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Investigating Healthcare 4.0 Transition Through a Knowledge Management Perspective

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***Abstract*—The impact of technological innovation on the healthcare sector is becoming increasingly significant, and the number of studies exploring this topic is rising rapidly. However, studies on the digital transition of healthcare services are still a challenge, both from a theoretical and managerial perspective. In this context, knowledge management discipline can guide the evolving environment to cover this research gap. Indeed, the digital transition is transforming how healthcare professionals access data, handle information, and manage knowledge by adopting 4.0 enabling technologies. Thus, drawing on the SECI model, this study aims to investigate the healthcare sector's technological innovation through a knowledge management perspective, and evaluate the impact of 4.0 technologies on knowledge creation processes (i.e., socialization, externalization, combination, internalization) in the healthcare domain. Finally, the article investigates the critical areas of the digital transition, and the future research directions that remain to be addressed.**

***Index Terms*—Digital transformation, digitalization, enabling technologies, healthcare 4.0, knowledge creation, knowledge management, SECI model, technological innovation.**

I. Introduction

SINCE the digital transition era carried out with the fourth industrial revolution, knowledge management (KM) is providing a broader and more important collection of techniques, and methods for finding, gathering, creating, storing, sharing, and applying knowledge [1] through the use of innovative technological resources available to organizational members [2]. KM is applied to support people to capture, communicate, and employ knowledge to increase their performance [3]. Besides, KM helps organizations increase competitiveness [4], [5] and manage intellectual assets, including expertise and creativity [6].

One of the sectors that appears to be most influenced by KM practices and reacting to their change due to the digital revolution carried out by the last industrial paradigm of Industry 4.0 (I4.0) is the healthcare sector, especially after the COVID-19 period [7], [8]. In the healthcare domain, KM is considered an effective vehicle for leading medical computing into the new millennium's healthcare environment both from practitioners and scholars [9].

The I4.0 paradigm was initially proposed in 2011 to integrate a set of different technologies and correlated concepts [10], [11], [12], such as advanced and additive manufacturing [13], virtual reality [14], horizontal and vertical integration [15], industrial internet, cloud computing [16], big data [17], and cybersecurity and blockchain [18]. Similarly, big data analytics allows grasping large quantities of data and extracting useful information; big data, opposed to traditional data, can be characterized by the 5 V model: huge volume, high velocity, high variety, low veracity, and high value [19], [20], [21]. This expertise can then be used in an organization to enhance the efficiency of several different processes and improve organizational processes with the adoption of new decision-making tools [22], [23], [24]. Artificial intelligence algorithms can capture tacit knowledge through repeated interactions, especially the underlying motives and objectives that drive people's behavior [25], [26]. Although some previous literature reviews have attempted to provide a systematization of existing findings on an organization's digital transformation, nevertheless in the healthcare domain, the focus has mainly been placed on the characteristics, state-of-the-art opportunities, and questions underlying certain technologies like big data, IoT, and machine learning [27], [28], [29]. On the contrary, the literature lacks a structured and global study that analyzes the impacts and support of 4.0 technologies on knowledge management processes in the healthcare domain (RQ), and our study focuses on covering this gap. Standing our research question, to design our study, we rely on the SECI model to systematically review the topic under investigation and categorize existing 4.0 enabling technologies according to the classic phases of knowledge management. The SECI model includes four types of knowledge conversion: tacit to tacit (socialization), tacit to explicit (externalization), explicit to explicit (combination), and explicit to tacit (internalization) [30]. On the other side, we approach these central processes of the SECI model by digging into which type of knowledge enabling technologies can manage. In this regard, the article aims to provide a systematic analysis for researching how the digital transition affects the healthcare sector with a knowledge creation model perspective. Since its reproducible and consistent process minimizes the findings' bias, we chose a systematic analysis approach over other review approaches. As a result, our conceptual effort helps to identify central topics that have

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received much attention and provides avenues for future research in critical areas underdeveloped to date. This study provides practical contributions for scholars and practitioners since this study can help in identifying how to manage knowledge using different 4.0 technologies that could support daily operations and decision-making processes. This study can also support decisions of healthcare organizations on how to invest in digital learning tools to improve employee learning and satisfaction, patient quality of care, and overall organization performance.

II. SECI Model in Healthcare

The SECI model provides a mechanism for converting explicit and tacit knowledge [31], [32], [33], [34], [35]. This model identifies four approaches to creating knowledge in organizations: socialization, externalization, combination, and internalization. The four modes are based on a dynamic interaction, creating a spiral, theoretically without end, of continuous organizational knowledge creation. These mechanisms can occur between individuals and groups, through groups of the organization, and even between organizations' networks. In the SECI model, socialization allows converting tacit knowledge into new tacit knowledge through social interactions and shared experience. The combination develops new explicit knowledge by categorization, fusion, reclassification, and synthesis. Externalization means turning implicit knowledge into new explicit knowledge. Internalization requires new implicit knowledge generated from explicit knowledge. The "spiral" process has two dimensions: the epistemological dimension includes the relations between implicit and explicit knowledge. The ontological dimension concerns the degree of sharing of knowledge between individuals and the organization. According to this model, an organization can only produce awareness through the people who work in it [34].

