DIGITAL TRANSFORMATION CHALLENGES OF EMERGING HOSPITALS IN DIGITAL DISRUPTION

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Abstract

In the era of Industry 4.0, hospitals face numerous obstacles when it comes to embracing digital disruption. One of the major challenges is dealing with big data. With the increasing amount of data being generated in healthcare, hospitals struggle to effectively manage and analyze this vast amount of information. This paper highlights the challenges faced by hospitals in adopting digital disruption in the era of Industry 4.0. Some of the challenges include big data, scalability, data management, security and privacy, standardization, interoperability and regulation, human factors, implementation costs, networking, integrated IT infrastructure, skills, and device/system heterogeneity. The study suggests that immediate implementation of information technology is required to achieve optimal data integration on a national scale. Various recommendations have been formulated, including improving knowledge management of big data analytics and systems, as well as empowering human resources within the organization. The study calls for more research in Healthcare 4.0, addressing key barriers and identifying trends and gaps that require further exploration.

Keywords: *Hospital, Digital transformation, Disruption, Industry 4.0*

1. INTRODUCTION

Healthcare is an industry that generates vast amounts of data, driven by the need to maintain patient records, ensure compliance, and adhere to care standards (Borges do Nascimento et al., 2021; Galetsi & Katsaliaki, 2020). With advancements in medical technology, increased life expectancy, and a rise in chronic non-communicable diseases, healthcare costs are projected to reach unprecedented levels in the coming decades (Janssen & Moors, 2013). Digital transformation and information technology play crucial roles in processing data into actionable intelligence to enhance healthcare services, patient care, and business process management, thereby meeting healthcare demands and improving therapy quality for patients (Behkami & Daim, 2012; Li & Mao, 2015; Lopes et al., 2021; Pai & Huang, 2011).

To fulfill its responsibilities in leading health efforts, the Directorate General under the Ministry of Health is tasked with developing reliable, accurate, fast, and up-to-date information that supports effective decision-making in policy formulation (Monalizabeth et al., 2015). The Health Information System encompasses a set of rules encompassing data, information, indicators, procedures, technology, devices, and human resources that are interrelated and managed integratively to guide valuable actions or decisions in supporting health development. In preparation for the era of healthcare disruption 4.0, numerous hospitals and healthcare facilities face various challenges (Hasibuan et al., 2023). The primary challenge lies in the lack of clarity in laws and regulations, as well as the absence of regulatory harmonization between relevant ministries.

Digital disruption has emerged as a transformative phenomenon across traditional industrial contexts, impacting businesses and societies at all levels. While the adoption of information and communication technology has influenced the healthcare sector since the mid-20th century, meaningful changes in the OPK (Organization, Processes, and Knowledge) paradigm have only occurred within the last two decades. Transformation in healthcare entails the adoption of new technologies that facilitate changes toward safer and higher-quality healthcare (Kraus et al., 2021).

The concept of digital transformation, as described above, illustrates the vast and interconnected realm of digital development in the healthcare field. Concerning healthcare marketing, the role of digital extends beyond disseminating information through social media and encompasses increasing interaction and engagement with the target market segment (Gillpatrick, 2019). Over the past 45 years, seven major areas of research have emerged in the realm of healthcare technology, namely: 1) Integrated health information technology management; 2) Medical images; 3) Electronic medical records; 4) Portable information technology and devices; 5) Access to e-Health; 6) Telemedicine; and 7) Confidentiality of medical data (Marques & Ferreira, 2020).

The adoption of digital technology in Indonesia exhibits considerable variation, not only among companies but also among users (Trinugroho et al., 2022). Hospitals also face challenges in internal digital technology adoption and in encouraging external parties, such as patients, to embrace digital technology (Budiyatno, 2023). This study aims to map the variables associated with hospital challenges in realizing digital transformation 4.0 using a systematic literature review method.

2. RESEARCH METHODS

2.1. Research Question

The research questions for this study are formulated based on the topic's requirements. The following are the research questions addressed in this study:

RQ1: How do hospitals achieve Digital Transformation 4.0?

RQ2: What challenges do hospitals face in realizing Digital Transformation 4.0?

2.2. Search Process

The search process involves obtaining or searching for relevant sources to address the research questions and find related references. The search was conducted using the Mozilla Firefox search engine with the website address https://scholar.google.com. In conducting a Systematic Literature Review (SLR), specific strategies and methods are employed to search for relevant research. The initial stage involves searching for literature using specific keywords. The keywords used in this study are "Hospital," "Digital Transformation 4.0," or "Hospital Digital Transformation 4.0" and "Hospital Digital Challenge 4.0" or "Digital Challenge 4.0." These keywords were entered into the search feature on Google Scholar, along with selecting the appropriate year range.

