SAOHEALTH 4.0: IMPLEMENTATION BARRIERS IN SLOVAKIA

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Abstract: In healthcare, the phenomenon of Industry 4.0 is called Health 4.0. It represents the integration of modern technologies using available data with the possibilities of artificial intelligence. The main goal of the study is to examine the barriers to the implementation of Health 4.0 in healthcare of Slovak Republic. By analysing many scientific studies dealing with the issue, we have identified obstacles to the transformation of the Slovak healthcare system from a purposefully compassionate system to a value-oriented and personalized system that can ensure an increase in the quality of provided health services. Based on the opinions of healthcare professionals, IT professionals and academic experts, the 15 most important barriers were selected. Subsequently, the TISM (Total Interpretive Structural Modelling) model was developed, which extracted the key barriers influencing the adoption of Health 4.0. The results show that the lack of support from top management and the growing demands on the workforce are the main obstacles with the most significant driving force. Urgent solutions by policy makers and management of healthcare facilities to remove these barriers will reduce the cost of medical interventions and improve the quality of healthcare provided, thus realizing the true potential of Health 4.0.

Keywords: Industry 4.0, Health 4.0, Health 4.0 barriers, health care, TISM

1 Introduction

The Industrial Revolution is the most important development milestone in human history.

Technological progress and industrialization went through four phases (Cline, 2017):

1. Phase - Industry 1.0 (18th century):
   Mechanization, weaving loom, use of a steam engine in industrial production.
2. Phase - Industry 2.0 (19th century):
   Electrification of production, electric motor as a part of assembly line, mass production.
3. Phase - Industry 3.0 (70s of the 20th century):
   Partial automation using memory-programmable controls and computers (robots).
4. Phase - Industry 4.0 (the beginning of the 21st century):
   Cyber-physical systems, digitalization and interconnection of networks of all systems through one network, while production is almost autonomous.

Industry 4.0 is a production concept designed in Germany. It connects the physical world with the virtual world in order to increase the competitiveness of the German manufacturing industry. (Kagermann et al., 2011) The creation of intelligent factories was conditioned by the combination of cyber physical systems with people connected through the Internet of Things with the support of Internet services. Factory management envisaged the organization of processes through intelligent resource planning and the support of human and virtual agents in product development, with responses to demand, market conditions and feedback taking place in real time. The timeliness of the data obtained enables the continuous improvement of products, which enables companies to increase their competitiveness on the global market. (Schrauf, Berttram, 2016)

The development of Industry 4.0 resulted in the launch of a number of changes in healthcare, which used the knowledge of the industrial concept in four phases as well (Thuemmler, Bai 2017):

1. Phases - Health 1.0 (end of the 19th century to the 20th century):

- Scientific research into the causes of diseases that until then were based on superstition and speculation.
- Development of vaccines and antibiotics that have helped in prevention and treatment.
- Expanding possibilities in epidemiology and laboratory science.
- The emergence of modular information system technology.

2. Phase - Health 2.0 (80s of the 20th century):

- Development and use of new medical imaging techniques that have enabled advances in disease diagnosis.
- Electronic Health Records (EHA).
- The Institute of Medicine (IOM) defines the mission of public health.

3. Phase - Health 3.0 (Present):

- Intensive informatization and digitalization of healthcare.
- Health is becoming a commodity, and new business models are emerging in healthcare.
- Technologies, information systems, use of data restructuring the patient's environment.
- Innovations in the use of genetic information, development of implants, wearable electronics monitoring biophysical processes in the human body and their connection with HER.

4. Phase - Health 4.0 (Future):

- Cyber-physical systems - CPS in healthcare.
- Internet of Things in Healthcare.
- Internet services.

Advances in science and technology within Industry 4.0 have an impact on all areas of people's lives and society as a whole. The present study focuses its attention on its effects on health, healthcare and medicine. By seizing the opportunities of the concept, the healthcare sector has the opportunity to become more collaborative, convergent and predictive. The result is the personalization of health care and the improvement of preventable health care, which will increase the quality of life of the person monitored, e.g. indicators of healthy life expectancy, decline in avoidable mortality and others. Negative consequences are deepening inequalities in access to new treatments, moral issues in the use of genetic engineering knowledge, healthcare professionals 'access to technological advances (e.g. conscientious objection), changes in the doctor-patient relationship or the safety and protection of patients' personal health data. . These issues pose challenges for the future and require education of the public, policy makers and providers on the possibilities of transformation, on the modernization of existing systems, on new governance structures and the development of a coordinated collective framework.

