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DIGITALIZATION OF HEALTHCARE SECTOR AS A TOOL FOR IMPLEMENTATION OF COMPETITION POLICY

Abstract. Competitiveness of modern states is increasingly dependent on the method and scope of using information-communications technologies (ICTs) in the economy and in the implementation of the states' care functions. The application of information-communications technologies (ICTs) in health care is of special importance due to observed dynamic changes taking place in social structures. The main factors contributing to the widespread use of information-communications technologies (ICTs) in health care include demographic changes, the increase in the duration of human life, the increase in health care expenditures, progress in medical science and the increase in patients' ability to use automated devices. The aim of this article is to characterize the main ideas forming the architecture of the Healthcare 4.0 concept and to place this concept in a broader perspective of the Industry 4.0 concept.

Key words: healthcare 4.0., public management, ICT

Health care in the face of challenges of technological transformation

The cultural changes taking place in the last decade of the twentieth century, resulting from the transition from an industrial civilization to a knowledge civilization (OECD 2020a) and the dominance of *information-communications technologies* (ICTs) have fundamentally affected not only the scope and quality of relationships between people, but also the conditions under which states, public entities and firms operate (Lindgren, 2017). The environment in which states, public entities and companies now compete is characterized by volatility, diversity, technological saturation and short economic cycles (Cavallone, Palumbo 2020). The new context of doing business and services implies the need to look at the success factors of managing organizations differently from the previous ones (Vogelsang, Liere-Netheler, Packmohr, Hoppe, 2019). Indeed, *information-communications technologies (ICTs)* have become the most essential element in the global development of the knowledge economy. As such, they are seen as the main driver of the growth of competitiveness of countries and organizations in the global economy.

The ongoing transformation from an analogue to a digital society has become so intense in recent years that it was decided to distinguish it as a new era of socio-economic development, and it was given the name of the fourth industrial revolution - Industry 4.0 (Acsente, 2010). The characteristics of this era are: (1) widespread digitization and the provision of technical capabilities for the continuous communication of people with each other, people with devices and devices with each other; (2) the increasing implementation of so-called disruptive innovations that allow for leaps in productivity and efficiency of the socio-economic system and (3) the development of machines in such a way that they acquire the ability to undertake autonomous behavior through the use of "artificial intelligence" (AI) in their control process (Liao, Deschamps, Loures, & Ramos, 2017; Xu, Xu, & Li, 2018, Rejikumar, Raja Sreedharan, Arunprasad, Jinil Persis, & Sreeraj, 2019, Philbeck& Davis, 2019).

One of the many strong social trends that can be observed globally in recent years is the dynamic increase in public spending on health care on the one hand, and the measurable effects in the form of improved health condition of societies on the other. More and more often the literature discusses the results of studies that aim at demonstrating the

relationship between health improvement and technological changes. It is obvious that improvement in patients' health results from the impact of various factors, but the incorporation of new information and information technology solutions into routine medical practice is treated as one of the important factors contributing to this improvement.

As the European Union has recognized health as a value of paramount importance for the harmonious development of societies and identified it as one of the objectives of the cohesion policy, the European Commission has prepared economic, legal and awareness forms of assistance to Member States in their efforts to provide it to their citizens at the best possible level. This decision made it possible, among other things, to implement financial instruments to support cooperation on health care between EU countries. Under the cohesion fund, many billions of euros have been allocated to the development of actions taken to improve medical care, including digitisation and automation[1].

A measurable result of actions taken by the EU is the increasing use of Healthcare 4.0 solutions in the practice of healthcare systems and organizations operating in them as a consequence of the development of the Industry 4.0 concept.