The second stage involves Review 1, which involves identifying and analyzing the literature obtained from the search. During this stage, the research papers retrieved are selected based on the following criteria: (1) Elimination of literature with titles that do not match the predetermined keywords. (2) Elimination of literature that falls outside the

specified year range. The results from Review 1 are then carried forward to Review 2 for a more in-depth analysis.

At the Review 2 stage, the abstracts of the selected papers are analyzed. The remaining literature is further refined by: (1) Elimination of literature with abstracts that are not relevant to the predetermined keywords. (2) Elimination of literature with research methodologies that are not aligned with web-based system development. (3) Elimination of papers with uncommon content or format. The remaining literature from Review 2 is grouped based on the information system development methods used. In the final stage, the researcher performs a selection process, assessing the quality of the papers based on a list of Quality Assessment (QA) criteria.

2.3. Quality Assessment

Quality Assessment (QA) is conducted based on a set of problem formulations to evaluate the literature's quality. The QA should encompass assessments that address all the problem formulations. In this study, the identified literature will be evaluated based on the following QA criteria:

QA1: Was the literature published between 2018 and 2022?

QA2: Does the literature provide information about the challenges hospitals face in realizing Digital Transformation 4.0?

For each literature, the corresponding value will be assigned based on the answers to the above questions:

Y (Yes): for literature that matches the criteria in the quality assessment.

T (No): for literature that does not meet the criteria in the quality assessment.

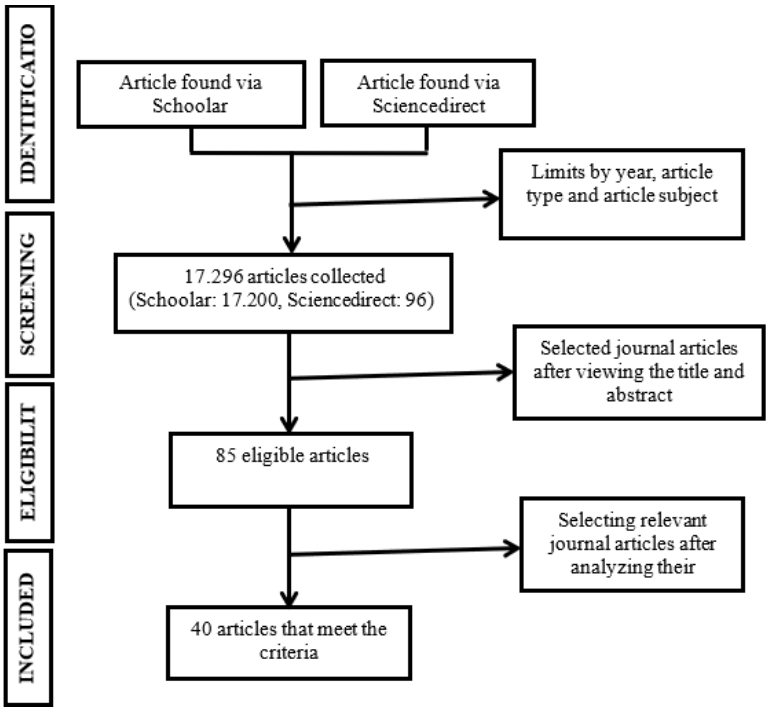

Figure 1 PRISMA screening method
Source: Author's Processed Data, 2023

3. RESULTS AND DISCUSSION

3.1. Research Results

The results of the Quality Assessment for the selected literature, which can be utilized as references to address RQ1, are presented in Table 1.