III. Methods

To realize an integrative view of the existent literature in the healthcare fields of research, we conduct a systematic literature review (SLR) to investigate the impact of 4.0 technologies on knowledge management processes in the healthcare domain. In contrast to a traditional literature review, SLR is a systematic method of analyzing and summarizing the material using predetermined eligibility criteria and little bias [36], [37], [38]. As a result, a systematic review is defined as a review that aims to identify, evaluate, and summarize all related studies on one subject using basic and reproductive methods [39], [40]. Since the aim of this research is to bridge the scarcity of systematic contributions on the topic and provide insights analyzing the papers published in leading academic journals, the systematic methodology looks to be the best one compared to the other literature review methodologies.

After an in-depth analysis of critical documents defining the 4.0 transition [41], [42], [43] and a brainstorming process among five researchers, a detailed list of keywords was identified. We used three distinct queries to collect pertinent items. The first relates to the 4.0 transition paradigm, the second relates to the enabling technologies, and the third relates to the healthcare domain. The data search was conducted in October 2020 through the Scopus database. Scopus has more than 4000 publishers, 500 conference proceedings, 600 trade papers, and 200 books from all knowledge fields, obtained over 33 million documents from over 15 000 peer-reviewed journals [44]. We conducted our search, including articles published between the period 1971–2020. The review was limited to empirical peer-reviewed journal articles, leaving out books, book chapters, and conference proceedings. In more detail, the search string is ("Industry 4.0" OR "industrie 4.0" OR "fourth industrial revolution" OR "4th industrial revolution" OR "industrial internet" OR "artificial intelligence" OR "cybersecurity" OR "cyber-security" OR "cybersecurity" OR "autonomous robot∗" OR "industrial robot∗" OR "cloud computing" OR "augmented reality" OR "simulation" OR "virtual reality" OR "internet of things" OR "iot∗" OR "big data" OR "horizontal integration" OR "vertical integration" OR "additive manufacturing" OR "3d printing" OR "rapid manufacturing" OR "advanced manufacturing" OR "intelligent system∗" OR "digital platform∗" OR "machine learning" OR "simulation" OR "blockchain" OR "block-chain") AND ("healthcare" OR "health-care" OR "health care").

This search strategy came back to 3622 objects. Given the general existence of certain search words, this large number is not entirely unexpected. It is not uncommon for literature reviews to have many hits in the first round of research [45], [46]. The number was systematically reduced in increasingly more finely tuned analysis steps. We used several selection criteria. The first criterion allowed us to select only articles focused on specific subject areas, namely computer science, engineering, social sciences, business, management, and accounting. According to this selection criterion, we excluded 2520 articles. The second follows the method recommended by Pittaway et al. [45]. We have carefully reviewed the abstracts of all the results so that only those articles whose abstracts focus on 4.0 technologies in the healthcare context can be chosen. To prevent making subjective judgements, two researchers reviewed the abstracts of the publications simultaneously, with a third researcher intervening if there was any doubt [47]. According to this criterion, we decided not to include 984 documents that did not help our systematic analysis cause generalizable data about the role of 4.0 enabling technologies on knowledge management processes in the healthcare domain. The third criterion is related to the article's full content. Thus, articles were read in full by two researchers simultaneously, adding a third one in case of uncertainty [47]. The in-depth study process helped us to remove 36 documents that were not based on the research subject. We used a "snowball" strategy for the fourth criterion [48] to classify our set's remaining potentially essential studies. This inclusion criterion allowed us to include 53 additional publications on the topic investigated. Ultimately, the final number of articles included in this review is 135 publications.

IV. Application of the SECI Model in Healthcare

According to the theoretical model adopted, Fig. 1 maps the distribution of 4.0 enabling technologies across the four SECI processes.

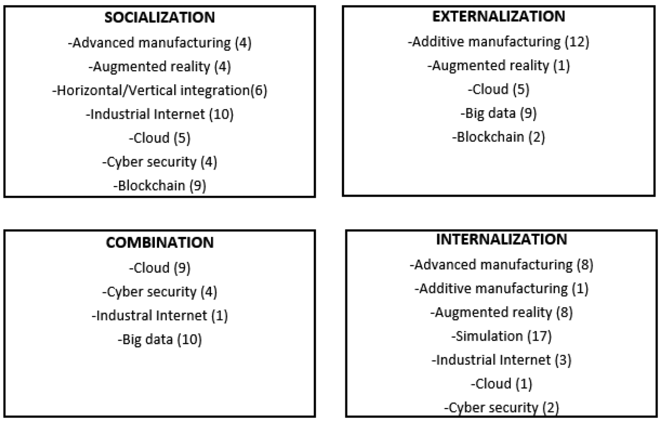

Fig. 1. Classification of papers according to the SECI model.

