Benefits and Challenges of Cloud Computing System in Malaysian Public Healthcare Organizations

Nurul Izzatty Ismail[1], Juhari Noor Faezah[2]*, Muhammad Syukri Abdullah[3], Masrina Nadia Mohd Salleh[4]
Centre For Value Creation and Human Well-Being Studies (INSAN), Faculty of Economics and Management, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia[1, 2, 3]
Center For Global Business and Digital Economy Studies (GloBDE), Faculty of Economics and Management, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia[4]

***Abstract*—Cloud computing has become an emerging technology in information systems (IS), which brings worldwide attention to healthcare management, including in Malaysia. Therefore, the present study aims to identify the benefits and challenges of the cloud system in the healthcare sector. The TOE framework was adopted to explain the benefits and challenges of cloud system implementation in the healthcare sector. The findings show that cost, scalability, data accessibility, and interoperability are factors in a technological context that may enable the successful implementation of cloud systems in healthcare organizations. Apart from that, the size of healthcare organizations and their training were also important factors in the organizational context, while government regulations and policies, as well as cyber threats, are considered crucial factors in the environmental context in cloud implementation in the healthcare sector. A conceptual framework of the cloud system was proposed to provide a comprehensive understanding to optimise future implementation or adoption of the cloud system in the Malaysian healthcare sector.**

***Keywords*—Cloud computing; technology; Malaysia; healthcare sector; public healthcare; TOE framework**

I. Introduction

The healthcare sector is essential for preserving and improving human health. It is imperative to safeguard population well-being and significantly contributes to economic stability and quality of life in every nation, including Malaysia.

Fig. 1 illustrates that the Malaysian population experienced a 2% growth, rising from 33.7 million in 2022 to 34.1 million in 2024 [1]. This circumstance positions healthcare as a predominant industry in Malaysia. Therefore, the Malaysian government has been systematically constructing additional hospitals and clinics nationwide to accommodate the population.

Currently, Malaysia has 146 public hospitals, 2699 public clinics, and 253 community clinics [2]. Despite the presence of numerous public healthcare providers in this country, the available resources are inadequate to meet the needs of all citizens. The shortage is due to patients requiring medical treatments in public hospitals, which offer extensive medical facilities and specialists to assess and treat critical cases. This situation elevates public hospitals as more significant institutions among various medical organizations.

A. Malaysian Public Hospitals

Public hospitals in Malaysia currently possess 45848 beds, with the Malaysian Ministry of Health (MOH) anticipating to increase this number by an additional 5600 beds in the near future [3]. In this nation, experiencing population growth, the available hospital beds are regrettably inadequate to meet the medical care demands. Pillay et al. [4] indicate that patients expressed dissatisfaction with the duration from registration to collection of medications, despite the consultation time being relatively short at approximately 15 minutes. Furthermore, Hassali et al. [5] noted that prolonged waiting times significantly affected patient satisfaction levels. Patients expressed dissatisfaction due to wait times exceeding two hours, indicating that the hospital services were inadequate.

