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Evaluation of eHealth Deployment at Primary Care in the EU Member States by Usage of Selected MCDM Methods

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Abstract: Information and Communication Technologies have become a revolutionary part of European healthcare in recent years. The European Commission considers eHealth as an important and appropriate tool that can contribute to cope with the challenges that are currently affecting the healthcare systems in Europe. The development of eHealth is therefore embedded in many EU strategies and is being evaluated on an ongoing basis. In the past, several studies have been carried out focusing on the evaluation of individual areas of eHealth - especially on the area of primary care secured by General Practitioners and Acute Hospitals. However, no synthesis of these works was made. This paper is focused on the proposing of an assessment for both mentioned areas of eHealth. The aim is to evaluate the eHealth deployment in the European Union Member States by the synthesis of Composite Indicators in existing studies into the evaluation model based on the application of Multiple-Criteria Decision-Making techniques. The evaluation is performed by the usage of TOPSIS, WSA, and MAPPAC method. The result of the research is the design of an evaluation framework for eHealth that enables the comparison of eHealth indicators in the international context and evaluation of eHealth deployment in European Union Member States in the form of a ranking. In this ranking, the Nordic countries are among the best-rated countries, while the worst-rated countries are in Eastern Europe.

Keywords: eHealth; European Union; EU countries; Evaluation; MCDM

JEL Classification: C38, H11, I11

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Introduction

Electronic healthcare, eHealth, or commonly used term "Health Information Technology" (HIT) is one of the current global modern trends in informatics, medicine, and politics (WHO, 2016a; Oh et al., 2005). It is a broad term that refers to the electronization of healthcare and health services and mainly describes the use of Information and

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Communications Technologies (ICT) in healthcare (European Commission, 2004; Eysenbach, 2001; Adebesin, 2013). eHealth is practiced and dealt with in most developed countries and, of course, also in European Union Member States. It is considered as an opportunity to meet the challenges caused by an aging society and the dramatically rising costs of healthcare (Chaudhry et al., 2006). As stated by Ross et al. (2015) or Chaudhry et al. (2006), there is a great potential of eHealth to deliver cost-effective and quality healthcare. The importance is also demonstrated by spending on eHealth by governments and healthcare systems, which is increasing worldwide (Truffer, 2010 and European Commission, 2012a).

eHealth includes health services such as electronic health records, electronic drugs prescribing, or health information systems, see Ahad et al. (2019) or Ben-Assuli (2015). As stated by many authors, it brings clear benefits for patients, doctors, and the entire health systems (Codagnone and Lupianez Villanueva, 2011; Currie and Seddon, 2014). eHealth is also a crucial issue within the European Union (EU) policy nowadays. The EU policy intends to link individual national eHealth projects and to coordinate them (European Commission, 2018). This effort is one part of the eEurope action plan approved in 2000, see (European Commission, 2012b). As stated by Bujnowska-Fedak (2015), the coordination of eHealth projects involves above all the rapid access to shared remote medical expert assessments through ICT; therefore, these solutions are of interest currently.

The presented article is focused on the evaluation of eHealth in primary care in the EU. The aim is a design of eHealth deployment assessment model for the EU Member States using the multi-criteria decision making (MCDM) methods (TOPSIS, WSA, and MAPPAC). In this research, eHealth was evaluated based on the synthesis of Composite Indicators of eHealth processed by the European Commission in the field of General Practitioners and Acute Hospitals. The input data comprised the results of "Benchmarking Deployment of eHealth among General Practitioners", see European Commission (2013) and European Commission (2018), and "European Hospital Survey: Benchmarking Deployment of eHealth Services "; see European Commission (2014). The empirical part of this article was processed by the usage of the SANNA software (System for Analysis of Alternatives), see more in Jablonský (2009).