A. *Knowledge Socialization*

The socialization process converts tacit knowledge into tacit knowledge. Tacit knowledge such as world views, mind models, and confidence can be generated and exchanged beyond the organizational boundaries [34]. It is crucial to highlight that 4.0 enabling technologies can benefit both healthcare professionals and patients: the future of healthcare will drastically change as technological companies provide solutions to improve, for example, how artificial intelligence prevents, diagnoses, and cures patients [49]. Therefore, there is a very close link between healthcare 4.0 and corporate social responsibility (CSR). Notably, the term CSR refers to the activities and policies that organizations voluntarily adopt in order to bring about positive social and environmental improvements that benefit a range of stakeholders [50]. Healthcare 4.0 provides a solid foundation for society's well-being and the achievement of better CSR performance. Collaborative robots can help healthcare professionals in day-to-day operations, reducing the risk of accidents and improving the quality of care. According to Ettelt et al. [51], the robot's healthcare aim is to assist nurses and other users in basic, repetitive tasks, including fetching and transporting laboratory specimens, food, medication, or documentation. Research can determine the robot's social function, improve all types of knowledge, and fix the intended effects on work [52]. Tacit knowledge in healthcare can be expanded with digital channels. Besides, this technology will promote control functions for providers, developers, and health professionals [53]. With augmented reality, it is also possible to carry out self-diagnosis and subsequently transmit the data to physicians, encouraging the transmission of tacit knowledge between physician and patients and speeding up diagnosis. For instance, Zhao et al. [54] describe low-cost and multimodal augmented therapeutic wellness exercise programs based on realities. Lush et al. [55] define a medical health tool made available to users for self-assessment and self-management. In some research, this technology is stimulated by wireless sensors, for example, by providing a new self-measurement device that tests the shoulder joint's mobility autonomously, even without a physician [56]. These sensors to collect health data is for both children and grown-ups [57]. With horizontal and vertical integration in healthcare companies, there is a more significant growth of the communication network and information sharing, thus increasing socialization. Integrated horizontally and vertically healthcare organizational systems may differ in origin, including providers and facilities, care management, and governance [58]. Notably, horizontal integration allows machines, IoT devices, and programming processes to work seamlessly together, while vertical integration ensures that operational data is used at the highest organizational levels in choices and decisions, optimizing processes, and reducing costs [59]. Size savings, risk-bearing capacity, transaction costs, and creative ability for management strategies are the main determinants for horizontal and vertical integration [60]. Vertical integration can support healthcare organizations, for example, by creating a local service relationship [61]. On the contrary, Walston et al. [62] argue that several organizational vertical integration models may be poorly adapted to healthcare's current environment. Moreover, Carlin et al. [63] highlighted that there could be minimal improvements in quality-of-care metrics as a clinical system transition into a vertically integrated delivery system. Bainbridge et al. [64] found that staff members function collaboratively at a high level and form part of an interprofessional community with horizontal integration. In recent years, research in the healthcare sector on the IoT has increased. It is a massive worldwide information system that enables sensors, actuators, and other devices to interact with one another in a smart environment [65]. In this way, the real world can interact correctly with the virtual, with physical devices, wearable devices, and smart "things" fitted with software and sensors [66]. Complex and intelligent systems can evaluate, identify behaviors, and make decisions. The propagation and adoption of technology in healthcare affect IoT product choices [67]. Furthermore, IoT technologies can expand medical resources [68]. The primary anxiety of workers for adopting IoT technology in healthcare facilities is about using medical knowledge [69]. In developing IoT healthcare applications, there is a need to combine skills and a high collaboration between nurses and engineers. Nurses need engineers to fully understand the use of technologies, their feasibility, and the benefit of IoT technologies. Engineers need nurses to understand patient needs and medical language. There are benefits for improving patients' health, managing the health system, and the suppliers of technologies [70]. The problem with health information systems is that to succeed a large audience of patients, they must achieve patients and their families [71]. IoT technology offers opportunities to monitor the patient continually and subsequently transmit the data to physicians, obtaining increasingly precise results. A smart home healthcare device can effectively integrate healthcare products and services to improve life quality [72]. The expectation that people of all ages receive adequate medical treatment increases every day. The resolution of several health-related issues of a child or adult [73] or older adults with reduced mobility living alone [74] are considered possible via the IoT or the monitoring of the lifelogging data through various assets such as wearable sensors and mobile applications [75]. IoT health solutions are developed from simple architectures in which the catalogued data are collected, transmitted, and visualized via field and wearable sensor networks. The other way to track the vital signs and detect biological and comportment change for people is through smart care technologies IoT based on health monitoring systems [76]. For instance, a new cloud computing platform was created to present national healthcare data [77]. This structure can help share medical expertise and information [78]. Physicians and nurses, who share knowledge on their everyday jobs, are more conscious of how various elements collaborate to enhance efficiency and how their actions can lead to mutual changes [79]. Furthermore, a key 4.0 technology used in the healthcare field is blockchain, namely a decentralized system that enables information integrity and ownership to be confirmed without a central authority [80]. Several systems were created based on the blockchain approach to offer patients better control, a data-sharing framework, and lower information fragmentation, with significant results [81]. The blockchain application includes intelligent contracts, fraud detection, and identity verification. However, there are fears about blockchain technology, and specific weaknesses and problems require addressing [82]. Possible use of the blockchain is regarding the smart contract system. It is possible to monitor patients' health status and schedule medical interventions through notifications, when necessary, and in real-time. Furthermore, this ensures a secure connection between patients and medical professionals [83]. Blockchain technology can be used for emergency management. For example, other hospitals can be notified only in real-time about hospitalization capacity and possible patient transfers from one hospital to another [84]. In fact, blockchain technology was essential during the pandemic due to COVID-19. The data of infected people, the number of hospitalizations, and the various structures' deaths are collected and used to monitor and develop regional models [85]. The blockchain is used to share health information between patients, hospitals, health offices, and health communities [86]. Despite the benefit of the sharing, processing, and storing health data between multiple systems, on-demand anytime and anywhere, these functionalities are not widely used in current healthcare facilities [87]. Regarding risk-based organizational priorities, external and internal context, and stakeholders' opinions, the cloud penetration of the health care sector remains poor [88]. As smart medical devices and mobile devices continue to be used, health organizations' weaknesses are increased. It makes it challenging to enforce effective cybersecurity measures in other malware and organizational complexity [89]. With big data and cloud storage, blockchain can be used as an extensive alternative to patients' fragmented, poorly managed, unorganized medical history to increase medical records' interoperability and availability [90]. Blockchain is also seen to enhance current organizational processes through healthcare providers' capacity to control all pharmaceutical supply chain steps and improve transparency in the provision of services [91]. According to Khezr et al. [92], blockchain technology is essential for pharmacists and healthcare suppliers to timely and adequately validate the flow of valid drugs and their distribution to the patients. Blockchain could facilitate interoperability, such as managing digital access rules, aggregation and accessibility of data, patient identity, and immutability [93]. Blockchain has high protection of personal data. In this way, patients can control and share their health data, which creates a new potential way to improve health systems' intelligence [94]. There are specifically approved physicians, indirectly authorized physicians, and unauthorized individuals who have access to personal health details and identity verification [95]. Various security protocols are created to improve patients' privacy, for instance, using identity-based encryption [96] or a small-weight authentication protocol for data sharing with a group of physicians securely and efficiently. There is also the possibility to externalize encrypted health records to cloud storage [97].