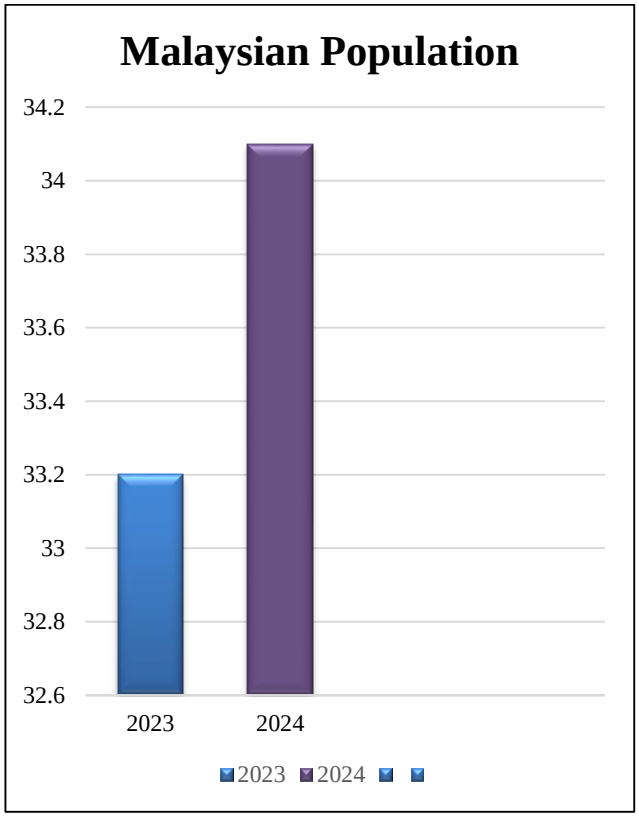

Fig. 1. Malaysian population from 2023 to 2024.

In addition, the Ministry of Health [2] reports numerous individual instances of negligence. In 2023, the Ministry of Health (MOH) approved ex-gratia payments and litigation totaling RM6, 891, 879.28 for 75 cases, representing an increase from the previous year.

This study addresses these gaps by examining the benefits and challenges of cloud computing adoption in Malaysian public healthcare organizations through the lens of the Technology-Organization-Environment (TOE) framework, as well as to propose a conceptual framework to guide future adoption, aligning with Malaysia's digital health aspirations.

This is because the implementation of efficient Information Systems (IS) is crucial for the healthcare sector in this country. Besides that, the cloud system is essential for managing all the aforementioned issues across healthcare organizations in this country.

II. LITERATURES

A. Information System (IS)

Information systems (IS) can be defined as a network of related components that engage in collecting, processing, storing, and distributing data for a designated target, especially to facilitate decision-making, coordination, and management within an organization [6], [7].

As illustrated in Fig. 2, the workflow follows a step-by-step process, where raw data is collected from different sources, processed using analytical methods, stored in structured databases, and delivered to the intended destinations. This approach improves data quality, supports smooth system integration, and helps generate useful insights for better decision-making. Beyond this, the workflow demonstrates enduring relevance across decades of technological evolution, maintaining its position as the foundational architecture for both legacy systems and contemporary cloud-based implementations.

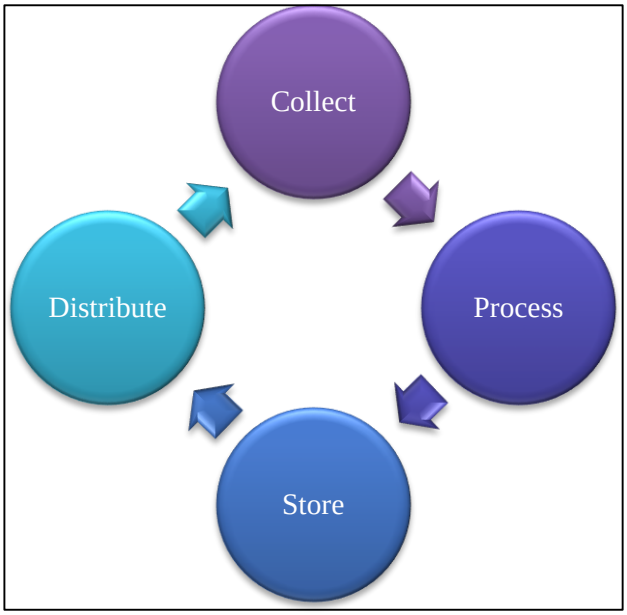

Fig. 2. Information systems (IS) flow.

In addition to the IS flow presented in the preceding figure, information systems fundamentally consist of six critical components named as hardware, software, data, procedures, people, and networks. The descriptions of these components are shown in Table I.