2 Objective and methodology

The main goal of the study is to identify the barriers to the implementation of the Health 4.0 concept existing in the healthcare system of the Slovak Republic.

To achieve the goal, we used the TISM methodology, which was defined by Sushil (2012) and is derived from the concept of the ISM methodology. It models direct and transient relations between various elements.

Process:

1. Identification of barriers
   In accordance with the TISM methodology, based on the analysis of 58 professional articles registered in the SCOPUS and WoS databases dealing with the issue, we identified a set of barriers that represent an obstacle in the implementation of the Health 4.0 concept in healthcare (Jain

and Raj 2016). We supplemented the obtained information with data from statistical databases of OECD, Eurostat, NCZI. Subsequently, we subjected the barriers to the evaluation of 21 experts using the Delphi method: 10 doctors, 5 nurses, 4 academic staff and 2 IT staff. Finally, we extracted 15 barriers to the implementation of the Health 4.0 concept in the healthcare system of the Slovak Republic.

2. Interpretation of mutual relations between barriers and construction of structural matrix, use of symbols according to table no. 1

Table 3 Structural matrix symbols

Symbol	Relation description
V	When barrier 'a' leads to barrier 'b', but barrier 'b' does not lead to barrier 'a'
A	When barrier 'b' leads to barrier 'a', but barrier 'a' does not lead to barrier 'b'
X	When barrier 'a' leads to barrier 'b' and vice versa
O	When the relation between barriers is not relevant

Source: Sushil, 2012

3. Construction of the range matrix by converting information in binary numbers 1 and 0, according to table no. 4

Table 4 Construction of a matrix and its conversion into binary numbers

Relation between barrier 'a' and barrier 'b'	Relation 'a' – 'b'	Relation 'b' – 'a'
V	1	0
A	0	1
X	1	1
O	0	0

Source: Sushil, 2012

4. Subsequently, the matrix is converted according to the reachability of the target by dividing the barriers into levels. Variables reaching a value of 1 are determined for the rows, followed by the columns, and the intersection of their reachability is determined (Sushil, 2012).

5. Creating a model of barriers to the implementation of Health 4.0

3 Solution

Barriers to the implementation of the Health 4.0 concept in healthcare in Slovakia (Tupá et al., 2021):

- Risk of disruption of low-skilled jobs (B1)

The basis of the Industry 4.0 concept are automated and robotic technologies that replace human labour in industrial production, which leads to job losses and the release of workers. The same scenario assumes Health 4.0, where vending machines and robots in health care facilities will replace the work of some health professionals, leading to a surplus of labour, which will then be laid off (Qureshi and Syed, 2014; Frey and Osborne, 2017). For example introduction of chatbots in outpatient clinics and medical facilities, robots dispensing drugs in hospitals of the World of Health network, robotic dry and wet vacuum cleaners, e-magazines and more. (World of Health, E-Time)

- Capital intensity (B2)

The implementation of the Health 4.0 concept requires a very high initial investment in the development of suitable infrastructure and advanced automated technologies for healthcare facilities. IoT technologies require huge capital investments, accompanied by fears of economic loss. (Kamble et al., 2018; Kamigaki et al., 2017)

In its report, the SAO SR states in most hospitals deficit budgets or significant shortcomings in the management of budgets and other management parameters. The INEKO organization has long been drawing attention to the increase in hospital debt in connection with breaches of applicable public procurement legislation in terms of efficiency and economy. Investing in new technologies would increase their debt. It would be a modernization debt. The return on funds allocated in this way would be reflected in the long term, but more importantly, it would be linked to increasing the quality of health care provided in reducing avoidable mortality, improving preventive care with increasing life expectancy and more. An unresolved issue is the management and security of such a vast amount of data, which raises concerns about the economic losses resulting from the failure of these capital-intensive systems and technologies.

- Growing demands for a skilled workforce (B3)

In order to successfully implement the Health 4.0 concept, it is essential that the workforce in healthcare facilities has the required technical knowledge and skills. The operation of automated machines and robots requires further specialized training, digitalization and use of the Internet of Things, in turn, advanced technical knowledge to ensure the security of sensitive data such as clinical patient data. (Benešová and Tupa, 2017; Gehrke et al., 2015)

NCZI statistics on the staffing of medical facilities show that 25% of doctors and almost 10% of nurses and midwives of retirement age work in Slovakia (NCZI, 2018). For this age group, education in new digital technologies is challenging and there is a presumption that their introduction into everyday practice would cause them to retire from active service. The readiness of the technological workforce requires systemic changes in the education of health workers at secondary schools and universities as soon as possible, as their entry into the labour market is expected to be delayed by 4 to 10 years.