B. *Knowledge Externalization*

The externalization process converts tacit knowledge into explicit knowledge. This process occurs when the company exposes its rules of operation or explicitly establishes organizational objectives. When the passage from tacit to explicit knowledge occurs, the knowledge is said to be "crystallized" and its sharing can create further knowledge [34]. Physicians can customize the drug and the doses based on their knowledge of individual patient care, thus reducing costs and time. Three-dimensional (3-D) printing is a manufacturing process to create a 3-D object in almost any shape by fusing or accumulating materials in the sheet. With the birth of 3-D printers, the entire prototype creation and design process are more expensive, simple to make, and more user-friendly. 3-D printing technology can positively impact the medical field, printing customized medical devices and products. It is possible to find solutions to everyday problems in medicine, as demonstrated by Rothenberg et al. [98], by creating a customized and alternative multilumen syringe with 3-D printing. The need to store vast amounts of generic medications by the hospital pharmacy and local pharmacies could be reduced with 3-D technology. There is also the possibility of quickly creating personalized medicines for the patient according to his health, metabolic, and clinical characteristics [99]. In the future, 3-D printing will change the delivery of drugs and move from current mass production to customized production in small batches. Besides, pharmaceuticals and medical devices can be tailored to the patient's clinical needs and requirements [100]. Furthermore, with 3-D printing, it is possible to create innovative and customized solutions for patients who need prostheses, organs, or tissues. Access to 3-D modeling is continuously growing, and its applications in healthcare settings are always growing [101]. 3-D printing will solve the problem of refusing conventional prosthetics by children. Online libraries provide a wide variety of designs that can be later tailored to children's needs and comforts [13]. This new technology has revolutionized the healthcare sector bringing apparent benefits for the patient. The method of 3-D bioprinting, according to Morris [102], can produce a wealth of organs besides the heart and save many more lives. As 3-D technology evolved, medicine has made considerable strides, such as printing a hand with a thermoset print that includes stress and pressure sensors [103]. Scaffolds with completely interconnected 3-D pores and various pores can be produced and sintered easily using alkaline-free bioactive glass for bone and tissue regeneration [104]. Overall, with 3-D printing, there is the possibility to create new materials to print wound dressings for patients on demand at a low price [105]. Even if additive manufacturing in medical applications is used, i.e., more plastics over metals [106], 3-D printing will enhance the efficiency of deliverables as it can manufacture personally tailored items that improve life quality [107]. During the Coronavirus disease-19 pandemic, the market for such healthcare products, like personal protective equipment, has quickly exceeded the world's available supply. Education and government agencies, commercial and noncommercial companies developed special medical devices using additive manufacturing [108]. Today in healthcare, there is an increasing need to have health information available at any time, free access to data from any enabled device, standardization of clinical practices, and the reduction of storing costs. In this context, cloud storage technology allows storing data on multiple virtual servers at third-party or dedicated servers. Notably, cloud computing is a paradigm that allows for the real-time leasing of computer resources such as processing power, storage, and associated networking resources with little contact with the provider [16]. This technology involves the transition from tacit to explicit knowledge. First, the data is collected and archived, and then it is made available to the health personnel to carry out analyses and predictions. Current healthcare cloud research focuses on data storage and related resources to make relevant information available in less time [109]. For instance, advanced corporeal sensors collect and store user-specific health information in the cloud-based repository [110]. Bio signals data can simultaneously eliminate and analyze a specific system with virtual reality [111]. Such outputs are generally produced from various sources, including clinical health systems, smartphones, and medical equipment. Then, they are distributed to team experts or in real-time dashboards to monitor patient health and prevent medical incidents [112]. Besides, health data are always synchronized to maintain a health surveillance system anywhere [113]. Many technology companies take advantage of the new medical needs to incorporate medical functions in wearable devices. Multiple software providers for data analysis develop tools linked to those sources tailored for health care specifically [114]. For example, Google aims to detect diseases at a much earlier stage; Samsung aims to build new sensors and algorithms for preventive health solutions; Intel seeks to improve blood monitoring and blood glucose measurement devices [115]. The new conceptual cloud-based modeling for healthcare management encompasses cloud computing systems as services, cloud communications, software as an application, and service networks [116]. Moreover, using cloud computing, a cloud infrastructure can be developed to implement a fully integrated health system that achieves high efficiency at an affordable cost [117]. Many people, devices, and sensors are connected via digital networks, and these entities generate enormous data [118]. With big data and analytics, physicians can archive an enormous amount of data every day. Through their automatic processing, they can acquire and improve their knowledge. Health organizations collect large quantities of knowledge from various organizations and healthcare administrators [119]. Blockchain technology allows patients to continuously share and control their medical data transmitted to those who have the permissions securely and without privacy violations. Thanks to this technology, the continuous safe cycle allows improvements to the entire health system [94]. Blockchain can further promote interoperability by patients, such as managing digital access rules, data aggregation and availability, patient identification, and immutability [93]. The advantage of big data is that they are always available in real-time from different sources. It can significantly impact traditional healthcare contracts' planning and management [120]. Furthermore, big data allows the disclosure of critical statistics and understanding in which action is needed more [121]. Furthermore, with the birth of these new digital technologies, healthcare organizations should take steps to create training courses or workshops for their employees to improve their work skills [122]. Patient health data is collected through continuous sensor monitoring with cloud technology. Health data can then be sent to the big data analytics system to personalize healthcare, forecasts of care, and statistical evidence for strategic planning [123]. Healthcare organizations can examine treatment patterns and uncover correlations from vast medical records, thereby offering clinical practice analysis based on evidence [124].