Table 1. Results of Research Question and Quality Assessment

Authors, Year of Publication	RQ1	RQ2	Q1	Q2	Authors, Year of Publication	RQ1	RQ2	Q1	Q2
(Aceto et al., 2018)	Y	Y	Y	Y	(Dautov et al., 2019)	Y	Y	Y	Y
(Ali et al., 2018)	Y	Y	Y	Y	(Hamidi, 2019)	Y	Y	Y	Y
(Beltrán, 2018)	Y	Y	Y	Y	(Hathaliya et al., 2019)	Y	Y	Y	Y
(Elhoseny et al., 2018)	Y	Y	Y	Y	(Hsu & Li, 2019)	Y	Y	Y	Y
(Guha & Kumar, 2018)	Y	Y	Y	Y	(Kharel et al., 2019)	Y	Y	Y	Y
(Kumari et al., 2018)	Y	Y	Y	Y	(Mavrogiorgou et al., 2019)	Y	Y	Y	Y
(Lin et al., 2018)	Y	Y	Y	Y	(Mishra et al., 2019)	Y	Y	Y	Y
(Aceto et al., 2018)	Y	Y	Y	Y	(Mutlag et al., 2019)	Y	Y	Y	Y
(Ali et al., 2018)	Y	Y	Y	Y	(Munzer et al., 2019)	Y	Y	Y	Y
(Beltrán, 2018)	Y	Y	Y	Y	(Onasanya et al., 2019)	Y	Y	Y	Y
(Elhoseny et al., 2018)	Y	Y	Y	Y	(Pan et al., 2019)	Y	Y	Y	Y
(Guha & Kumar, 2018)	Y	Y	Y	Y	(Ricciardi et al., 2019)	Y	Y	Y	Y
(Kumari et al., 2018)	Y	Y	Y	Y	(G. Wang et al., 2019)	Y	Y	Y	Y
(Lin et al., 2018)	Y	Y	Y	Y	(Burton-Jones et al., 2020)	Y	Y	Y	Y
(Mahmoud et al., 2018)	Y	Y	Y	Y	(Cui et al., 2020)	Y	Y	Y	Y
(Manogaran et al., 2018)	Y	Y	Y	Y	(Klinker et al., 2020)	Y	Y	Y	Y
(Pace et al., 2018)	Y	Y	Y	Y	(Marques & Ferreira, 2020)	Y	Y	Y	Y
(Pang et al., 2018)	Y	Y	Y	Y	(Maiurova et al., 2022)	Y	Y	Y	Y
(Pappas et al., 2018)	Y	Y	Y	Y	(Soltanisehat et al., 2020)	Y	Y	Y	Y
(Puthal et al., 2018)	Y	Y	Y	Y	(Tortorella et al., 2022)	Y	Y	Y	Y

Source: Author's Processed Data, 2023

Figure 2 illustrates the journals from which the majority of the papers were selected. Future Generation Computer Systems stands out with the highest number of published articles, totaling four. This is followed by Computers & Electrical Engineering and

International Journal of Computer Science and Network Security, with three papers each. Additionally, Enterprise Information Systems, IEEE Access, IEEE Reviews in Biomedical Engineering, and International Journal of Production Research each had two papers included in the selection. It is worth noting that compared to publications in other journals, certain fields of study may have a relatively lower representation, suggesting a need for further research in the specialized areas covered by these journals.