- Cyber security and privacy issues (B4)

Safety is one of the biggest obstacles to the successful implementation of the Health 4.0 concept. In the cloud, a large amount of confidential patient information is available online. Securing this highly sensitive private data is a key challenge for healthcare, as cyber systems are vulnerable to cyber-attacks. According to the latest studies, the solution is to work in the Edge interface, not the cloud. (Kamble et al., 2018; Alaba et al., 2017; Babiceanu and Böjtös, 2019)

In Slovakia, cyber security issues are subject to applicable legislation: Regulation (EU) 2016/679 of the European Parliament and of the Council on the protection of individuals with regard to the processing of personal data and on the free movement of such data (GDPR), Personal Data Protection Act - no. 18/2018 Coll., Act on Cyber Security - no. 69/2018 Coll., From an ethical and moral point of view, it is about ensuring secrecy between the doctor and the patient.

- Insufficient IT infrastructure (B5)

The successful implementation of the Health 4.0 concept presupposes an advanced IT infrastructure for the full use of the Internet of Things. The absence of an efficient communication network and weak signal strength can disrupt the whole process, as continuous data security in both horizontal and vertical levels will not be ensured. One solution is to use data processing on the Edge interface, which is not so demanding on the infrastructure. (Hecklau et al., 2016; Yan et al., 2014; Pace et al., 2018). Nevertheless, the use of the possibilities of Health 4.0 presupposes access to the Internet on the part of patients as well. According to Eurostat (2019), 82% of households in Slovakia have an internet connection and two thirds of the population had basic computer skills. For households, the investment is not only the provision of internet connection but also the purchase of IT equipment (computer, tablet or telephone). For retired patients, securing the IT infrastructure to take advantage of the opportunities offered by Health 4.0 is essential.

- Insufficient motivation of health professionals (B6)

Insufficient number of health care workers in health care facilities, their insufficient financial remuneration and job dissatisfaction represent a fundamental obstacle to the staffing of the application of the Health 4.0 concept. (Benešová and Tupa, 2017; Gehrke et al., 2015, Bonczek et al., 2014)

SKSaPA, SLK, Think-thank institutions and others have been drawing attention to the above-mentioned problems of the Slovak healthcare system for a long time. The biggest problem of the Slovak healthcare system is the unsustainability of the staffing of medical facilities. NCZI statistics show that almost 19,000 doctors work in health care establishments, of which 4,700 are of retirement age in the case of nurses, 33,000 of them, of which more than 3,000 are of retirement age. In an international comparison, there are 3.4 doctors per 1000 inhabitants in Slovakia, which is a value at the level of the EU average, but if all doctors of retirement age left the system, there would be only 2.58 doctors per 1000 inhabitants. In the case of the nurses, the situation is even more alarming. The EU average is 8.4 nurses per 1000 inhabitants, in Slovakia it is only 5.4, without nurses of retirement age it would be 5 nurses per 1000 inhabitants. The number of graduates of secondary medical schools or universities of medicine and medical disciplines has not been declining for a long time, but their problem is their emigration to work abroad.

- Inconsistency in rules for the exchange of clinical information (B7)

Health 4.0 is a relatively new concept. The lack of uniform standards for the exchange of information, connection to digital networks and at the same time insufficient information is an obstacle to its implementation. (Christians and Liepin, 2017)

- Lack of legislation on the use of clinical data (B8)

The digitalization and functioning of health care challenge legal professionals to create a legal framework that ensures and supports the proper and safe functioning of digital technologies and artificial intelligence in health care. This requires a redesign of the system of functioning and provision of clinical healthcare, reflecting the requirements for the legal security of clinical data in the Health 4.0 concept. (Christians and Liepin, 2017; Shelbourn et al., 2005)

- Insufficient maintenance support system (B9)

The implementation of the Health 4.0 concept requires an extensive IT infrastructure (factor B5), which needs to be managed, maintained and controlled. Any disruption of the integrated process will disrupt the whole system, which is a basic requirement for the healthcare sector. It is essential to have intelligent maintenance systems that can identify the smallest deviations with an emphasis on alerting possible errors or self-healing methods to prevent malfunctions. (Lee et al., 2014)

- Political support (B10)

The present is a period that places huge demands on capabilities such as big data analysis, cloud computing / edge computing security, searching for other options in the field of the Internet of Things or services. This requires government support to create support for the implementation of Health 4.0, e.g. financial, personnel, administrative, legislative, etc. At the same time, it is important to create standards at the international level, or and at national level to assist in the free and secure exchange of information (Bonczek et al. 2014).