C. *Knowledge Combination*

The process of combination represents the passage of knowledge from explicit to explicit. Following the collection of explicit knowledge, which can be from inside or outside the organization, the new explicit knowledge can be disseminated, modified, or combined among the organization's members. Communication networks can simplify this mode of knowledge conversion. An example is when an organization's auditor uses the information available, and it is used to create a report. The report represents a combination of the auditor's explicit knowledge [34]. In healthcare, the combination process takes place with some cloud application uses. Moreover, data can be retrieved directly to ensure that patient priority is given according to the disease's prevalence and reduces response time [125]. Healthcare cloud computing can be divided into the main groups: treatment tracking, receipt, sharing, patient information storage, and remote therapy [126]. Medical diagnosis is moving to prevention, prediction, and care focused on a patient. For example, applying a mobile cloud healthcare system and big data analysis can identify and prevent all care types [127]. Big data is essential for quality healthcare access [128]. The highest benefit of big data is that analytics provide new ways to diagnose, forecast, and automatic algorithms to help people make decisions [129]. Through explicit knowledge processing, patients can also study big data in the cloud independently. Overall, big data analytics play a significant role in searching for more severe diseases occurring today. Furthermore, with this technology, it is possible to find new technological solutions to medical questions that are still awaiting an answer [130]. Big data analytics is increasingly being endorsed for its potentially crucial role in addressing healthcare sectors' challenges [131]. This technology has two potentials in an organization: it increases IT quality and efficiency and promotes clinical operations optimization [132]. On the contrary, big data analytics are still little used as medical technology, which restricts this technology's operational, management, and strategic benefits [133]. There are technical difficulties with organizational, social, economic, and policy barriers [134]. It is challenging to incorporate big data systems if medical institutions do not eliminate such hurdles [135]. Furthermore, companies have to balance the advantage of big data analytics and the negative impact on privacy risk to make critical decisions and improve patients' care [136]. The merging of IoT and big data analytics has led to immediate health checking systems, pervasive sensing, life care systems, and IoT-based systems for avoiding and identifying illnesses [137]. Karaca et al. [138] created a mobile cloud computing-based stroke healthcare system. The study findings are produced by the knowledge from past years to educate patients about their health conditions. Cloud computing offers cost-saving and creative options for healthcare [139]. Gao et al. [140] analyze different variables that influence health organizations' adoption of cloud computing: technology, organization, environment resources, data, and stakeholders. Instead, a lack of analytical guidance and empirical studies of healthcare cloud services' overall benefit suggests that this research field lacks maturity [141]. One of the key reasons for adopting cloud computing in healthcare is patients' confidential records [142]. However, data collection can become a problematic source without adequate privacy protection [143]. The confidentiality of e-healthcare record systems is one of the most important issues concerned by patients [144]. Citizens should be made fully aware of their sensitive health data exposed to another country's surveillance system, shared by many and guaranteed by few [145].