From the Industry 4.0 concept to the Healthcare 4.0 concept

The concept of Healthcare 4.0. grew out of the fourth industrial revolution – Industry 4.0. Industry 4.0 is the name used to describe the system architecture and designed functionalities using value chain logic (Kim, Park, & Choi 2017). The term was originally used in Germany – Industry 4.0 – to name the new national industrial strategy prepared by the government of the Federal Republic of Germany (Kagermann, Wahlster, & Helbig, 2013, Kagermann, 2015). At the same time, similar terms appeared in other countries of the world, for example: Industrial Internet Connected Enterprise, Integrated Industry, Advanced Manufacturing Partnership, Smart Industry, Smart Manufacturing, Smart Factory, or Internet of Things for Manufacturing. Soon the name Industry 4.0 became a collective name for a new concept describing the principles of production of goods and services, which is characterized by moving towards digitization and automation of production and service environments (Lee, Kao, & Yang 2014; Oesterreich & Teuteberg, 2016; Sreedharan & Unnikrishnan, 2017). It has been noted that industrial automation systems enable the creation of new and innovative functions through network and cyberspace access. Access to the network and cyberspace has enabled the creation of entirely new business frameworks, processes, and methods for implementing innovations. They will also affect the efficiency of organizations and how they are managed. Moreover, technologies such as IoT, cloud, blockchain, and Big Data can be integrated into organizations operating according to Industry 4.0 architecture to deliver smart services (Schaffers et al., 2011; Witkowski, 2017, Schuh et al.., 2014; Trappey et al., 2017; Wang et al., 2016).

Industry 4.0 allows products, machines, components, people, and systems to form an intelligent network (Mrugalska & Wyrwicka, 2017; Sreedharan & Unnikrishnan, 2017; Kamble, Gunasekaran, & Gawankar, 2018; Kamble, Gunasekaran, & Sharma, 2018) that can integrate cyber-physical systems. It has also been noted that integration by combining information and physical memory with the smart grid allows for faster and more efficient customer service (Erol et al., 2016; Saldivar et al., 2015; Shafiq et al. 2016).

Industry 4.0 can deliver smarter services and make business processes in various sectors such as manufacturing, healthcare, agriculture, logistics, public sector, government institutions, higher education institutions and other business areas more efficient. Moreover, organizations can empower their customers by responding to their needs using facilities such as 3D printing, cloud applications, mobile devices, and Big Data, creating a whole new smart environment (Lobo, 2016; Hofmann & Rüsch, 2017).

The basic building blocks of the Industry 4.0 system architecture are: Internet *of Things* (IoT), *electronics/wearable devices*, Big Data, *mobile apps*, blockchain, and artificial *intelligence (AI*) (Maier, Emery, & Hilliard, 2001). Importantly, these elements integrate while providing *interoperability*, *decentralization*, *virtualization*, *modularity*, *services orientation and real-time capabilities*. The development of Industry 4.0 led to the emergence of systems dedicated to separate areas of functioning of social and economic

[1] https://ec.europa.eu/poland/news/210326_sante_pl

structures, for example, the public sector (Government 4.0), health care (Healthcare 4.0) or society (Society 5.0). For healthcare, the fourth industrial revolution has meant a fundamental modernization of the functional architecture assumptions from individual-distributed activities and processes to the widespread use of information technology to create a more efficient system ensuring new quality and value for society. The concept of Healthcare 4.0 will be further discussed below due to the topic of the paper.

The concept of Healthcare 4.0 developed gradually as a response to the growing demand for efficient and less costly healthcare services.

Table 1

Transformation from Healthcare 1.0 to Healthcare 4.0

	Healthcare 1.0	Healthcare 2.0	Healthcare 3.0	Healthcare 4.0
Main objective	Improve efficiency and reduce paperwork	Improve date sharing and productivity	Provide patient-centered solutions	Provide real-time tracking and response solution
Focus	Simple automation	Connectivity with other organizations	Interactivity with patients	Integrated real-time monitoring, diagnostics with AI support
Information sharing	Within an organization	Within a cluster of healthcare providers	Within a country	Global healthcare supply chain
Key technologies Used	LIMS (laboratory instrument management system) and administrative systems	EDI (electronic data interchange) and cloud computing with HL7messages for exchange	EMR, Big data, wearable devices, optimization system	IoT, Blockchair, AI, Data analytics
Limitations	Stand-alone systems with limited functionality	Sharing of critical information only but not interacting with patients	Different standards used within the community with limited interoperability	New and untested technologies with concerns about data privacy