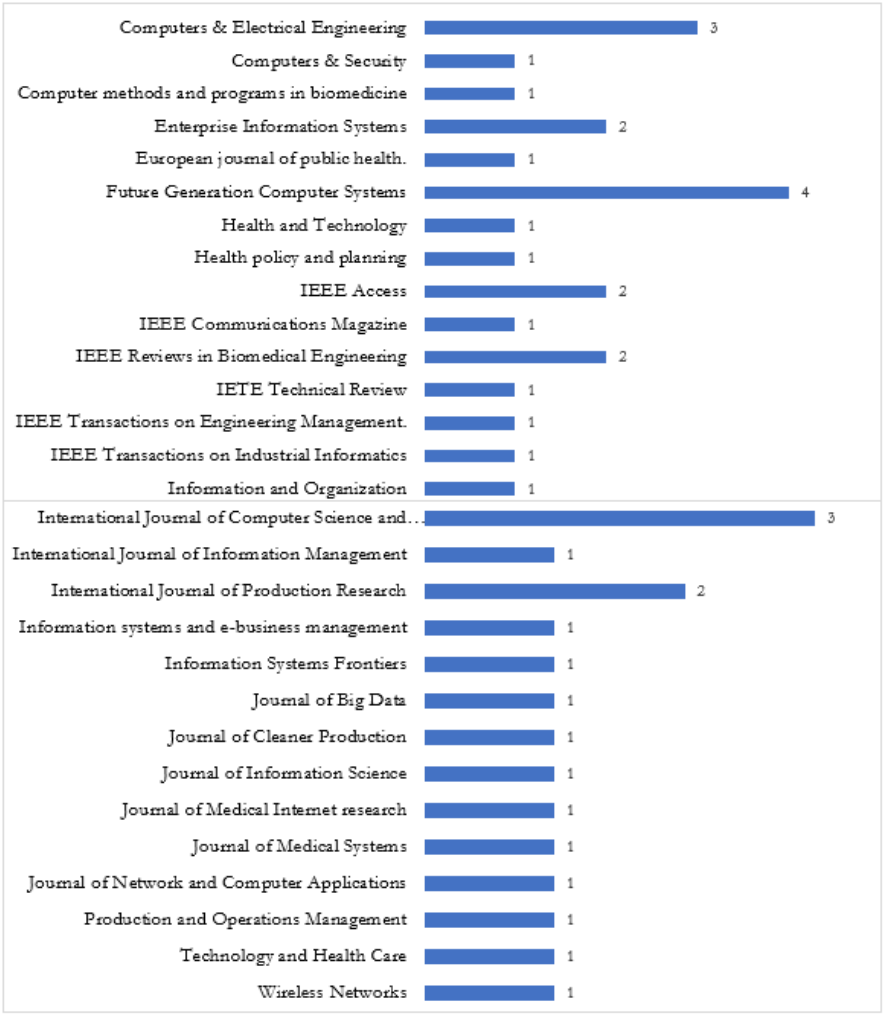

Figure 2. Journals with most publications selected from the literature review
Source: Author's Processed Data, 2023

The impact of digital technology advancements on the healthcare sector is significant. Therefore, the healthcare industry needs to be ready to embrace the era of healthcare disruption 4.0. However, there are several challenges and issues, such as big data, data security, regulations, and human resources, that need to be addressed to ensure a successful and high-quality digital transformation system. It is important to find effective solutions to overcome these challenges so that all hospitals can be well-prepared to deliver healthcare services. In Table 2, we have compiled a list of eleven challenges that must be tackled for the successful adoption of Digital Transformation 4.0.

Table 2. Challenges for Hospitals Realizing Digital Transformation 4.0

Country	Big Data	Scalability	Data management, Data quality	Security and Privacy	Standardization, Interoperability and Regulation	Human factors	Cost	Network	ICT Infrastructure	Lack of skills	Device/system heterogeneity
Italy	√√			√√	√√		√√	√	√√	√√	√
Australia					√	√	√		√	√	
Spain				√	√						
Egypt								√	√		
United States of America				√			√√		√√	√	√
India	√	√		√√√√	√	√	√√√		√√	√√√	
China	√	√	√√	√√√	√√		√√√		√√√	√√√	√
Saudi Arabia				√√√	√		√	√	√√	√	√
Sweden				√		√					
Norway	√										
Sydney					√						
Morocco	√				√	√	√	√	√	√	
Russia			√				√	√			√
Iran					√		√		√		
South Korea				√			√		√	√	√
Greece			√								
Nepal			√								
Malaysia				√			√		√		√
Canada				√							
Singapore				√			√		√	√	
Germany	√										
Portugal	√							√			
Russia	√										
Iran		√		√	√		√		√	√	
Brazil	√										
Total Frequency	10	3	5	20	12	4	18	6	19	15	7

Source: Author's Processed Data, 2023

3.2. Discussion

In addition to variations in frequency, the barriers identified in our study encompass a range of aspects, including technical difficulties, social challenges, and organizational hurdles. Social barriers encompass emotional or intangible factors that can impede the implementation of Digital Transformation 4.0, such as misalignment with hospital strategy and a lack of technological knowledge. On the other hand, technical barriers pertain to tangible or logical components that are deemed crucial in the successful implementation of Digital Transformation 4.0. These include big data management,

scalability, data security and privacy, standardization, interoperability and regulation, human factors, implementation costs, networking, integrated IT infrastructure, insufficient skills, and device/system heterogeneity.

3.2.1. Big Data

In today's digital age, patients are increasingly focused on preventive health and have a greater interest in accessing various medical information. As a result, numerous companies have invested in medical devices that allow patients to monitor their health status. However, significant investments in capacity building, training, digital literacy, workforce management, supervision, and logistics are required. The sustainability of community health worker programs is a critical issue to address. While the initial rollout and maintenance of digital devices involve significant costs, the availability of affordable digital devices and improved internet connectivity can expedite the digitization of community health worker programs and yield long-term benefits (Mishra et al., 2019).

Existing health devices include heart rate detectors, exercise trackers, sweat flow meters, devices for measuring blood sugar levels, and oxygen levels (Hathaliya et al., 2019). Patient records are stored in electronic medical record repositories that can be centralized or distributed, enabling doctors to easily access patient health data from anywhere and at any time. However, due to the open channel nature of accessing this data from the database repository via the internet, security and privacy are significant concerns (Hathaliya et al., 2019).