D. Knowledge Internalization

Knowledge internalization converts explicit knowledge into tacit knowledge, which is internalized into tacit knowledge. Any explicit knowledge formation's internalization is divided through an organization and converted into implicit knowledge. Internalization is closely related to learning by doing. For instance, the experience can be acquired through training programs, documents, books, or handbooks. Machine learning is an evolving field of study that enables computer-controlled programs to collect process data, recognize patterns in it, and make inferences from those patterns. With artificial intelligence and machine learning, advanced manufacturing can become more autonomous, efficient, and profitable. Machine learning is a subfield of artificial intelligence, where computers may be enabled to adjust functions or performance parameters without being explicitly reprogrammed. The key challenge at the management level is the resistance to data sharing needed by artificial intelligence technology. The hospital kept the patient's data at the time of care [146]. This technology can be used in high-stake medical and criminal justice decisions for trust issues. Inappropriate use of machine learning could result in the drastic loss or nondiscrimination of patients' right to informed consent. For this reason, to help patients new professionals should be involved, such as health information consultants [147]. By exploiting the technologies of artificial intelligence, digitalization, and machine learning from knowledge management and development perspective, the 4.0 transition can provide concrete support for healthcare that can involve patients and anticipate their health needs [148]. Machine learning can have a predictive model to support decision-making based on processed data to help physicians make the right decisions and internalize knowledge. According to De la Torre et al. [149], the most crucial objective is to create a structure that can help in clinical decision-making, make diagnoses, evaluate treatments' effectiveness to save resources, and provide customized and personalized treatments. Several computer-aided methods were used to help physicians determine whether other exams are needed to identify serious health issues [150]. Besides, this technology can accurately predict the length of practice for health practitioners in the public health sector through demographic information [151]. Furthermore, machine learning is used to estimate waiting times in the emergency room, to provide patients with real-time information on the remaining wait [152]. Furthermore, adopting digital learning, in addition to the standard CSR drivers, seems to be a straightforward and successful approach in enhancing personal fulfilment, the quality of care, and the overall healthcare organizations' CSR performance. Digital learning entails many training activities via intelligent support technologies and new human–machine interfaces, resulting in increased employee satisfaction [153]. This form of training requires a continual and creative process of developing didactic models that include narrative, gamification, an immersive approach, and the ability to make the most of technology developments to make learning more exciting and successful. Through technologies, the training of students, physicians, and nurses involves a passage of knowledge from explicit to tacit. 3-D printed models, fabricated according to the patient's specification, can be used to train physicians before performing surgery. In this way, it is possible to reduce costs and learning times [154]. Virtual reality (VR) is modern technology and for this reason there are few articles on this topic [155]. Thanks to VR, students, physicians, and nurses can acquire knowledge and facilitate the internalization process. Furthermore, there is always an increasing use of virtual reality technology in education and healthcare practice. Indeed, thanks to VR technology, it is possible to improve patient skills and safety, have remote access to training, and create an innovative innovation environment [156]. VR may distract a person from experiencing pain, teach medical residents how to conduct different operations, such as how to deal with unusual issues that might occur during an operation, help nurses visualize the transition from one surface to another of germs, preserve a sterile surgical area, and train operators to provide their patients with the best treatment [157]. Augmented reality and simulation allow performing clinical procedures in realistic environments. Patient simulators enable much more than just the acquisition of procedural techniques. This opportunity enables clinicians to be better prepared. It offers higher quality care, thanks to internalization knowledge, rather than waiting for an experience built on the field early in their careers. Incorporating a VR simulation into an interprofessional course has a significant learning influence on participants' communication skills from various disciplines: participants have greater empathy for the patient [158]. Virtual reality and simulation technology in the health sector allows students to create mental models of technological and interpersonal skills in a dynamic environment. Besides, computer games and virtual reality modify perceptions and behaviors in health care. There is also a decrease in costs with the educational game development approach to teaching procedural information in healthcare [159]. Healthcare managers' task is to achieve a stable healthcare system that regulates information, costs, and quality of care [160]. These interactive simulations of computers can create persuasive, attractive, and exciting environments by providing users with precise details and messages simultaneously [161]. Augmented reality as a teaching method would connect the gaps between training and conduct training in medical care, thereby eliminating local and language barriers for students [162]. Virtual clinical simulations are the perfect setting to engage students proactively in building awareness on practical problems, developing problems, and creating an artificial social structure where problematic scenarios can be developed [163]. Role-playing simulation strategies can be used successfully for strategy/management preparation and educating health practitioners [164]. After participation in simulation and client preparation, generally, there are improved