Source: (Chanchaichujit, Tan, Meng, Eaimkhong, 2019)

The term Healthcare 4.0 has emerged recently and is derived from the concept of Industry 4.0 (Jayaraman, Forkan, Morshed Haghighi, & Kang, 2019). Healthcare 4.0 is an ***umbrella concept*** term for digital health technologies based on solutions such as smart health, mHealth (mobile health), wireless health, eHealth, online health, medical IT, telehealth/telemedicine, digital medicine, health informatics, pervasive health, and health information system, among others. Many factors have influenced the emergence and development of Healthcare 4.0.

· The first was the desire of governments of highly developed countries to more effectively achieve societal goals of increasing access to healthcare and improving patient outcomes. The aforementioned goals were to be achieved as a consequence of the creation of national information systems that enable the integration and exchange of data within the ***electronic medical record (***EMR) (Qin et al., 2016; Sligo, Gauld, Roberts, & Villa, 2017).

· The second factor was the dynamic increase in the number of people using technological facilities in the delivery of medical services provided because of the use of various IT solutions as tools to increase the efficiency of the activities undertaken (Eysenbach et al., 2013).

· Another significant factor contributing to the development of Healthcare 4.0 was the ability to create large databases containing the results of diverse diagnostic tests (e.g. laboratory, radiological, haemodynamic). Easy and relatively inexpensive use of ***information-communications technologies (ICTs)*** for data collection and transmission, combined with the use of cheap and fast connections (Internet communicators) for contact between medical professionals and patients and medical professionals among themselves, enabled rapid development of personalized forms of integrated care. As a result of the use of such solutions, it has become possible to make a fast and reliable diagnosis based on the assessment of multiple laboratory parameters (Eysenbach et al., 2013) without the need for physical contact between the parties involved in the described process.

The functionality and capabilities of Healthcare 4.0 are determined by three main components: Internet of Things, cyber-physical systems and cloud computing.

The Internet of Things (IoT) is a technology that makes it possible to connect any device to the Internet, remotely access and manage it from any place with Internet access. An example application of IoT is remote health monitoring and performing at home medical procedures that can be done in this way (e.g., response to heart rate). The data obtained from biosensors and electronic devices, in addition to being used for remote monitoring of the patient's health, can also be helpful in scientific research.

Cyber-physical systems are intelligent systems that include machines, devices, and software that operate autonomously or in a network, communicate over the Internet and use Internet services, and make decisions in a decentralized manner or in collaboration with humans. These systems are used to monitor and control devices in the physical world and the processes in which these devices are used. The main application of cyber-physical systems in the healthcare sector is the modelling of treatment processes.

Cloud computing is a technology that allows data to be remotely stored and processed on secure servers. The source of data can be medical records, laboratory test results, prescription data, well-being data, data generated by electronic galleries and demographic factors such as zip code, local weather, shopping habits. Cloud computing uses analytics and calculation systems to process data.

The elements of Healthcare 4.0 characterized above make it possible to effectively use elements such as IoT, Blockchain, AI and Big data to improve healing processes. IoT and AI enable patients to self-monitor their health and thus better manage their own health. The ability to quickly contact medical professionals when a health condition arises that requires external intervention is also not insignificant. Blockchain allows real-time creation and exchange of information about a patient's clinical data and uses it to diagnose and determine medical intervention. With artificial intelligence, it is possible to provide detailed predictive models about a patient's health status. And Big data and mobile applications help to maximize the efficient use of healthcare resources and enhance the preventive and predictive aspects of planned and ongoing health procedures to deliver the best possible healthcare to all those eligible (Chanchaichujit, Tan, Meng, & Eaimkhong, 2019). The other elements that make up the Healthcare 4.0 architecture are shown in the figure below (Fig. 1).