- Lack of clusters for physician research and development (B11)

There is a need for continuous research and development in healthcare, as physicians should be well versed in the latest diagnostic techniques and surgeries. There is therefore a requirement to build sufficient research facilities to create a network of collaborating facilities and organizations in clusters (Raghupathi and Raghupathi, 2014). Clusters in the Slovak healthcare system are a unique exception. Their creation and cooperation is essential for modern healthcare (World of Health)

- Lack of strategy for digitization of medical facilities (B12)

Some hospitals do not have their own IT infrastructure, due to which managers have difficulty using IT technologies and finding the most suitable solution. Another problem is the incompatibility of software, indicators, units and parameters used by Schröder devices (2016). In Slovakia, there is an Action Plan for Informatization and Demand Challenges of the Industrial Property Office, which, however, is general for public administration. The strategy of health care development with an emphasis on informatization and digitalization is completely absent (Office for Investment and Informatization, 2018, Modern Health Care: The Greatest Diagnoses of Slovak Healthcare: Survey Results)

- Lack of top management support (B13)

The implementation of the Health 4.0 concept requires extensive initial investment in the construction, development and maintenance of infrastructure in healthcare facilities (factor B2). Additional costs are required to train staff (factor B3). If top management does not support the adoption of Health 4.0, this process will not be successful (Kamigaki et al., 2017). The introduction of the concept into modern healthcare in Slovakia is not a priority for the management of healthcare facilities. The support of top management is paramount for the improvement and streamlining of medical facilities. (Modern healthcare: The biggest diagnoses of Slovak healthcare: results of a survey, SAO: Results of inspections of selected healthcare facilities)

- Fragmented and non-standardized clinical data (B14)

The healthcare industry is very fragmented and rarely standardized. It is difficult for doctors, patients and managers to maintain a general overview of the various dimensions of care. (Raghupathi and Raghupathi, 2014)

- Concerns about the use of the Internet of Things and their economic return (B15)

The Internet of Things (IoT) is one of the important pillars of the Health 4.0 concept and, when used wisely, can bring great economic benefits to healthcare organizations. With the rapid expansion of wearable devices and smartphones, the combination of technology and IoT support shifts healthcare from a conventional system based on a framework approach to all patients to more personalized healthcare systems (Qi et al., 2017). However, staff are still unclear about the potential benefits and proper use of the Internet of Things in terms of value and rapid delivery of services. Several applications and technologies from IoT are still in their infancy and their results are uncertain. (Ryan and Watson, 2017; Li et al., 2015)

Table 5 Summary of barriers to the implementation of the Health 4.0 concept in the Slovak Republic

Number	Barriers to the implementation of the Health 4.0	
1	Risk of disruption of low-skilled jobs	B1
2	Capital intensity	B2
3	Growing demands for a skilled workforce	B3
4	Cyber security and privacy issues	B4
5	Insufficient IT infrastructure	B5
6	Insufficient motivation of healthcare professionals	B6
7	Inconsistency in regulations for the exchange of clinical information	B7
8	Lack of legislation on the use of clinical data	B8
9	Insufficient maintenance support system	B9
10	Political support	B10
11	Lack of clusters for physician research and development	B11
12	Lack of strategy for digitalization of medical facilities	B12
13	Lack of top management support	B13
14	Fragmented and non-standardized clinical data	B14
15	Concerns about the use of the Internet of Things and their economic return	B15

Source: own processing

Based on the evaluation of barriers to the implementation of Health 4.0 by selected experts from practice and academic

experts, we constructed an initial matrix of SSIM, which captures the evaluation of the interrelations between the criteria. (table 6)

Table 6 Structural self-interaction matrix (SSIM)