abilities as knowledge, experience, and confidence [165]. According to Dunston et al. [166], with real-time 3-D visual simulation, it is possible to create a room model equal to that existing in the healthcare environment, thus allowing an almost real perception of the interior environment. Using Healthcare 4.0 technologies, healthcare professionals can internalize new knowledge. For instance, augmented reality's smart glass prototype can assist health practitioners with the hands-on visualizing of processes during care [167]. Simulation technology is also used to carry out strategic planning simulations or external and internal logistics simulations to evolve healthcare quality and improve patients' health. According to Roy et al. [168], there are two types of logistics for healthcare: external material-based and internal patient-based. Internal logistics with simulation approaches is the one most used by researchers. There is a need to have a fair evaluation system to have a high-quality health care organization's efficacy. Furthermore, the simulation can calculate the financial impact, followed by a cost-efficiency review for clinical impact evaluation [169]. The simulation technology makes it possible to improve medical staff by carrying out new tasks [170]. According to Ordu et al. [171], simulation can create a new hospital model that links every service to forecast demand for all outpatient attendances, capturing all the patient's uncertainties and providing a precise estimate of the critical needs. In emergency departments, simulation devices are also used to boost metrics such as patient stay time, the rate of utilization of services, and the waiting time in emergencies [172]. This technology will help health managers in challenging health environments challenging and high-performance healthcare environments [173]. Team learning and a standard conceptual model will make decisions easier [174]. Simulation can be used for surgical care policies to design and analyze simulation experiments [175]. Simulation can eliminate steps that add no value for the patient, so health professionals can become more efficient and value the organization [176]. It is claimed that reducing the attention to technical innovations can favor the users' needs and the healthcare community [177]. Jahangirian et al. [178] address the disparity between simulation and stakeholder groups as the key contributing factor in the low participation of stakeholders in simulation health programs, followed by inadequate management support, high labor costs for clinicians, and failure to produce tangible and quick results. Long-lasting disruptions and activating a new supplier represent the most efficient mitigation strategy to design and plan a more flexible and resilient healthcare supply chain [179]. The IoT applications can also help the passage of knowledge; there is the possibility also to offer services for all special needs. For example, a new approach is focused on different places near medical centers and the distance from it in an emergency to assist tourists [180]. Laplante et al. [181] describe IoT systems used to support activities to improve workflow and maintain patient privacy. Maintenance of security and privacy is required for the patient's medical data, and it is possible with the authentication protocol [182]. Covering information for users who cannot access the present information across the network is crucial to ensure protection and confidentiality [183]. The IoT concept allowed smart health care systems to be integrated with the cloud environment to guarantee the patient priority based on the prevalence of disease and reduce the time for reaction. The ability to use the cloud allows doctors and patients to manage diseases and prevent them from worsening. Lin et al. [184] report that health data can easily be obtained by implementing EHRs. Health data can then be used to prevent chronic diseases using data in a cloud computing system. The transmission of knowledge from explicit to tacit is facilitated using technologies that allow a self-assessment of the results obtained. Indeed, with the auto assessment module using a cumulative numerical scoring system, it is possible to carry out therapeutic health exercises assisted by augmented reality [54]. Moreover, with wearable sensors integrated with virtual reality, the participants can follow the system instructions and have self-measurements of their mobility [56]. For instance, there is a provision of care for mental well-being. It is a reliable self-assessment service focused on real-life expertise, understanding of mental health, and support for people with mental health issues [55]. As life expectancy increases, the population gets older, and eventually, people are old. Thus, the continuous surveillance of data, which may be a source of information and research, must ensure a quality of life and protection. Users can collect, store, visualize their multidimensional health data, quantify, and track wearable devices' daily physical activity or mobile applications with the platform. They can further contribute to quicker, more reliable preventive care for chronic conditions [75]. Existing and emerging technologies as tools, especially for health monitoring, fall detection, behavior recognition, and classification, can support older adults in their everyday life, making them easy and safe [74]. A big data system can be designed to operate with wearable sensors through mobile phones to monitor the wellness of the elderly and internalize knowledge about people's health [123]. With the continuous monitoring of vital functions that can occur, thanks to IoT technologies, healthcare personnel can acquire useful information. Therefore, the joint monitoring system with wearable technology enables constant monitoring of our bodies' vital signs. Thus, emergency services are reached immediately after or, in some cases, before the physiological issue or disease arises [73]. Generally, IoT data collection systems monitor individuals' status and receive the analyzed cloud output to determine, when appropriate, to send the data to a health care provider to avoid illness [76]. A robust big data framework allows the health data to be read and analyzed by researchers using their preference tool [114]. Support for decision-making is one of the primary data analytics skills. Health staff needs adequate knowledge and realistic thinking about the possible findings [112].