TABLE I. THE COMPONENTS OF INFORMATION SYSTEM

Key Components of IT	Definitions
Hardware	Hardware refers to the physical devices and equipment used in an information system that provide the infrastructure for processing and storing data, such as computers, servers, storage devices, networking equipment, and peripherals [6].
Software	Software includes the programs and operating systems that manage hardware resources and enable users to perform specific tasks [8].
Data	Data is the raw material of an information system, which consists of facts, figures, and information that are processed to produce meaningful outputs [9].
Procedures	Procedures are the rules, guidelines, and workflows that govern how data is processed, stored, and disseminated within an information system. They ensure consistency, efficiency, and security in the operation of the system [6].
People	People are the users, developers, and managers of an information system. They include end-users who interact with the system [8].
Networks	Networks enable communication and data exchange between different components of an information system; for example, they include local area networks (LANs), wide area networks (WANs), and the internet [9]

These components depend on each other to ensure that data is properly collected, preserved, and distributed to meet specific goals, especially in the healthcare sector. Hence, the evolution of cloud systems needs to be highlighted.

According to [10], cloud system development began in 2006, initiated by Amazon, and in 2008, Google launched its Google Cloud, while Microsoft launched its Windows Azure.

The cloud system provides on-demand access to IS resources, such as servers, storage, databases, networks, software, and analytics over the internet with pay-as-you-go pricing, providing significant cost savings when users avoid upfront costs with hardware or infrastructure [11].

B. IS in the Healthcare Sector

A health information system is a core function of the health system; it integrates data collection, processing, and reporting to help support decision-making at the public health level and avoid problems pertaining to healthcare (WHO, 2016). Moreover, [12] expanded on this, noting that this system brings together collecting, processing, and reporting data to improve the delivery and outcome of care.

Information systems in healthcare have revolutionized the delivery, management, and optimization of medical services. They cover a broad spectrum of technologies that aim to capture, manage, and share patient information. Aside from that, IS may be able to structure clinical workflows and assist with decision-making processes. Such systems are crucial in today's health structure.

The popularity of cloud computing technology in the healthcare sector is growing widely recently. An example of cloud computing includes the Electronic Health Records (EHRs), which allow secure storage, access, and sharing of patient records via multiple locations [13].

In Malaysia, an online cloud-native web known as Medical Program Information System (MPIS) has been developed by the Hospital Services Management Unit (Medical Development Division) for use in public health care institutions [3]. This system was developed following COVID-19 to ensure efficient patient services during the pandemic. The MPIS application remains an ongoing process that has not been fully utilized by all Malaysian public healthcare institutions. In this case, the Ministry of Health (MOH) and the Malaysian government are to shoulder the responsibility of enabling digitalization for the country's healthcare sector; their initiatives will benefit both healthcare sector practitioners and citizens.

C. The Advantages of Cloud Systems in the Healthcare Sector

Cloud system provides several advantages, such as better data accessibility, cost-effectiveness, scalability, flexibility, and better data security and audits.

1) Accessibility of data: Cloud technology has the capability of increasing the accessibility of data among healthcare providers [14]. For example, doctors and nurses can access patient data on their smartphones, tablets, or laptops anywhere, even outside the hospital setting. This is because the data is accessible to all healthcare providers, including doctors and specialists, regardless of their location. Furthermore, the study [15] asserts that facilitating data sharing grants access and allows healthcare providers to collaboratively review and modify patient records, resulting in improved care coordination and reduced medical errors. In addition to that, cloud technology enables patients to access their health information, set appointments, and consult their providers through the patient's portal [16].

2) Cost-effectiveness: Marston et al. [17] point out that cloud computing provides a more affordable option compared to legacy IT infrastructure. In this case, the organizations pay only for the resources they consume [18]. For instance, a pay-as-you-go model could minimize overprovisioning and wasted capacity [19]. Cloud tech provides lower maintenance and IT staffing. This advantage is due to the fact that cloud providers take care of server-side maintenance, security patches, and upgrades [16], minimizing the need to have IT personnel in place. Furthermore, cloud technology has the potential to cut energy and space costs, as it can replace on-site servers and significantly lower power and cooling costs [20]. It could manage system maintenance, updates, and security, alleviating the burden on healthcare IT personnel.

3) Scalability and flexibility: Cloud technology in the healthcare sector is also beneficial because of its scalability and flexibility. Scalability is the ability of a system to handle a growing or consistent workload by adding resources at a fixed cost [21]. In this scenario, the cloud technology could adapt effortlessly to the increasing volume of healthcare data and represents a significant advantage regarding data-hungry trades, such as the healthcare sector [11]. Other than the above, healthcare institutions would be able to implement new applications or services on the cloud technology, which would facilitate faster responsiveness to emerging clinical or operational requirements.