	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
B1	A	o	a	a	o	a	a	o	o	a	a	o	a	x	
B2	A	a	a	a	o	a	a	o	x	o	o	a	a		
B3	V	v	a	v	o	v	v	o	v	x	v	v			
B4	A	o	a	a	o	o	a	a	v	x	o				
B5	v	v	a	v	o	a	a	v	v	o					
B6	a	x	x	a	a	a	a	o	o						
B7	o	o	a	o	x	o	a	o							
B8	a	o	a	x	v	a	o								
B9	v	v	a	v	v	x									
B10	v	v	a	v	v										
B11	o	o	a	o											
B12	o	o	a												
B13	v	v													
B14	a														
B15															

Source: own processing

In the next step, the SSIM is converted to the binary digits of criteria 1 and 0 according to table no. 3, which is shown in Table no. 7. as initial reachability.

Table 7 Initial reachability matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
B1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
B2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
B3	1	1	1	1	1	1	1	0	1	1	0	1	0	1	1
B4	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0
B5	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1
B6	1	0	1	1	0	1	0	0	0	0	0	0	0	1	0
B7	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
B8	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0
B9	1	1	0	1	1	0	1	0	1	1	1	1	0	1	1
B10	1	1	0	0	1	1	0	1	1	1	1	1	0	1	1
B11	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
B12	1	1	0	1	0	1	0	1	0	0	0	1	0	0	0
B13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B14	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0
B15	1	1	0	1	0	0	0	1	0	0	0	0	0	1	1

Source: own processing

Subsequently, we evaluated the matrix in terms of transitive bonds and then divided into levels of different repetitions. The matrix is reviewed for the transitivity links and then partitioned and the levels of different iterations (table 8).

Table 8 Iterations

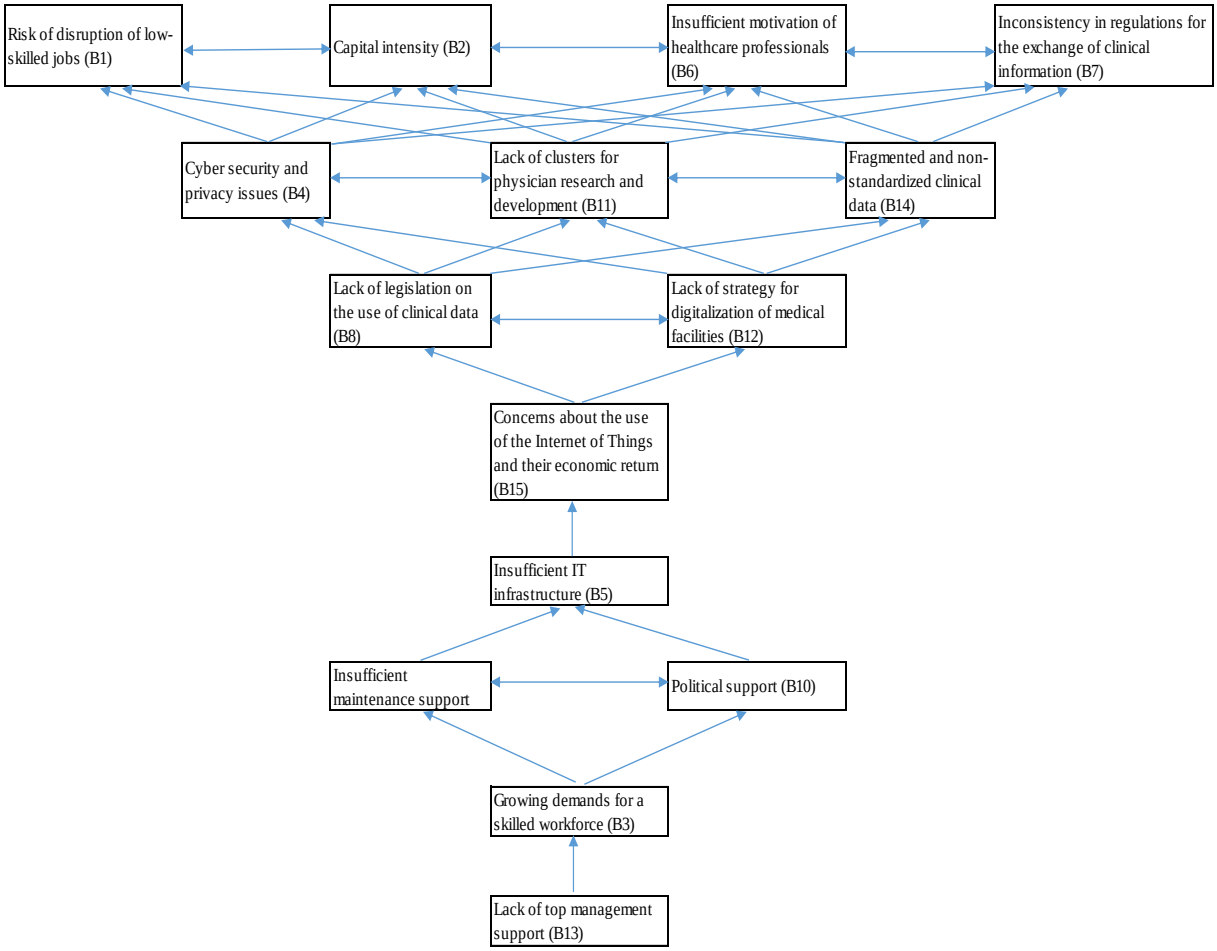
	RS	AS	AS ∩ RS	LEVEL
B1	1,2,6	1,2,3,5,6,9,10,12,13,15	1,2,6	I.
B2	1,2,7	1,2,3,4,7,9,10,12,13,14,15	1,2,7	I.
B3	1,2,3,4,5,6,7,9,10,12,14,15	3,6,13	3,6	VII.
B4	2,4,6,7	3,4,6,8,9,12,13,15	4,6	II.
B5	1,5,7,8,12,14,15	3,5,9,10,13	5	V.
B6	3,4,6,14	1,3,4,6,10,11,12,13,14	3,4,6,14	I.
B7	2,7,11	2,3,4,5,7,9,11,13	2,7,11	I.
B8	4,8,11,12	5,8,10,12,13,15	8,12	III.
B9	1,2,4,5,7,9,10,11,12,14,15	3,9,10,13	9,10	VI.
B10	1,2,5,6,8,9,10,11,12,14,15	3,9,10,13	9,10	VI.
B11	6,7,11	7,8,9,10,11,13	7,11	II.
B12	1,2,4,6,8,12	3,5,8,9,10,12,13	8,12	III.
B13	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	13	13	
B14	2,6,14	3,5,6,9,10,13,14,15	6,14	II.
B15	1,2,4,8,14,15	3,5,6,9,10,13,15	15	IV.