MCDM methods were used because they represent a suitable tool for the selection and creation of the ranking of the larger number of variants, see Fiala (2008). The purpose of the presented research is to synthesize the results of eHealth evaluations of the European Commission presented in individual studies focusing on selected eHealth areas in primary care. The results are presented in the form of Composite Indicators, which were used as a base of the assessment processes in this research. The output is a comprehensive evaluation of eHealth deployment at primary care in the EU Member States and the design of an evaluation model using MCDM methods. This synthesis has not been carried out yet by other authors or European Commission, although it has been proposed by the European Commission, see (European Commission, 2013).

In practice is the evaluation of eHealth an important matter because it leads to the selection of appropriate measures for further progress in the field of electronic healthcare and to propose recommendations for the development of eHealth in the EU countries (European Commission, 2019; OECD, 2019 or Raghavan et a., 2015).

Implementation of eHealth in the Context of eGovernment Development

eHealth is the subject of interest of major global international organizations (European Commission, 2012a). The evidence base for the benefits of eHealth has been established by World Health Organisation (WHO), that in 1998 recognised the importance of regulating cross-border advertising and the promotion of medical products through the internet (WHO, 1998). In 2005 WHO adopted a resolution on eHealth (WHO, 2005), that invited the WHO Member States to conceive and implement health information systems, to evaluate eHealth activities and to share knowledge on cost-effectiveness, thus ensuring quality, safety, ethical standards, data confidentiality, privacy, equity and equality (European Commission, 2013). According to the WHO report, see WHO (2016b), more than half of WHO Member States have an eHealth strategy. Actual recommendations of WHO on digital interventions for health system strengthening are set down by recommendations on digital interventions for health system strengthening, see (WHO, 2019).

eHealth is also highly supported in European countries. European Commission is considering eHealth as an appropriate tool to cope with the actual challenges of European health systems, including the system sustainability ensuring and quality preserving in the context of the ageing population (European Commission, 2013). The quality of the health system is together with the good health of the citizens the priority in all EU Member States (Gulliford and Morgan, 2003). The importance of this economic sector is demonstrated by the spending on health services that are explicitly rising worldwide in the last decades (OECD, 2012). The main reason for this trend is connected with the consequence of demographic change and improvements in medical treatment in Europe. Public expenditure on health and long-term care has been increasing over the last decades in all EU countries and is expected to rise even further as a consequence of an aging population (European Commission, 2013; Lau and Kuziemsky, 2016). In 2015, it accounted for 8.7 % of GDP in the EU and could reach up to 12.6 % of GDP in 2060, according to the European Commission's "Joint Report on Health Care and Long-term Care Systems and Fiscal Sustainability" (European Commission, 2019). However, another factor influencing the growth of expenditures in healthcare is the involvement of ICT. ICT implementation in this area is a rapidly evolving and expensive resort, which is why the financial demand for healthcare is increasing (Health ICT Industry Group, 2009).

eHealth Definition

eHealth is the collective term used to refer to tools and services that use modern ICT that can improve prevention, diagnosis, treatment, monitoring, and management of health in health care (Eysenbach, 2001). As stated by Lau and Kuziemsky (2016), it is important to note that the term eHealth is used slightly differently across countries. According to European Commission, eHealth is defined as the use of ICT in health products, services and processes combined with organisational change in healthcare systems and new skills, to improve the health of citizens, efficiency and productivity in healthcare delivery, and the economic and social value of health (European Commission, 2012b).

eHealth is also the question of lifestyle. It comprises the acquisition, management, storage, and usage of health information in connected networks, see Bujnowska-Fedak (2015). According to Jung and Loira (2010) and European Commission (2013 and 2018)

is considered as potential tool to improve access to care and quality of care. It is the way how to support information exchange, reduce costs, improve the quality of patient care, and increase the efficiency of the health sector, see European Commission (2012b). eHealth covers areas such as information and data sharing (between patients and health service providers, hospitals, health professionals and health information networks), electronic health records, telemedicine services, portable patient-monitoring devices, operating room scheduling software or robotised surgery (Europa, 2018, Dobrev et al. (2008).