4) Enhanced data security: Aside from that, the cloud technology can improve data security [16], mainly due to the encryptions that have been employed in the movement and storage of data, which decrease the danger of breaches. In addition, the most popular applications of cloud technology in the healthcare sector come with built-in compliance with strict healthcare regulations, such as the HIPAA (Health Insurance Portability and Accountability Act) and the GDPR (General Data Protection Regulation), safeguarding patients' sensitive information in both secure and legal processes. Furthermore, Gabriel et al. [22] assert that patient records in cloud-based EHR systems can only be edited by authorized personnel.

5) Disaster recovery and business continuity: Sultan [23] contends that cloud technology can minimize data redundancy and reduce the likelihood of data loss resulting from hardware failures or natural calamities. Al-Issa et al. [20] agreed that cloud storage ensures redundant backups so that data loss resulting from ransomware may be prevented. For example, healthcare providers can recover data to resume interrupted workflows in the event of system failure or disruption.

D. Evolving IS Issues and Challenges in the Healthcare Sector

Notwithstanding the advantages, the implementation of cloud technology in the healthcare sector encounters obstacles, including high implementation costs, data privacy and security dilemmas, interoperability issues, user resistance and training requirements, system downtime and reliability challenges, as well as ethical concerns.

1) High implementation costs: The problem of implementing the cloud technology in healthcare organizations is that of high implementation costs. To develop, deploy, and maintain healthcare information systems is a costly business [24]. For instance, development costs could increase if cloud technology needs to interact with platforms that require specialized APIs or middleware [22]. Egress fees, which are costs related to data transfer, are often considered hidden costs of cloud technology in the healthcare sector, especially concerning large medical datasets [25].

2) Data privacy and security: Another challenge faced by cloud technology in the healthcare sector is data privacy and security. Certain implementation issues are more prominent in this case, like certification, authentication, privacy, and confidentiality [26]. In fact, using cloud technology makes it vulnerable to cybersecurity attacks, e.g., ransomware, phishing, and unauthorized access, all of which pose significant threats to patient data [16].

3) Interoperability: Interoperability is also a challenge facing the implementation of IS in the healthcare sector. Many

healthcare systems are single-directional (i.e., standalone), rendering data transfer between organizations a challenge. According to Häyrinen et al. [12], such a system is not standardized because the data formats and protocols for data sharing are incompatible. In addition, any obsolete or incompatible data cannot be updated in real time [19]. In the future, this situation may pose a difficulty or issue integrating with another system.

4) User resistance and training: In the implementation of cloud technology in the healthcare sector, a lack of training is a serious issue. According to McGinn et al. [27], implementation of new systems can disrupt frequent workflows and result in dissatisfaction among users. Gagnon et al. [28] agreed that users of cloud system in the healthcare sector might find it disruptive. In addition, these users experience strain and exhaustion when adapting to entirely new cloud interfaces, which indicates poor training programmed [29]. Hence, comprehensive training programmers are necessary for all staff.

5) System availability and stability: System downtime and reliability are also challenges in the implementation of IS in the healthcare sector. According to Raghupathi and Raghupathi [30], certain hospitals reported delays of as much as 30 seconds in viewing the patient records stored in the cloud. Furthermore, the cloud system in the healthcare sector may lack effectiveness [19]. Technical glitches, bugs, and crashes can jeopardize patient care. As a result, routine maintenance is required to minimize downtime, which can be both costly and time-consuming [13].

6) Ethical concerns: The final challenge in the implementation of IS in the healthcare sector is ethics. This difficulty is due to the fact that the patients' data is used, which raises concerns about ethically obtaining consent and using the patients' data or information [31]. Previously, 500,000 patient records were exposed due to misconfigured storage [32]. Moreover, the cloud technology can give rise to the cloud computing vulnerabilities such as cyberattacks, insider misuse, and third-party sharing of sensitive patient records, thereby breaching patient privacy and data security [33], [16].