Source: own processing

Interpretive structural model was plotted (figure 2) using Iterations (Tab. 8). This model consists of eight levels.

Challenges at the higher levels have the less effective (levels 1–3) and challenges at low levels are basic and levels 7-8 have the most effective on other challenges and the recruitment system.

Figure 2 Interpretive structural modeling-based model



Source: own processing

4 Interpretation of results

We used expert opinions on the implementation of Health 4.0 as a basis for the creation of the ISM model and the analysis of the relationships between the barriers leading to the introduction of Health 4.0 elements in the healthcare system of the Slovak Republic.

Barriers that can be considered as challenges in this model have been grouped into three categories: key challenges, strategic challenges and dependent challenges. The holistic model is logical and the relationship between barriers is a picture of important factors and the elements that depend on them.

Some of the barriers have been extracted to the lowest level: lack of top management support (B13) and growing demands for a skilled workforce (B3). These barriers represent the challenges of Health 4.0 with the greatest impact on higher level barriers. We can identify these challenges as key, and any attempts to address them can positively influence the solution of other barriers.

Political support (B10), insufficient technical support system (B9), insufficient IT infrastructure (B5) and concerns about the use of the Internet of Things and their economic return (B15) are in the middle level of the ISM model. These challenges are described as strategic due to the strong impact on the success of the implementation of Health 4.0 elements in the healthcare system of the Slovak Republic. Public policy makers influencing health care should pay increased attention to them if their goal is to increase the quality of services provided in the health care sector in Slovakia by using the potential of this new concept. At the highest level of the ISM model, barriers arising from lower-level challenges are strongly dependent. These include: risk of undermining low-skilled jobs (B1), capital intensity (B2), insufficient motivation of health professionals (B6), inconsistencies in rules for the exchange of clinical information (B7), problems with cyber security and privacy (B4), lack of clusters for research and physician development (B11), fragmented and non-standardized clinical data (B14), lack of legislation on the use of clinical data (B8), and a lack of digitalization strategy for healthcare facilities (B12).