According to European Commission (Europa, 2018 or WHO, 2016a), digital technology can improve health and care provision, allowing citizens to live longer and more healthy life years, and it can help innovating the way we deliver and receive health and care services. Digital technologies such as 4G/5G mobile communication, artificial intelligence, or supercomputing offer new opportunities to transform healthcare systems, see Ahad et al. (2019). They enable new approaches to personalized medicine, independent living or integrated health and social care, accelerating scientific progress, early diagnosis of diseases, and more effective treatments (European Commission, 2019).

Challenges and Barriers of eHealth Development

The real implementation of eHealth in European countries is, to a large extent, linked to the level of eGovernment in individual countries (WHO, 2016b). In the area of communication between citizens and government are widely used electronic communication technologies in recent decades (Abu-Shanab and Bataineh, 2014). The computerization of government is called "eGovernment", see Heeks (2001) or OECD (2003). Internet and the usage of ICT caused and enabled the development of many spheres of life as well as services; see Walczak and Pólkowski (2013). Also, the field of medical services is no exception. So, eGovernment currently includes inter alia also the computerization of health care (OECD/EU, 2016). eHealth gradually came out of a wider field of eGovernment. However, the success factors and implementation problems are largely similar (Stroettman et al., 2011). Recognising and understanding success factors and barriers is crucial for the implementation of strategies and interventions to improve the use of eHealth and addressing blockages to implementation (Ross et al., 2015).

The basic factors of successful implementation of eGovernment according to Heeks (2001) are built on three pillars:

- technology architecture, interoperability, and standardization,
- harmonization of data and systems,
- information management and security

Abu-Shanab and Bataineh (2014) describe the key success factors of eGovernment projects. They are classified into three main dimensions: infrastructure-related, human-related, and government-related. According to Alshehri and Drew (2010), the common challenges of eGovernment implementation comprise:

- technical barriers – ICT infrastructure and privacy and security (OECD, 2003)
- social barriers – digital divide and culture and attitude
- organizational barriers – management support, resistance to change, collaboration, lack of technical support

- financial barriers – high implementation and maintenance cost (Gil-Garcia and Pardo, 2005; Al-Wohaibi et al., 2002)

eGovernment for Development Information Exchange project coordinated by the University of Manchester's Institute for Development Policy and Management, see (egov4dev, 2008) states, that eHealth success and failure mainly depends on the size of the gap that exists between "current realities" and "design of the eHealth project". The larger this design-reality gap, the greater the risk of eHealth failure. Equally, the smaller the gap, the greater the chance of success. Analysis of eHealth projects indicates that seven dimensions are necessary and sufficient to provide an understanding of design-reality gaps: information, technology, processes, objectives and values, staffing and skills, management systems and structures, and other resources (time and money).

Huang and Bwoma (2003) deal with the successful implementation of eGovernment and recommendations. Crucial parts are strategic planning of government when developing governmental websites. IT projects are cumbersome, controversial, and expensive. For this reason, for projects to survive and succeed, there must be political will and leadership support to ensure smooth implementation. The same is true for eHealth projects. The main conditions for success dealt by Adebesin et al. (2013) comprise: understanding of the significance of eHealth, initialization of ICT infrastructures, involvement in eHealth standards development and human resource capacity for eHealth standard development (Adebesin et al., 2013; Truffer et al., 2010).

There are initialized a large number of national initiatives designed to eHealth implementation worldwide, and this trend is increasing, see Waterson (2014). He describes the most frequently used examples of eHealth technologies: management systems, computerised decision support systems, communication systems, and information resources. According to Ross et al. (2015), despite the potential benefits of eHealth, implementation of these systems is often reported as problematic. For example, the implementation of electronic health records and electronic prescribing systems has lagged in most European nations as well as in the USA until 2013 (Ben-Assuli, 2015).