III. IS THEORIES

A theory is a well-substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment [34]. Gregor [35] asserts there are five main purposes of theories in IS: analysis (theory to point out), explanation (theory to illustrate), prediction (theory to predict), prescription (theory to prescribe), and design and action. Theories are based on a body of evidence that supports them; they explain and predict phenomena relevant to this evidence. In IS studies literature, there exist numerous theories to account for IS adoption and implementation. These are the Theory of Reasoned Action (TRA) [36], the Theory of Planned Behavior (TPB) [37], the Technology Acceptance Model (TAM) [38], the Technological, Organizational, Environmental Framework (TOE) [39], the DeLone and McLean Model [40], the Diffusion of Innovation Theory [41] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [42].

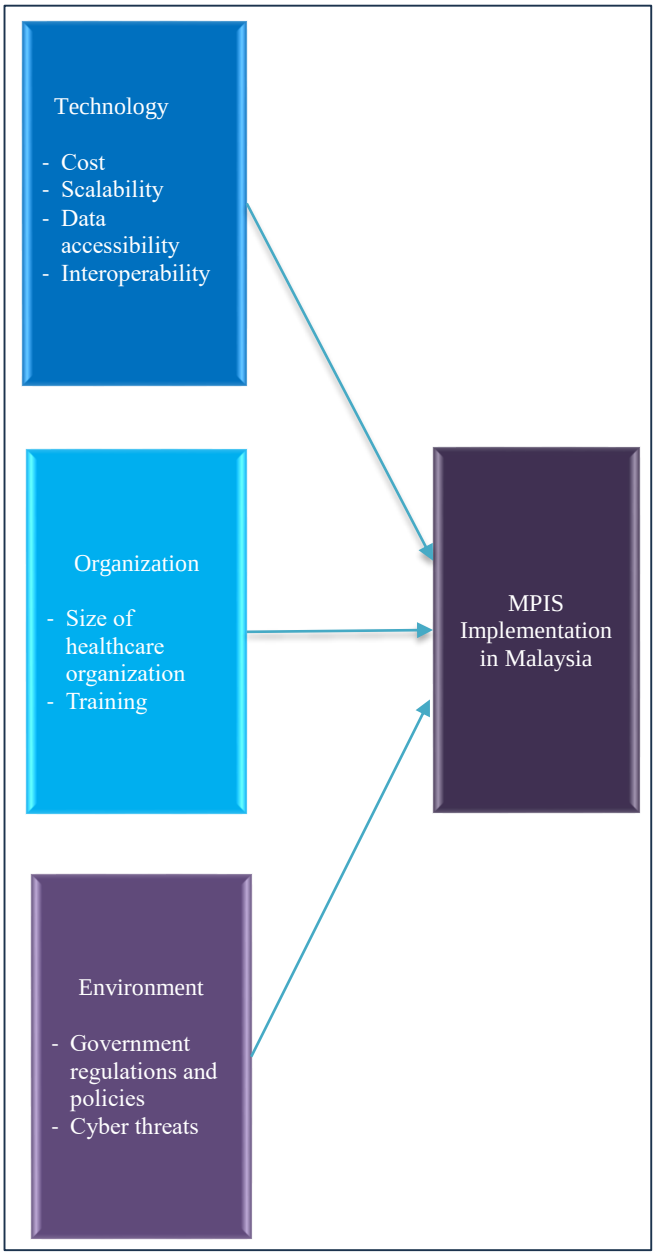

Fig. 3. A conceptual model of cloud system implementation in Malaysian healthcare.

In the present study, the TOE framework [39] was employed to tackle the cloud implementation in the healthcare sector as illustrated in Fig. 3. This conceptual model systematically organizes the critical dimensions of Technology (cost, scalability, data accessibility), Organization (healthcare institution size, training protocols), and Environment (government regulations, cyber threats) that collectively determine cloud adoption success. This is important to identify total cloud technology utilization in Malaysian healthcare organizations and to improve its implementation.