Leveraging the vast volume of patient data to improve healthcare and healthcare services is crucial for meaningful advancements in quality care. Big data combines extensive information from various sources and formats, including social media usage, e-commerce, online transactions, financial transactions, and identifying future business trends and patterns ((Klinker et al., 2020); (Marques & Ferreira, 2020); (Maiurova et al., 2022); (Pappas et al., 2018); (Ricciardi et al., 2019)). In the healthcare industry, big data offers several advantages, such as reducing medical error rates, facilitating preventive healthcare, and enabling more accurate predictions for human resource recruitment in hospitals and clinics (e.g., predicting patient influx over a period of time) (Tortorella et al., 2022). Each day, a wealth of patient information is collected, including details about diseases, their progression, and treatment outcomes. The integration and analysis of various structured and unstructured data from diverse sources play a critical role in diagnosing patients, matching treatments with desired outcomes, and predicting potential health complications. This has the potential to elevate evidence-based medicine to a global scale and provide decision support systems for doctors when making medical decisions (Pang et al., 2018).

3.2.2. Scalability

Achieving proper scalability is a crucial requirement in today's various sectors. The software is designed to be fully scalable, taking all factors into consideration. Data collection can be done using sensors or portable medical devices. The infrastructure should cover the entire hospital to enable every patient to access medical services and check health status updates through their smartphones. Additionally, Healthcare 4.0 can be scaled up to encompass entire communities or cities. It saves patients time by reducing waiting periods for appointments and results, while providing immediate access to

specific medical resources. The benefits of scalability for smart cities include increased efficiency, saving valuable time, and building trust between patients and medical staff (Kumari et al., 2018).

3.2.3. Data Management and Data Quality

Effective data management is a significant motivation for healthcare facilities to adopt IT-based systems. With an increasing burden of data generation day in and day out, managing data using conventional methods becomes increasingly challenging. Patient records, treatment records, laboratory reports, diagnosis reports, billing, stock management, and other aspects make the situation complex. A centralized system integrates and retrieves information with just a few clicks, eliminating ambiguity or duplication of data.

In the digital age, patients have become more focused on preventive health and show greater interest in accessing various medical information. The potential for digitization in community health worker programs is promising, but it also brings challenges. Benefits range from expanding the scope and quality of services to improving efficiency in record-keeping, reporting, personnel management, and catalyzing research and evaluation processes. Big data, gathered from various sources including social media, can assist companies in developing health recommendation services for patients ((Maiurova et al., 2022); (Pappas et al., 2018); (Ricciardi et al., 2019); (Tortorella et al., 2022)). The diversity of devices involved in the network poses another challenge to the success of IoT in healthcare. Ensuring effective communication and connectivity among multiple devices and users is complex. The challenge lies in the absence of agreed-upon communication protocols and standards among device manufacturers. Although various mobile devices can be connected to the network and collect data actively, different communication protocols complicate the aggregation process (Rghioui & Oumnad, 2018).

Healthcare 4.0 systems share characteristics with Industry 4.0 systems. These systems may operate in different contexts, encompassing diverse political authorities, cultures, managerial practices, legal systems, or governance policies. Achieving harmonized cooperation is essential, not only on a technical level but also regarding legal and political aspects. These systems involve critical and valuable assets and exchange data that is strategic and vital to multiple stakeholders. Therefore, data and facility security are of paramount importance. User privacy and compliance with privacy-related regulations and activities, which vary across countries, can determine the success or failure of the revolution in both industry and healthcare (Pang et al., 2018).

Medical devices generate a large volume of patient data, which faces the challenges of "5 Vs" of big data: value, volume, veracity, variety, and velocity. Handling this data is closely related to the capabilities of fog nodes to receive, store, process, and communicate information. Fluctuations may occur between fog computing and cloud computing, necessitating monitoring by system administrators. Standardized protocols and data formats are needed at the fog layer to handle diverse data types, such as text and image files, originating from different sources such as smartphones and smartwatches (Kumari et al., 2018). In the paper by Lin et al. (2018), an extensive review of recent advances in medical big data on chronic diseases and health monitoring is provided, covering the

complete cycle of medical big data processing, including data preprocessing, tools and algorithms, data visualization,

3.2.4. Security and Privacy

Twenty papers have identified security and privacy as the main barriers in healthcare, with three papers specifically highlighting them as critical challenges (Ayuni, 2019; Hathaliya et al., 2019; Kumari et al., 2018). Other contributing factors to this finding include associated costs (Aceto et al., 2018); (Ali et al., 2018); (Guha & Kumar, 2018); (Kumari et al., 2018); (Mahmoud et al., 2018); (Pace et al., 2018); (Pan et al., 2019); (Rghioui & Oumnad, 2018); (Singh et al., 2018); (Dautov et al., 2019); (Hamidi, 2019); (Mutlag et al., 2019); (Munzer et al., 2019); (Pan et al., 2019); (G. Wang et al., 2019); (Soltanisehat et al., 2020). Additionally, the collaboration required between various stakeholders in healthcare systems necessitates stringent security and privacy measures (Pang et al., 2018). Notably, several studies propose solutions to address these issues, which will be discussed later in this section.