As main eHealth implementation obstacles are described financial, legal, social and ethical barriers as well as security concerns (Currie and Seddon, 2014 and Mair et al, 2012). According to European Commission, the most important barriers in primary healthcare include the lack of financial incentives, lack of time or training, lack of technical support, lack of framework on confidentiality and privacy and lack of sufficient ICT skills or motivation (Alshehri and Drew, 2010; European Commission, 2018).

However, as stated by Healthcare Information and Management Systems Society (HIMSS) it is also important to realize, that the development of eHealth is not driven only by the governments of individual countries or international organizations, but also by the companies in the technology sectors because they are responsible for the transformation of health care systems and for sharing knowledge (HIMSS Europe, 2020 or Abu-Ahanab and Bataineh (2014).

eHealth Tools of the European Union

ICT has become an essential part of European healthcare in recent years (European Commission, 2019). Although eHealth tools and services have been well established in many EU countries, they are commonly used today, but very often, individual

healthcare facilities, hospitals, or physicians chose the best, individual system for themselves without any coordination (European Commission, 2018; Health ICT Industry Group, 2009). So, the implementation of eHealth in individual European member states is greatly fragmented and disparate nowadays, see Lau and Kuziemsky (2016). eHealth concept in the individual EU Member States is mainly influenced by the concept of eHealth in the EU legislation and the recommendations of the World Health Organization (WHO, 2016a or WHO 2016b).

Therefore, the potential cross-system communication is here yet one of the main steps that can encourage and enhance the benefits of computerization (European Commission, 2019). For this reason, the aim of the European Union health policy is to link and coordinate individual national eHealth projects. This effort is also a part of the "European eHealth Action Plan" that covers the period from 2012 to 2020, see (European Commission, 2012b). This is an overview of EU actions contributing to the creation of a European eHealth area (Europa, 2018). It was launched in March 2011 as the second strategy (after 2004 - 2010 strategy) dedicated to the issue of healthcare electronisation in the EU. It provides a long-term vision of European eHealth in synergy with other documents as "Europe 2020", the "Digital Agenda for Europe" or the "Digital Single Market strategy". Coordination includes fast access to shared and remote medical expertise through telecommunication and information technology, no matter where the patient or relevant information is located (Stroettman et al., 2011). Also, the "Horizon 2020 programme" contributes significantly to the area of digital technology for health and aging. In this context, the "European Innovation Partnership on Active and Healthy Ageing" provides a platform to link the efforts of many regions and ecosystems across Europe, some of which are recognized as reference sites on digital innovation for health and care (Europa, 2018).

In the European Union, where people are absolutely free to move to the other EU Member States, there is a need to engage in mutual communication that should ensure the highest standards of health care, whether patients are anywhere (Waterson, 2014; Stroettmann et al., 2011). The main aim is to build a common European eHealth space that will successfully solve this problem and thus become one of the main objectives of the European Commission's work. In 2012, the eHealth-focused working group of European Commission produced a report on "Redesign of Health in Europe by 2020", see European Commission (2012a), highlighting the major challenges that prevent the reorganization of European healthcare with the use of existing information technology (European Commission, 2004). The goals of the European Commission are mainly to improve citizens' health by making health information available using digital health and care tools, including across border, to increase healthcare quality and access by making digital health and care a part of health policy and coordinating EU member states' political, financial and technical strategies and to make digital health and care tools more effective, user-friendly and widely accepted by involving professionals and patients in strategy, design and implementation (European Commission, 2011; Europa, 2018).

