastructure limitations, improve patient data management, and improve the quality of health services in Southeast Asia. One is Singapore, which can be an example of optimizing heuristic algorithms for using technology for all public services [72].

B. Heuristic Algorithms in the Health Sector

A heuristic algorithm is a problem-solving approach that relies on estimation and literacy to find a good enough solution in an efficient time [1]. It focuses on practical solutions that are close to optimal and can be achieved with limited resources. With their flexible basic principles, heuristic algorithms are often used in various fields, including optimization, big data management, and dynamic decision-making [17]. The advantage of heuristic algorithms over conventional methods lies in their ability to handle problems with many variables and constraints, producing adequate solutions without requiring large amounts of time or resources [73]. This makes it an essential tool in real situations, such as managing large and complex medical data in the health sector [74].

In its application in the health sector, heuristic algorithms have shown great potential for solving various challenges, from patient data analysis to optimizing medical schedules and disease prediction [32]. For example, genetic algorithms are used to identify disease risk patterns based on patient, temporal data *simulated*

annealing, and *tabu search*, which assist in preparing hospital operational schedules, such as allocating operating rooms and doctor schedules. In addition, algorithms like *ant colony optimization* (ACO) and *particle swarm optimization* (PSO) have been applied to manage logistics and drug distribution channels, as well as analyze patient data for chronic disease prediction [75], [76]. The ability of heuristic algorithms to process big data with high efficiency enables the integration of this technology into medical informatics systems to create more responsive and accurate health services [77]. In Southeast Asia, applying this algorithm can help overcome data fragmentation, technological limitations, and the need for better health system management, thereby supporting improvements in the quality of health services in the region [78].

C. Patient Data Challenges

Managing patient data in healthcare systems faces significant challenges, especially with data volumes increasing as populations and medical services develop. Data privacy and security issues are a significant concern, considering that patient data is very sensitive and vulnerable to cyber security threats [79]. Additionally, cross-platform integration in healthcare systems is often challenging, where patient data is spread across multiple institutions without effectively interconnected systems [59]. These challenges hinder operational efficiency and slow clinical decision-making, requiring rapid and accurate access to patient information [64]. Current solutions, such as conventional methods for managing patient data, have limitations in dealing with the complexity and scale of these challenges. This is where heuristic algorithms offer great potential as an innovative alternative to simplify the analysis and management of medical data. This algorithm can process large amounts of data quickly and efficiently, producing solutions close to optimal without requiring significant resources [13]. In medical informatics systems, heuristic algorithms can increase the efficiency of the data integration process, speed up disease pattern analysis, and increase accuracy in clinical decision-making [68], [69], [80]. By implementing this technology, healthcare systems can be more responsive to patient needs while overcoming operational obstacles faced in data management [81].

5. CONCLUSION

This research identified and analyzed the application of heuristic algorithms in managing patient data in Southeast Asia. Heuristic algorithms can significantly improve the efficiency of medical data management, including disease pattern analysis, medical schedule optimization, and patient data grouping. Data security and privacy issues remain a serious concern, with recommendations to utilize technologies such as

blockchain to protect patient data and ensure information integrity. Nevertheless, the successful application of heuristic algorithms in driving health services shows the technology's great potential to overcome complex data management problems and improve the quality of health services in Southeast Asia.

Policymakers in So policy makers countries and related health institutions need to encourage the application of heuristic algorithms in medical informatics systems for data management so that services run optimally and better. Several strategic steps are recommended for continuous improvement in patient data management practices. First, investing in developing integrated and secure information technology infrastructure is necessary, including increasing connectivity, procuring adequate hardware, and developing compatible health information systems. Second, training and education for healthcare workers and IT professionals should be a priority to ensure understanding and skills in using heuristic algorithms and medical informatics systems. Third, policymakers must formulate regulations supporting new technologies, including protecting patient data and privacy, to build public trust in digital health systems.

This research strengthens the application of heuristic algorithms in Southeast Asia and helps understand the local context and unique challenges. Further research that can evaluate the long-term impact of implementing algorithms on the quality of health services and patient health outcomes is also vital. Technological innovations, such as the use of blockchain for data security and telemedicine to expand health access, must continue to be encouraged to expand the potential application of heuristic algorithms. By overcoming these challenges, the application of heuristic algorithms in patient data management in Southeast Asia can become more effective and sustainable.

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