Security challenges involve managing credentials and controlling access to patient requests and confidential information (Aceto et al., 2018). For instance, a healthcare provider may be granted access to a device in response to a patient's request, but the utilized internet connection could be a public or unstable Wi-Fi network vulnerable to man-in-the-middle attacks. Various authentication techniques can be implemented to enable patients to verify and authorize access to their internal devices by healthcare professionals (Rghioui & Oumnad, 2018). Security and privacy are significant concerns in the implementation and deployment of Healthcare 4.0, necessitating protection at each layer (Puthal et al., 2018) and integration of these layers. Currently, there are no standardized rules and regulations for protocols and interfaces across the wide range of products and devices in Healthcare 4.0. Standardization efforts should address topics such as device interfaces, data aggregation interfaces, communication protocols, and gateway interfaces. Similarly, the diverse range of communication protocols, such as WiFi, adds to the complexity (Kumari et al., 2018).

Moreover, according to Burton-Jones et al. (2020), the negative impact of digital culture on the health sector is evident in terms of digital security, particularly regarding personal data and privacy. The digital culture has created opportunities for criminal activities by exploiting other people's personal data for profit. The COVID-19 pandemic has accelerated digital transformation in the health sector, emphasizing the importance of information technology in daily activities. Digital transformation involves the application of digital technology across all aspects of people's lives. In healthcare, it includes raising digital awareness among the public and utilizing digital processes that enable innovation and creativity in specific digital products (Burton-Jones et al., 2020).

3.2.5. Standardization, Interoperability, and Regulation

There is currently a lack of standardized rules and regulations for protocols and interfaces of the diverse products and devices in Healthcare 4.0. To address this issue, efforts should be made towards standardization, including the establishment of organizations dedicated to standardizing health technologies. This would facilitate real-time response and resolve data discrepancies. Standardization should cover various areas such as device interfaces, data aggregation interfaces, communication protocols, and

gateway interfaces. Similar to the challenge of device diversity, there is a wide range of communication protocols, including WiFi. Therefore, for interoperability, the fog node (FN) must perform the necessary protocol translation at different internal layers, such as the network layer, message layer, and data annotation layer of the fog layer (FL). Additionally, a comprehensive regulatory framework must be in place before health products are made available in the market for patients (Kumari et al., 2018).

However, issues related to the security and privacy of patient data, as well as the potential loss of data management control to cloud service providers (CSPs), must be carefully evaluated, especially considering the stringent regulations governing the healthcare sector. Consequently, many companies are working on improving and adapting policies to secure patient data and enhance confidentiality. Cloud applications offer the potential for accessing multifaceted data for decision-making, making them a significant opportunity for researchers and practitioners in the healthcare sector (Ali et al., 2018).

SIMRS (*Sistem Informasi Manajemen Rumah Sakit*) is a communication information technology system in Indonesia designed to integrate and process all hospital service process flows, including coordination networks, administrative procedures, and reporting, to obtain accurate and precise information. SIMRS serves as the central system for smooth service delivery in hospitals. It is encouraged for every hospital to implement this system to enhance their services. SIMRS implementation can expedite access to patient data, facilitate integration with other departments such as insurance, and even reduce waiting times. The legal basis for SIMRS is outlined in the Minister of Health Regulation Number 82 Year 2013, Article 3, which mandates all hospitals in Indonesia to implement SIMRS. Hospitals can utilize either the provided open-source application or develop their own application, as long as it meets the minimum requirements set by the minister.

3.2.6. Human Factors

To create user-friendly interfaces and patient-focused medical devices for Healthcare 4.0, it is important to involve end users or stakeholders in the design process, gathering feedback on their comfort, likes, and dislikes (Kumari et al., 2018). The widespread adoption of modern information and communication technologies presents new opportunities and applications that can help overcome traditional challenges in healthcare organizations (Aceto et al., 2018). Additionally, ICT has had a positive impact on the way hospitals interact with patients and stakeholders, as mentioned by Y. Wang et al. (2018). The adoption of digital transformation technology implies the development of a set of routines within an organization, which can be challenging due to technological changes. Conducting a scoping review to identify trends, challenges, and theoretical gaps is a crucial step towards proposing a roadmap for digital transformation 4.0, allowing for the mapping and initial consolidation of knowledge in this area (Tortorella et al., 2022). Therefore, future studies can use the theoretical consolidation from this review as a conceptual foundation for developing an implementation roadmap for digital transformation 4.0.