Importance of eHealth in Primary Care

The widespread and effective use of eHealth in primary care is considered by the European Commission as pivotal (European Commission, 2019). Primary care is a key process in the health system (European Commission, 2018). It is first-contact, accessible,

continuous, comprehensive, and coordinated care given by a health care provider. First-contact care is accessible at the time of need (European Commission, 2013). Patients commonly receive primary care from professionals such as a primary care physician (general practitioner or family physician), a nurse practitioner (adult-gerontology nurse practitioner, family nurse practitioner, or pediatric nurse practitioner), or a physician assistant (WHO, 2018). The World Health Organization attributes the provision of essential primary care as an integral component of an inclusive primary healthcare strategy (WHO, 2019).

Adoption of eHealth tools and applications in primary care is mainly essential for strengthening European healthcare systems, see Greß et al. (2009). Above all, the general practitioners play an important role in facilitating access to, and delivery of care, see Atun (2004). They represent the first point of contact and gather important information needed across the whole of the health and social care systems (European Commission, 2019). Good quality of the country's primary care is positively associated with health outcomes, for example decreasing all-cause mortality, premature mortality as well as less frequent hospitalization and declining use of specialist and emergency care, see Macinko, et al. (2003) and WHO (2018).

Evaluation of eHealth in the European Union

eHealth deployment in Europe is the subject of evaluation of international organizations as the EU or OECD (OECD/EU, 2016). eHealth evaluation is described as an act to assess whether an eHealth system is functioning and producing the effects as expected (Lau and Kuziemsky, 2016). Fostering the development and implementation of national eHealth policies and strategies has been a key goal of the European Union eHealth Action Plan (European Commission, 2004). In 2011 the European Commission prepared an overview and synthesis report on eHealth in Europe "European countries on their journey towards national eHealth infrastructures - evidence of progress and recommendations for cooperative actions" analysing Action Plan priorities, see European Commission (2011). In 2016 in the cooperation with OECD was developed the joint Commission and OECD report "Health at a Glance: Europe 2016" (OECD/EU, 2016). New edition of "Health at a Glance" presents the most recent comparable data on the health system performance in OECD countries (OECD, 2019). There was noted that improvement in the adoption of digital technology in the primary care and hospitals is needed across Europe. However, there are monitored only a few comparable eHealth indicators. In 2017 the European Commission also published a Eurobarometer survey (TNS opinion & social, 2017) presenting European citizens' opinions on the impact of digitalisation and automation of health care. The eHealth study from 2017 "Transforming eHealth into a political and economic advantage", see (Arak and Wójcik, 2017), evaluated then the level of eHealth implementation in EU member states. The results demonstrate a lack of harmonisation of eHealth implementation within the EU and unsatisfactory access to cross-border healthcare.

Evaluation of eHealth in Acute Hospitals and among General Practitioners

The European Commission monitors in detail two areas of eHealth adoption. Adoption of eHealth in primary care by General Practitioners and by Acute Hospitals. General Practitioners and Hospitals with acute treatment play a crucial role in providing health

care, see European Commission (2013). There were carried out three measurements of eHealth adoption among General Practitioners in the European Union in 2007, see Dobrev et al. (2008), 2013, see European Commission (2013) and 2019 see European Commission (2019). The studies have the objective to measure the adoption of eHealth applications and functionalities among General Practitioners in the EU Member States, while at the same time explaining what drives or hampers it (European Commission, 2013). The data were gathered by the usage of interviews with General Practitioners and processed by the usage of multivariate statistical tools, see more in European Commission (2013 and 2019). There are used the four measurement indicators that emerged from the combined efforts of the European Commission, OECD, and WHO:

- Electronic Health Records (EHR) - systems that are used by healthcare professionals (doctors and nurses) to enter, store, view, and manage patient health and administrative information and data.
- Health Information Exchange (HIE) - is the process of electronically transferring / sharing / enabling access to patient health information and data.
- Telehealth - is the use of broadband-based technological platforms to provide health services, medical training, and health education over a distance.
- Personal Health Records (PHR) - are electronic systems allowing patients to have secure access to, and manage, their health information.