5 Conclusion

The elements of Health 4.0 represent an opportunity to transform the healthcare sector in the Slovak Republic from a purposefully compassionate system to a value-oriented and personalized system that can provide proactive preventive measures. The results will be reflected in the positive development of important indicators, e.g. life expectancy in health, reducing the number of avoidable deaths, increasing life expectancy at birth and others, due to increasing the quality of services provided in health care facilities. The barriers identified in this research will help public policy makers and managers of health care facilities to take concrete steps to enable the Health 4.0 program to be successfully implemented in the health care system of the Slovak Republic. The result of this study is an evaluation of key factors

according to importance. It is essential to design strategies in the long term that address high-priority barriers, thus enabling the opportunities offered by technical and technological progress to be fully exploited.

Literature:

1. Alaba, F. A.; Othman, M.; Hashem, I. A. T. & Alotaibi, F.: Internet of things security: A survey. Journal of Network and Computer Applications, 2017, Vol. 88, pp. 10 – 28. https://doi.org/10.1016/j.jnca.2017.04.002
2. Babiceanu, R. F., Seker R.: Big Data and virtualization for manufacturing cyber-physical systems: A survey of the current status and future outlook. Computers in Industry, 2016, Vol. 81, pp. 128-137. https://doi.org/10.1016/j.compind.2016.02.004
3. Benešová, A. & Tupa J.: Requirements for education and qualification of people in industry 4.0. Procedia Manufacturing, 2017, Vol. 11, pp. 2195–2202. https://doi.org/10.1016/j.promfg.2017.07.366
4. Bonczek, R. H. , Holsapple C. W. & Whinston, A. B.: Foundations of decision support systems. Academic Press, New York, 2014, p. 412. ISBN 9781483268729
5. Cline, G.: Industry 4.0 and industrial IoT in manufacturing: A sneak peek. 2017. [online]. [cit. 2020-10-10]. Available on: https://www.aberdeen.com/featured/industry-4-0-industrial-iot-manufacturing-sneak-peek/#iLightbox[gallery37632]/null
6. Eurostat (2019): Štatistika digitálnej ekonomiky a spoločnosti – domácnosti a jednotlivci. [online]. [cit. 2020-11-10]. Available on: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals/sk
7. Frey, C. B. & Osborne, M. A.: The future of employment: how susceptible are jobs to computerisation? Technological Forecasting and Social Change, 2017, 114 (C), pp. 254-280. https://doi.org/10.1016/j.techfore.2016.08.019
8. Gehrke, L.; Kühn, A.; Rule, D. , Moore, P. et all: A discussion of qualifications and skills in the factory of the future: a German and American perspective. VDI/ ASME Industry, 2015, 4:1–28. [online]. [cit. 2020-11-05]. Available on: https://www.researchgate.net/publication/279201790_A_Discussion_of_Qualifications_and_Skills_in_the_Factory_of_the_Future_A_German_and_American_Perspective
9. Christians, A. & Liepin, M.: The Consequences of digitalization for german civil law from the national legislator's point of view. Zeitschrift fuer Geistiges Eigentum/Intellectual Property Journal, 2017, Vol. 9, pp. 331–339. http://doi.org/10.1628/186723717X15069451170900
10. Hecklau, F., Galeitzke, M., Flachs, S., Kohl, H.: Holistic approach for human resource management in industry 4.0. Procedia CIRP, 2016, Vol. 54, pp. 1-6. https://doi.org/10.1016/j.procir.2016.05.102
11. Jain, V. & Raj, T.: Modeling and analysis of FMS performance variables by ISM. SEM and GTMA approach International J Production Economics, 2016, 171:84–96. https://doi.org/10.1016/j.ijpe.2015.10.024
12. Kagermann, H., Lukas, W. D. & Wahlster, W.: Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution. VDI nachrichten 13. No 13, 2011. [online]. [cit. 2020-10-01]. Available on: http://www.wolfgang-wahlster.de/wordpress/wp-content/uploads/Industrie_4_0_Mit_dem_Internet_der_Dinge_auf_dem_Weg_zur_vierten_industriellen_Revolution_2.pdf