IV. DISCUSSION

In the present technological era, information technology is a cornerstone of every organization globally. This principle is applicable even in the healthcare sector. For this reason, the

healthcare sector frequently employs cloud computing. The aforementioned case study illustrates that developed nations have successfully implemented cloud-based tech due to its robust technological and financial capabilities; however, cloud applications are also viable in developing countries such as Malaysia.

During the COVID-19 pandemic, the MOH has been so much more careful in adapting cloud computing, in particular MPIS in Malaysia. In the future, some public hospitals nationwide will deploy the system. Nevertheless, the system has not yet been fully adopted in all public hospitals in this country. Thus, a high-level adoption model based on the benefits and challenges experienced by the cloud technology represents an important instrument that helps to guide the overall MPIS implementation process.

The significance of this study can be tagged as additional support for the relevancy of the TOE framework for IT adoption in the healthcare sector. It builds on the model (which had not previously considered the impact of telehealth and cloud analytics) to provide insights into new moderating variables. Thus, the TOE Framework was used to examine the adoption of new technologies, including cloud computing in the healthcare sector, consistent with earlier studies [43]. Applying this model provides considerations for cloud technology implementation issues and challenges, such as MPIS, which are to be divided into three types of contexts: technology, organization, and environment. The conceptual model of cloud system implementation in the Malaysian healthcare sector is presented in Fig. 3, which was based on the TOE framework.

Hence, it ensures the best alternative for the healthcare sector to cope with optimal patient data over cloud technology tailored for first-class, cost-effective extensibility [44]. However, Jones et al. [45] argued that concerns over security are still a major barrier, especially regarding compliance with HIPAA and GDPR. However, multi-factor authentication (MFA) and zero-trust architectures, as shown in the literature, can mitigate these risks [46]. Moreover, they embraced the Fast Healthcare Interoperability Resources (FHIR) standards to improve data sharing [47] due to the barrier that this technology has for interoperability in both cloud-based systems and EHR.

The literature suggests that the size of an organization influences the adoption of cloud technology in healthcare. For instance, large hospitals would be appropriately budgeted for the technology, while smaller clinics may have budget limitations [48]. In addition, a lack of leadership support and staff training is another major factor that impacts the organization's implementation efficiency [49].

In other contexts, this technology implementation has been significantly influenced by numerous external pressures, such as government regulations and competitive dynamics. To substantiate this, the HITECH Act and the 21st Century Cures Act advocate for a digital shift, which may simultaneously heighten compliance obligations and potentially engender instability [50]. As a result, there are cyber threats like ransomware and other attacks on healthcare's data, despite improved trust in cloud implementation by the developers, such as AWS, Microsoft Azure, and Google Cloud [51].

A. Recommendations and Future Research

This study proposes recommendations, including implementing hybrid clouds (combinations of private and public clouds) in healthcare organizations. Hybrid cloud models are preferred in healthcare because they facilitate a balance between security and scalability [52]. The close collaboration between cloud providers and policymakers is essential to mitigate the significant cyber threats and risks in the healthcare sector [53]. Accordingly, national digital health strategies are crucial for policy and governance to assess how the system can be standardized and rendered interoperable. Hence, the Ministry of Health must collaboratively develop a cybersecurity framework with health informatics experts from Malaysian universities.

V. Conclusion

The implementation of online cloud technology in Malaysia marks a transformative step towards modernizing the nation's healthcare delivery through the cloud system. Piloting the implementation of interoperability standards at leading hospitals would be a major step forward in MPIS implementation in the Malaysian healthcare sector. However, its implementation success might be negatively impacted by certain technological, organizational, and contextual challenges. Instead, Malaysia needs to take a strategic, multi-phased approach towards policy alignment, technological innovation, and human capital development. By fortifying digital infrastructure, scaling up Artificial Intelligent (AI) capabilities and tackling rural versus urban inequities, Malaysia can turn its vision for a fully integrated, data-driven healthcare system into reality. These initiatives may lead to improved national healthcare services through continued cooperation between the MOH, technology providers, and informatics professionals until a nationwide implementation of MPIS is successful. With sustained effort and appropriate implementation, MPIS can help lay the groundwork for a more inclusive, responsive, and technologically prepared Malaysian healthcare system, which translates into improved outcomes for all Malaysians.

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