In relation to eHealth in Acute Hospitals, two surveys have been carried out with the aim of gathering data for benchmarking eHealth. The first one was carried out in 2010, see results in Codagnone and Lupiañez-Villanueva (2011), and the second one in 2013, see results in Sabes-Figuera and Maghiros (2013). The overall objective of the European Hospital Survey was assessing the level of eHealth usage in acute care hospitals in the EU Member States. To profile eHealth capabilities in the countries, there were selected 13 indicators, see European Commission (2014).

Nevertheless, the way how eHealth is evaluated and the actual implementation of the benchmarking exercises have not been as systematic as in other areas of the Information society (Codagnone and Lupiañez-Villanueva, 2011). This was caused by the multidimensional complexities of the field and by the higher cost and difficulty of getting the required data in comparison with other fields where web-based measurement is feasible and valid (e.g., eGovernment), see (Sabes-Figuera and Maghiros, 2013).

Material and Methods

The presented research is based on data set across multiple data sources, see European Commission (2014), Codagnone and Lupiañez-Villanueva (2011) and European Commission (2013). The input data formed Composite Indicators per area of Acute Hospitals and per area of General Practitioners, summarized in Tab. 1 and 2. Composite Indicators $CI_1 – CI_4$ describe the level of eHealth use in Acute Hospitals in the EU Member States. They cover the area of: Infrastructure, Medical Applications, Integration, and Security. Composite Indicators $CI_5 – CI_8$ describe the level of eHealth use among General Practitioners in EU Member States. They cover the area of: Electronic Health Record, Health Information Exchange, Telehealth, and Personal Health Record.

Results presented in the studies of European Commission concern only doctors working in primary care and hospitals with acute care. The results are presented in separate studies, and the results for both areas are not synthesized or related. So, it is not possible to draw from them conclusive generalisations on the status of eHealth adoption at primary care in general. For this reason, the presented research is focused on the synthesis of the results of the 2012 survey of eHealth Deployment in Acute Hospitals and the 2013 survey of the General Practitioners. The evaluation is performed by usage of averaging and by the usage of MCDM methods. In the case of averaging, the procedure was based on the construction of the Aggregated eHealth Deployment Index and was the same as for the construction of the Overall Composite Index of European Commission, see Codagnone and Lupiañez-Villanueva (2011) and Sabes-Figuera and Maghiros (2013). The Composite Indicators I_1- I_8 were assessed with equal weights (0.125) and averaged. It was necessary to convert the values to the same scale because there were used different scales in the original studies. Then the calculation was performed using MCDM methods (WSA, TOPSIS, and MAPPAC). MCDM methods were used because there is no need to convert data. They are objective and reflect the variability; for example, the range of values among countries, and they are designed for creating rankings.

Data and Composite Indicators

The original data were obtained using benchmarking methods by the European Commission surveys aimed at General Practitioners and Acute Hospitals. Benchmarking plays a crucial and fundamental role in enabling the Member States to monitor actual performance, enhance policy learning, and the on-going policy processes (Sabes-Figuera and Maghiros, 2013). There were identified the individual indicators, which were describing the selected areas of the survey. Then, factor analysis was performed on the individual variables, for more details see Codagnone and Lupiañez-Villanueva (2011). Weights of individual indicators were obtained from factor analysis. Then Composite Indicators were formed, on the bases, that individual indicators were compiled into a single index on the basis of an underlying conceptual model with the support of the empirical exploration of the dataset, see Sabes-Figuera and Maghiros (2013). To develop the Overall Composite Index, European Commission followed the steps described in the OECD-JRC Handbook on constructing composite indicators methodology and user guide, see OECD-JRC (2008).

In the area of Acute Hospitals, the indicators were grouped into four Composite Indicators of eHealth, see Table 1.

The Overall Composite Index for the area of Acute Hospitals was obtained by assessing equal weights (0.25) of four Composite Indicators. The procedure was similar in the case of General Practitioners study. The indicators were also grouped into four categories (Composite Indicators), see Table 2. Then the Overall Composite Index for the area of General Practitioners was determined.