V. Discussion, Conclusion, and Future Directions

This article provides a transparent picture of the different 4.0 enabling technologies supporting the four phases of the SECI model in healthcare. Notably, by reviewing the existing literature on the digital transition of healthcare in terms of knowledge management processes, we have developed a structuring framework. The present SLR provides different theoretical contributions. First, it provides a framework highlighting the role of digital transition and knowledge creation processes while specifying whether tacit and explicit knowledge is being managed in healthcare. Accordingly, these results can emphasize what the literature has looked at and which enabling technologies have gained much attention. Notably, the proposed taxonomy shows that the majority of 4.0 enabling technologies support the phases of socialization and internalization, thus allowing physicians to learn more quickly about patients' state of health and consequently formulate faster and more accurate diagnoses. Indeed, it is feasible to use wearable technologies to self-diagnose and then transfer the results to physicians, promoting the exchange of tacit knowledge between healthcare professionals and patients. Furthermore, our synthesis provides prescriptive considerations concerning future research avenues' development according to the proposed research framework. Specifically, the papers' content analysis has highlighted four primary areas of investigation concerning the support of enabling technologies to knowledge socialization; knowledge externalization; knowledge combination; and knowledge internalization. From these four areas of investigation, some gaps in the literature have emerged. In providing a comprehensive overview of what scholars have studied so far on the digital transformation in healthcare through the lens of knowledge management, this article highlighted the enabling role of cloud technologies in every phase of the SECI model [110], [184], [185], [186]. Their application was emphasized in many contexts and functions, highlighting their pervasiveness and potential. Due to rapid population growth, the complexity of researching and analyzing the massive amount of patient data worldwide is growing. This aspect allows for improved data-based decision-making and faster development of precision medicine. A productive research frame has begun in recent years around the IoT role, especially in explaining data acquisition. Some authors showed how the IoT solutions, connecting things, sensors, and other smart technologies, allow companies to collect valuable data to improve healthcare, e.g., [73], [187]. Furthermore, many articles deal with training for medical and nursing students that can take place through technologies such as augmented reality and simulation, e.g., [157], [161], [163]. Thanks to these technologies, they can first put new knowledge into practice by simulating real situations and using the knowledge acquired. Applying the principles and tools for knowledge management will provide the basis for improving health decisions [188]. Using technologies to exchange knowledge between physicians, nurses, or patients can improve clinical practice and health management. Progress in information and collaboration in healthcare, support for informed decisions, EHR systems, practical communities, and advanced care planning are several transformative healthcare opportunities [189]. Another research gap concerns the low number of articles for horizontal and vertical integration technology in healthcare. Vertical integration concerns the organization's communication and sharing of knowledge, while horizontal integration concerns parties external to the organization, such as suppliers or external consultants. The few articles are synonymous with a low focus on communication and knowledge sharing analysis. These integration systems are designed to transform the way workers interact with each other and with the environment, improving both end-users' and service providers' experience. Besides the focus on specific technologies, overall, the analyzed studies are qualitative. This, in turn, calls for research that seeks to examine organizational learning phenomena in the digital era through quantitative approaches (e.g., larger scale quantitative studies). Furthermore, future studies should adopt a longitudinal perspective of analysis. The digital transition takes time to be implemented, and healthcare organizations also require adjusting to this transformation. This means that the implementation stage and differences within the same organization exist as the digital transition takes its course, eventually affecting the intertwined effects between implementing digital technologies and organizational learning over time.

This article provides practical contributions. Healthcare professionals could use this study's findings to acquire knowledge regarding the use of different 4.0 technologies that could support day-to-day operations, enabling better data-driven decision-making. Digital technologies, such as IoT, cloud computing, and blockchain, are becoming more popular in the healthcare industry to gather and analyze data and transmit data between operators and patients. For instance, blockchain technology offers the possibility to provide a secure and reliable system for managing and exchanging EHRs data. Interoperability across systems allows for the elimination of local health [190], [191], allowing for the exchange of clinical data over long distances, resulting in improved healthcare for people and reducing geographic obstacles to data analysis and interpretation. This study also suggests that healthcare organizations should invest in digital learning tools (e.g., virtual reality, smart glasses) to improve employee learning and satisfaction, patient quality of care, and overall performance.

As for the research limitations, our analysis was carried out using only the Scopus database. Second, although the filtering process may have excluded relevant research, our systematic review's rigorous procedure has decreased the risk that the study omitted would have provided details that would dramatically alter our findings. Despite these limitations, we first contribute to the literature on the digital transition of healthcare using a knowledge creation perspective. Finally, we offer future research opportunities for those desiring to focus on this field. We hope that this structure will converge innovation study resources in healthcare research and practice. Primary data should be acquired from sizeable, highly innovative healthcare organizations experienced in relying on technological innovation processes to achieve this aim. More in detail, interviews with organizational members should be conducted to understand the degree of implementation of enabling technologies and how it has affected healthcare organizations' modus operandi, especially regarding the socialization, externalization, combination, and internalization processes, thus helping scholars to assess the influence of digitalization on knowledge creation. Then, in-depth case studies should be carried out for specific technological innovation projects to scrutinize how enabling technologies are now being employed to manage knowledge and the main constraints and advantages of projects not involving digital solutions. Besides further case studies should be carried out for different developed country in order to highlight similarities and differences linked to the different country environment.

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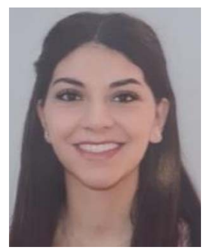

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