3.2.7. Implementation Costs

Healthcare organizations consist of various departments that require resources, including infrastructure and information. When considering the adoption of ICT in a specific department, it is important to analyze the benefits both locally and systemically. For example, ICTs that enable online monitoring of patients' vital signals are relevant not only for care providers but also for operating room managers who schedule procedures and identify suitable candidates for specific procedures (Dautov et al., 2019). Healthcare 4.0 is a technology-driven movement that involves high levels of capital expenditure and requires a skilled workforce, which can significantly impact the success of its implementation. Contextual factors, such as the socioeconomic development of the region or country and the type of hospital (public or private), can directly influence a hospital's ability to extensively implement Healthcare 4.0 (Tortorella et al., 2022). Studies investigating the influence of contingencies on Healthcare 4.0 implementation have focused on various variables. Albesher (2019) highlights the range of ICT use in healthcare systems, varying from pilot projects to full-scale implementation in countries like Japan, France, and Sweden. These different contexts contribute to the high variation in approaches used and outcomes achieved, emphasizing the importance of better understanding the influence of contingencies on Healthcare 4.0 implementation.

3.2.8. Network

From an infrastructure perspective, a Smart Healthcare ecosystem comprises multiple interconnected edge devices, network nodes, and servers (virtual/physical). These elements are connected in an IoT network and can be classified into four categories, as described in Table 1. The taxonomy identifies six features based on the resources provided by each node. The Sensing/Actuation parameter refers to the presence of sensors and actuators that enable corresponding capabilities. The basic network connectivity feature is referred to as Internet Facility. Other features include Processing and Memory/Storage capabilities. Advanced Connectivity features involve dispatching and/or routing functions, as well as support for software-defined networking and virtualization. Lastly, Service/Resource Delivery capabilities allow the provision of resources and services to third parties on-demand in a service-oriented manner.

Marques & Ferreira (2020) developed a system for recording patients connected via a local wireless network to the hospital intranet system. They concluded that improving the frequency, inclusiveness, and accuracy of vital signs data collection is a crucial step in early problem identification among patients.

3.2.9. Integrated IT Infrastructure

Another significant barrier/challenge identified in twenty papers was the ICT infrastructure, which was frequently mentioned in the literature due to poor infrastructure and information security risks. Pan et al. (2019) highlighted that the adoption of new ICT may face resistance from physicians who perceive automated medical decision systems as a substitute for their expertise. Device integration and interoperability pose challenges as new smart wearables continue to enter the market and need to be seamlessly integrated into existing edge infrastructure, serving as a layer of abstraction and compatibility. An effective edge platform should support priority-based service administration to define and prioritize critical services such as fall detection or cardiac failure (Pace et al., 2018).

The basic infrastructure for a digital hospital is the integrated IT infrastructure, as it encompasses four main systems: Supply Chain Management Systems, Customer Relationship Management Systems, Enterprise Systems, and Knowledge Management Systems. By managing these systems digitally, a hospital can be categorized as a digital hospital (administratively managerial). Such an infrastructure enables the hospital to manage data related to all involved parties, allowing for improved attention to these parties. For example, the hospital can offer congratulations to patients who have given birth or provide the first offer to infrastructure provider partners when planning construction projects, among other benefits.

3.2.10. Skills

Skills are crucial for achieving digital transformation 4.0 in hospitals. With the continuous evolution of technology, hospitals need to ensure that their staff possess the necessary skills and knowledge to adopt and utilize new technologies effectively. One of the key challenges faced by hospitals is providing adequate training to ensure that their staff are well-prepared for the rapid and dynamic changes in medical technology and hospital management. The required skills include understanding hospital information systems, data management and analytics, cybersecurity, healthcare software usage, and healthcare application development. If hospitals fail to address these challenges, they may struggle to embrace new technologies and enhance the efficiency, quality, and safety of patient care. Therefore, having the right skills is essential for realizing digital transformation 4.0 in hospitals. Some of the skills needed encompass information technology proficiency, data processing, data analysis, cybersecurity, project management, and the ability to adapt quickly to technological advancements. Hospitals face the challenge of enhancing the skills and capabilities of their workforce, both through internal training programs and collaboration with relevant educational or training institutions. By possessing adequate skills, hospitals can optimize the utilization of technology in achieving digital transformation 4.0, thereby providing more effective and efficient healthcare services for patients.