Table 1 Composite Indicators of eHealth use in Acute Hospitals

Composite Indicator	Indicator	Characteristic
CI_1 - INFRASTRUCTURE ($I_1 – I_3$)	I_1 - Externally connected	Inter-connectivity between healthcare stakeholders. Access to the infrastructure outside the hospital - extranet systems, value-added networks and proprietary infrastructures.
	I_2 - Broadband > 50Mbps	High-speed broadband - enables the processing and transfer of an increasing amount of data, such as images, reports, telemonitoring services.
	I_3 - Single and unified wireless	Such infrastructure allows mobile access to different applications and services in every location of the hospital.
CI_2 - APPLICATIONS ($I_4 – I_8$)	I_4 - Single EPR shared by all departments	The unique file where patient clinical information is stored, managed, viewed, completed, and shared everywhere in the hospital.
	I_5 - PACS usage	PACS facilitates quick access to images and reports, reduces the number of duplicate images and easy acquisition of a chronological view of the patient's radiology history.
	I_6 - ePrescribing	Crucial to avoid prescription duplicates and errors.
	I_7 - Integrated system for eReferral	Crucial to avoid faxes or letter losses in communications between two medical directors.
	I_8 - Tele-monitoring	Useful for patients living with chronic illnesses or elderly patients.
CI_3 - INTEGRATION ($I_9 – I_{11}$)	I_9 - Exchange of clinical care information with external providers	The ability of the hospital to communicate with healthcare stakeholders those are outside the hospital in area of clinical care information.
	I_{10} - Exchange of laboratory results with external providers	The ability of the hospital to communicate with healthcare stakeholders those are outside the hospital in area of laboratory results.
	I_{11} - Exchange of radiology reports with external providers	The ability of the hospital to communicate with healthcare stakeholders those are outside the hospital in area of radiology reports.
CI_4 - SECURITY ($I_{12} – I_{13}$)	I_{12} - Clear and structured rules on access to clinical data	To ensure privacy of data and access to certain types of data.
	I_{13} - EAS for disaster recovery in less than 24 hours	EAS (Enterprise Archiving Strategy) enables users to restore clinical information facilities and information when necessary.

Source: Autors processing according to European Commission (2014) and Codagnone and Lupiañez-Villanueva (2011).

Table 2 Composite Indicators of eHealth use among General Practitioners

Composite Indicator	Indicator	Characteristic
CI_5 - Electronic Health Record ($I_{14} – I_{18}$)	I_{14} - Health info & data	Core functionalities of EHR (Electronic Health Record).
	I_{15} - Clinical Decision Support System' (Clinical DSS)	Contraindications, Drug-drug interactions, Drug-lab interactions, Drug-allergy alerts, Clinical guidelines, alerts to a critical laboratory value.
	I_{16} - Order-Entry & Result Management' (OERM)	Medication list, Prescriptions / medications, Immunizations, Lab test results and Ordered tests.
	I_{17} - Image	Radiology test images and Radiology test reports.
	I_{18} - Administrative	Aspects of EHR.
CI_6 - Health Information Exchange ($I_{19} – I_{21}$)	I_{19} - Clinical Data	Exchange of health-related information.
	I_{20} - Patient Administration	Certification and other administrative purposes.
	I_{21} - Management	Exchange of data with payers (i.e., insurances) and other healthcare providers.
CI_7 - Telehealth ($I_{22} – I_{23}$)	I_{22} - Professional to Patient	Consultations with patients and Remote monitoring of patients at home.
	I_{23} - Professional to Professional	Use of telehealth for professional training purposes and consultation with other healthcare practitioners.
CI_8 - Personal Health Record ($I_{24} – I_{25}$)	I_{24} - Clinical information	Include View medical records, Supplement medical records, and View test results.
	I_{25} - Requests	Include Request referrals, Request appointments, and Request renewals or prescriptions.