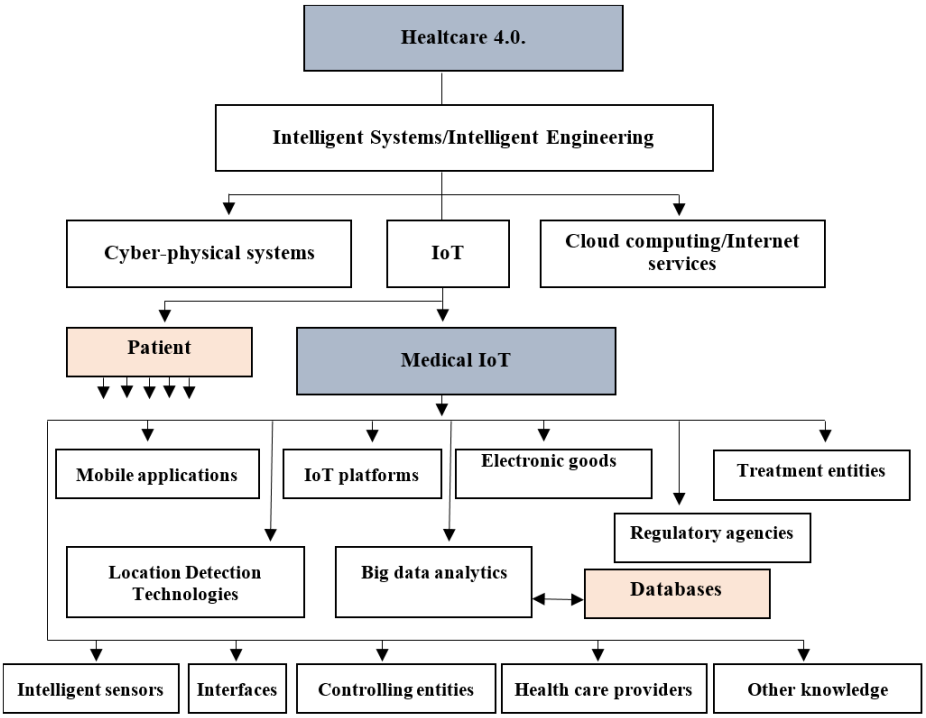

Fig.1. The Healthcare 4.0 architecture

Source: (Estrela et al., 2020).

Healthcare 4.0, has various applications that contribute to improving healthcare (Orcajo, 2021), including: diagnostic and therapeutic decision support (Corral-Acero et al, 2020); patient monitoring (Schwartz, Wildenhaus, Bucher, & Byrd, 2020); surgery simulation – surgery risk assessment (Morrison, Pathmanathan, Adwan, & Margerrison. 2018); medical device design and optimization – MedTech (Morrison, Pathmanathan, Adwan, & Margerrison. 2018); drug development and dosage optimization – clinical trials (Pappalardo, Russo, Tshinanu, & Viceconti, 2019), regulatory decision making (Morrison, Pathmanathan, Adwan, & Margerrison, 2018), and others.

The comprehensive applicability of Healthcare 4.0 to improve healthcare has significantly influenced the development of the *Value Based Healthcare* (VBHC) concept (Teisberg, Wallace, & O'Hara, 2020). The indicated concept is in line with one of the major challenges of the European Union countries, i.e., striving to create a basis for sustainable development (Kapferer, 2016). In the indicated concept, value is defined as the relationship between the achieved treatment effects and the incurred treatment costs. In addition, the analysis of the results of studies of entities operating in the health care sector indicates that the application of information and information technologies in the treatment of patients can positively affect the financial performance of companies and the organization of work and service to patients in the short term, and can also improve management processes in the long term (Das, Yaylacicegi, & Menon, 2011; Sanal, 2019).

The design and implementation of increasingly sophisticated information and information technology and the readiness of medical professionals to use it in the delivery of health care services is beginning to play a key role in effectively meeting patient needs and improving the quality of health care (Gellerstedt, 2016). The design and implementation of increasingly sophisticated information and information technology and the readiness of medical professionals to use it in the delivery of health care services is beginning to play a key role in effectively meeting patient needs and improving the quality of health care (Gellerstedt, 2016). The widespread use of information and information technology is enabling the development of *information-communications technologies (ICTs)*, new health care services that can help both providers (e.g., physicians, hospitals, and clinics) and users (patients and their families) move toward personalized, proactive, and predictive models of health care. The comprehensive use of information and information technology has expanded the application of artificial intelligence and digitization in various areas of health (Sultan, 2014; Yang et al., 2015, Kobayashi et al., 2019), creating the conditions for a fundamental change in the structure and operation of healthcare (Emanuel & Wachter, 2019).