13. Kamble S., Gunasekaran, A, Sharma, R.: Analysis of the driving and dependence power of barriers to adopt industry 4.0 in Indian manufacturing industry. Computers in Industry, 2018, Vol. 101, pp. 107–119. https://doi.org/10.1016/j.compind.2018.06.004
14. Kamigaki, T.: Object-Oriented RFID with IoT. A Design Concept of Information Systems in Manufacturing. Electronics, 2017, Vol. 6(1):14. https://doi.org/10,3390/elektronika6010014
15. Lee, J., Kao, H. A. & Yang, S.: Service innovation and smart analytics for industry 4.0 and big data environment. Procedia Cirp, 2014, Vol. 16, pp. 3–8. https://doi.org/10.1016/j.procir.2014.02.001
16. Li, S., Da Xu, L. & Zhao, S. (2015). The internet of things. A survey Information Systems Frontiers, 2015, Vol. 17, pp. 243-259. https://doi.org/10.1007_s10796-014-9492-7
17. Moderné zdravotníctvo 2019. [online]. [cit. 2020-09-16]. Available on: http://www.modernezdravotnictvo.sk/
18. Nariadenie EP a Rady (EÚ) 2016/679 o ochrane fyzických osôb pri spracúvaní osobných údajov a o voľnom pohybe takýchto údajov (GDPR)
19. NCZI: Statistical. [online]. [cit. 2020-11-16]. Available on: http://www.nczisk.sk/Statisticke_vystupy/Zdravotnicka_rocenka/Pages/default.aspx
20. Pace, P., Aloi, G., Gravina, R., Caliciuri, G., Fortino, G., & Liotta, A.: An edge-based architecture to support efficient applications for healthcare industry 4.0. IEEE Transactions on Industrial Informatics, 2018, Vol. 15(1), pp. 481-489. [online]. [cit. 2020-11-22]. Available on: https://scholar.google.com/citations?user=DLa81JMAAAAJ&hl=en
21. Raghupathi, W. & Raghupathi, V.: Big data analytics in healthcare: promise and potential. Health Info Sci Syst, 2014, 2:3. https://doi.org/10.1186 / 2047-2501-2-3
22. Ryan, P. J. & Watson, R. B.: Research challenges for the internet of things: What role can OR play? Systems, 2017, Vol. 5 (1), pp. 24. https://doi.org/10.3390/systems5010024
23. Qi, J., Yang, P., Min, G., Amft, O., Dong, F. & Xu, L. (2017). Advanced internet of things for personalised healthcare systems. A survey, Pervasive and Mobile Computing, 2017, Vol. 41, pp. 132-149. https://doi.org/10.1016/j.pmcj.2017.06.018
24. Qureshi, M. O. & Syed, R. S.: The impact of robotics on employment and motivation of employees in the service sector, with special reference to health care. Saf Health Work, 2014, 5(4), pp.198-202. https://doi.org/10.1016 / j.shaw.2014.07.003
25. Schrauf, S. & Berttram, P.: Industry 4.0: How Digitization Makes the Supply Chain More Efficient, Agile, and Customer-Focused. Pricewaterhouse Coopers: London, UK, 2016. [online]. [cit. 2020-12-10]. Available on: https://www.strategyand.pwc.com/gx/en/insights/2016/digitization-more-efficient.html
26. Schröder, C.: The challenges of industry 4.0 for small and mediumsized enterprises. Friedrich-Ebert-Stiftung: Bonn, Germany, 2016. ISBN 978-3-95861-543-4
27. Sushil: Flowing Stream Strategy: Managing Confluence of Continuity and Change. Journal of Enterprise Transformation, 2012, 2: 26–49. https://doi.org/10.1080/19488289.2011.650280
28. Thuemmler, Ch. & Bai, Ch.: Health 4.0: how virtualization and big data are revolutionizing healthcare. Springer, New York, 2017, ISBN: 978-3-319-47617-9
29. Tupá, M., Masárová, T., Karbach, R.: Implementácia prvkov konceptu Industry 4.0 v zdravotníctve SR. In: The Impact of Industry 4.0 on Job Creation 2020. Proceedings of scientific papers from the international scientific conference. TnUAD, Trenčín 2021. pp. 477-487. ISBN 978-80-8075-939-1
30. Yan, Z., Zhang, P., & Vasilakos, A. V.: A Survey on Trust Management for Internet of Things. Journal of Network and Computer Applications, 2014, Vol. 42, pp. 120 - 134. https://doi.org/10.1016/j.jnca.2014.01.014
31. Zákon č. 18/2018 Z. z. o ochrane osobných údajov
32. Zákon č. 69/2018 Z. z. o kybernetickej bezpečnosti

Primary Paper Section: F

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