3.2.11. Device/System Heterogeneity

Wireless technology has been a remarkable achievement in the realm of technology and continues to evolve rapidly. This evolution has significantly transformed people's lifestyles compared to the past, making transportation, communication, and education much more convenient. Beyond everyday life, the impact of wireless technology is also felt in industries, healthcare, and other sectors. In the healthcare domain, the advancements in wireless systems have been extensively utilized in telemedicine and pervasive computing (Kharel et al., 2019).

In addition to software-related challenges, there are several other challenges concerning information confidentiality, integrity of sensitive medical data, service availability, fault tolerance, authentication, and authorization. Information confidentiality ensures that only authorized users have access to medical information, and various techniques have been implemented and are expected to be further developed as technology improves. Data integrity prevents unauthorized alteration of data during transmission in the Internet of Healthcare Things (IoHT) network. Service availability is crucial to ensure that healthcare services are accessible to end users whenever and

wherever needed. Any downtime or denial of service would reduce the utilization of IoHT services and applications. Moreover, the service must be fault-tolerant, enabling it to remain available even during errors and attacks. Finally, authentication and authorization mechanisms play a vital role in ensuring that the IoHT device communicates with the intended peer without false presence, and only authorized nodes can utilize and access IoHT peers and network resources (Albesher, 2019).

Healthcare is one of the domains greatly influenced by the pervasive adoption of IoT technologies, which support the core functions of healthcare institutions. In this context, traditional hospitals are being transformed into intelligent digital environments of the next generation. These environments extensively employ interconnected sensor systems and utilize (big) data collection and processing techniques. From this perspective, Smart Healthcare can be viewed as a complex ecosystem of intelligent spaces (such as hospital rooms, ambulances, pharmacies) supported by a robust infrastructure stack consisting of edge devices, sensors, wired and wireless networks, Cloud platforms, and driven by innovative business and legislative models that enable Healthcare Industry 4.0 (Dautov et al., 2019).

As healthcare systems shift rapidly from traditional paper-based practices to computer-supported processes, organizations face significant challenges related to interoperability between systems. These challenges arise due to limited ICT skills and the complexity of the overall healthcare framework (Aceto et al., 2018). The combination of IoT applications and big data analytics has the potential to bring revolutionary changes to various industries and academic research. In addition to the data generated, smart devices with sensors collect data from the real-world environment, opening up new possibilities for analysis and insights (Guha & Kumar, 2018).

4. CONCLUSION

Implementing Industry 4.0 and Healthcare 4.0 technologies in hospitals presents several challenges. One key obstacle is the shortage of skilled human resources proficient in information and communication technology (ICT), hindering the effective utilization of digital tools. Additionally, the significant investment required for infrastructure, software, and trained personnel poses financial challenges, especially for hospitals with limited budgets. The use of digital technology also introduces concerns about data security, as it may elevate the risk of breaches and compromise patient privacy, necessitating proactive measures for protection. The presence of separate information systems in different hospital departments creates difficulties in system integration, impeding the overall digital transformation process. Choosing appropriate technology aligned with the hospital's needs is critical for success, ensuring enhanced efficiency and quality of healthcare services. Moreover, training medical staff and end-users is vital to ensure effective technology utilization, requiring hospitals to invest in developing the necessary skills and knowledge among their employees.

To address these challenges, hospitals should allocate budgetary resources to update their technology infrastructure, including robust and high-speed Wi-Fi networks, the latest medical hardware and software, and servers capable of handling large volumes of data. Moreover, hospitals need to adopt stringent cybersecurity practices, such as continuous network monitoring, data encryption, and regular system security testing, to

mitigate the increased cybersecurity risks associated with digital transformation 4.0. Implementing clear policies and procedures for managing patient data, utilizing digital technology, and conducting employee training is crucial for improving efficiency, service quality, and cybersecurity within hospitals.

Furthermore, hospitals can foster partnerships with digital technology service providers, universities, and research institutions to access the latest technological advancements and strengthen their innovation capacity. Embracing emerging technologies like artificial intelligence (AI), the Internet of Things (IoT), and big data analytics can significantly enhance efficiency, quality of care, and the understanding of patient health. Overall, addressing the aforementioned challenges and embracing digital transformation can lead to improved healthcare outcomes and better patient experiences within hospitals.

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