The impact of the COVID-19 outbreak on the development of Healthcare 4.0

The current pandemic situation is a challenge for creating new *information-communications technologies (ICTs)* applications in health care. Further development of the use of *information-communications technologies (ICTs)* in health care activities depends on the course and final results of the Covid-19 pandemic. Like any global threat, the Covid-19 pandemic contributes to changing individual and collective social behavior. Suffice it to say that the last three major epidemic threats have significantly affected the way health systems operate. After the Spanish Flu epidemic in 1918, which is estimated to have killed at least 50 million people, many governments around the world introduced public health systems and created ministries of health, and developed countries initiated actions that led to the creation of the World Health Organization (Spinney, 2020). The outbreaks of SARS in 2003 and Ebola in 2014 contributed to the creation of the Coalition for Epidemic Preparedness Innovations (CEPI), an institution that internationally supports vaccine development to improve the world's preparedness for future infectious diseases. The current COVID-19 epidemic has already had a significant impact on redefining the role and importance of digital technologies, Big Data solutions and artificial intelligence in socio-economic life and is contributing to dynamic technological advances, including in health care.

The authors of the report *What future for science, technology and innovation after Covid-19* (OECD 2021) identified many changes in the use of *information-communications technologies (ICTs)* in healthcare as consequences of the global COVID pandemic19. Some of these are characterized below. The first consequence is the need for countries and

societies to prepare for longer-term disruptions, including a possible backlash against globalization. Seric and Winkler (2020) believe that a prolonged COVID-19 crisis or other future shocks could lead to accelerated automation and wider adoption of digital tools. Fear of possible trade barriers and possible tendencies to move production back to places where labor is expensive may further contribute, because of the search for cost efficiency, to increased automation efforts in firms. The best confirmation of this thesis is the jump observed at the beginning of the pandemic in the use of 3D printing to produce personal protective equipment for medical staff or simple medical instruments useful in the care of coronavirus patients. Not without significance is the currently observed strengthening of supply chains as a consequence of deeper than previously digitized logistics systems and especially the tools monitoring the course, flexibility and consistency of supplies in the medical industry. This is being served, among other things, by increased investment in the Internet of Things (IoT) and blockchain technologies, which are helping to increase transparency, security, and trust in supply chains (Khurshid, 2020). A good example is the US hardware and software manufacturer IBM, which has extended blockchain solutions for supply chain verification to pair suppliers with governments and hospitals in the early stages of a crisis improving the ability to deliver equipment to those facilities with the greatest shortage. In March 2021, IBM also announced a partnership with Moderna, a pharmaceutical company that makes COVID-19 vaccines. The goal of the partnership was to use a tracking platform based on supply chain logic (blockchain) to distribute vaccine doses. As McGrail (2021) points out the current positive effects of using blockchain to track and monitor the distribution of medical supplies including vaccines may encourage its wider adoption in health systems in the future. The deepening use of ICT in healthcare results in work being undertaken to ensure digital security and privacy. Content analysis of international reports (Interpol, 2020; OECD, 2020b, 2020c). unequivocally leads to the conclusion that the acceptance of widespread digitization will depend on the guarantee of safety of work with the use of information and information technology, especially the resistance of systems to cyber-attacks. The referenced reports strongly emphasize that, in particular in the field of healthcare, consumer willingness to digitize sensitive health data may continue to enable innovation in digital health services but concerns about privacy and data security may hinder this development. Thus, it is reasonable to believe that the risks identified are prompting increased implementation of cybersecurity practices in organizations and encouraging investment in the development of technologies to counter the spread of online fraud and phishing messages by ransomware-based cybercriminals. The capacity and speed of adoption of *information-communications technologies (ICTs)* by both individual and institutional users and the level of financial resources (especially in view of the post-pandemic economic crisis, the symptoms of which are already visible) are also important consequences of the pandemic for ICT development. These last two identified consequences of the COVID-19 pandemic have a significant impact on the emergence of constraints in access to and the ability to use *information-communications technologies (ICTs)* infrastructure as a major barrier to digital uptake in research and business.

Conclusions

The processes within healthcare provider organizations and the overall outcomes of the healthcare system are strongly dependent on information and knowledge sharing (Lenz et al., 2012; Lenz and Reichert, 2007). The environment in which these entities operate is characterized by high complexity, restrictive regulations and limited financial and human resources. The basic logic of functioning is on one hand increasing the quality of services and on the other reducing the costs of activity. Providing patient care often requires combining multiple areas of expertise and multiple interventions throughout the care cycle (Porter, 2010). The use of technology-enabled management in healthcare delivery organizations can greatly simplify services and processes, making them more efficient, while providing better quality, wider access and shorter waiting times for patients. Changes resulting from the application of *information-communications technologies (ICTs)* in the healthcare environment contribute to the emergence of a new business model (Buttigieget al., 2016). In this new business model, clinicians and managers have better access to tools to effectively shape processes in order to achieve better performance in the healthcare system. Regardless of the

improvements resulting from the introduction of modern technology – due to the purpose and nature of the business – employees are the primary resource that determines the success of healthcare delivery organizations. They are the ones who design and use technological solutions, create organizations, and actively participate in their functioning (Battaglio, 2015). Equally important are the financial resources that can be devoted to the development of *information-communications technologies (ICTs) information-communications technologies (ICTs)* applications in healthcare. To meet the emerging needs in a post-pandemic world, the European Union's development goals in force for 2021–-2027 (EC, 2020), within the framework of the EU4Health Programme 2021–2027 strategy, [2]identified a number of directions for financing activities supporting the development of Healthcare 4.0. The most important of these are:

· To deploy, operate and maintain mature interoperable digital service infrastructures and processes that ensure high quality data for access, sharing and reuse;

· Cross-border networking, including through the use of electronic health records, medical registries and other databases;

· Digital transformation of healthcare and health systems as a consequence of using innovative tools and technologies to create benchmarking;

· Improving the digital skills of healthcare workers;

· Implementation and interoperability within and between Member States and with the institutions and bodies of the Union of digital tools and infrastructures;

· Developing, within the European Health Data Area, appropriate governance structures and sustainable interoperable EU health information systems;

· Strengthening citizens' access to and control over their health data.

· Optimal use of telemedicine/telehealth via satellite communications in remote regions;

· Supporting digital organizational innovation in health care entities and promoting digital tools;

· Supporting coordinated and personalized health care.

Summarizing the considerations carried out, we note that technological innovations, more specifically the digital revolution on the one hand and the challenges of competitiveness on the other hand, are profoundly changing the way healthcare operates. There is no doubt that the applications of Industry 4.0 concepts in healthcare include many diverse processes not only medical, but also strategic management, organizational design, and management control (Sanal et al., 2019). From this point of view, it is not surprising that researchers and practitioners note that the digital turn and the post-digital revolution are rapidly transforming the future of healthcare and preparing it for new challenges (Noorbakhsh-Sabet et al., 2019). This can lead to smarter management of healthcare resources, thereby achieving greater efficiency in the delivery of healthcare services, better quality of services, and getting better results from the public funds spent (Abidi & Abidi, 2019). They will also contribute to redefining the ways in which professionals work with patients and medical professionals with each other.

Digital health solutions are systematically changing the way healthcare is delivered in the 21st century. They are addressing the complexity of healthcare by considering its efficiency and effectiveness of operations and sustainability (Spohrer, 2007), and supporting the long-term sustainability of healthcare (Faggini, 2019). It is very important for leaders, designers, and strategists of the digital health space to integrate sustainability goals into long-term business strategies and to take the sustainability aspect seriously by following a sustainability-healthcare-ICT triad approach (Gerlach, 2019).

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