Source: European Commission (2013)

Model and Methods

Multi-criteria decision models are used in various cases with multiple criteria. They are described by a set of variants, a set of evaluation criteria, and the links between the criteria and the variants (Fiala, 2008). In this research, a discrete model is used, where a final set of variants $A = \{a_1, a_2, \ldots, a_p\}$ is given, which is evaluated according to the set of criteria $F = \{f_1, f_2, \ldots, f_k\}$. Variants and criteria are arranged in a criterion matrix y_{ij}, where $i = 1, 2, \ldots p$ and $j = 1, 2, \ldots, k$. The purpose of this model is to arrange a set of variants (the ranking of variants). In the research, there was selected the final list of 28 variants (EU Member States) and eight criteria (Composite Indicators). The ranking of EU Member States according to the eHealth deployment was performed by a synthesis of results of TOPSIS, WSA, and MAPPAC methods. All mentioned MCDM methods provide the complete ranking of the variants starting from the best towards the worst one. However, each method is based on a different principle. TOPSIS method is based on the usage of the principle of minimizing the distance from the ideal option. It arrang-

es the alternatives according to the indicator of relative distance from baseline (hypothetically worst) alternative (Chen and Hwang, 1992). This method determines in the result the overall order of alternatives. WSA method is based on the principle of utility maximization. It arranges the alternatives in the order according to the total utility, which is taking into account all represented criteria. MAPPAC method evaluates according to the preferential relations, it is based on a paired comparison of variants in terms of each pair of individual criteria leading to the decision which of the two objects are considered better, or whether they are indistinguishable in terms of the criteria (Matarazzo, 1991).

Selected MCDM methods were applied from the following reasons:

- they have the same requirements for input (information on the weights of the criteria is required),
- every individual MCDM method is based on the different principle (good verification of the result),
- the evaluation of variants according to individual criteria can be in different units, and at different scales, the values are during the calculation normalized (different scales are used)
- they allow the objective comparison of the resulting arrangement of variants (the decision-maker does not intervene in the further course of the calculation)

The application of TOPSIS method (The Technique for Order of Preference by Similarity to Ideal Solution) is described in Yoon and Hwang (1995). TOPSIS method is frequently used nowadays to solve problems in both public and private sectors, for example Karadayi and Karsak (2014) used TOPSIS for evaluation of performance in health system or Vrabková et al. (2019) for evaluation of social care in the public sector of the Czech Republic. Ardielli (2019) used TOPSIS for the evaluation of good governance in public administration. The process of TOPSIS procedure is as follow:

- data are organized into the criteria data matrix,
- the normalized data matrix is created,
- weight normalized data matrix is created
- determination of the ideal and basal variant relative to the matrix values
- distance calculation of variants from the ideal variant, respectively basal variant is made
- calculation of the relative distance indicator of variants from basal variant
- creation of the ranking by non-growing values of relative distance indicator c_i.

The calculation of the relative distance indicator of variants from basal variant is processed by formula (1):

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{1}$$

where $i = 1,2, \ldots m;$

The values of the calculated index range between 1 and 0. Value 0 corresponds to the basal variant; value 1 corresponds to the ideal alternative.

The application of WSA method (Weighted Sum Approach) is described by Chen and Hwang (1992) and consists of :

- compilation of the criteria data matrix,
- normalization of input data
- calculation of the utility value of individual variants
- ranking of the variants according to the utility

Calculation of the total utility according to the following formula (2):

$$u(a_i) = \sum_{j=1}^{k} v_j r_{ij} \quad (2)$$

where $u(a_i)$ is the total utility of the variant a_i, r_{ij} are normalized values from the previous step, v_j is the weight of j-th criteria and k is the number of criteria.

The MAPPAC (Multicriterion Analysis of Preferences by means of Pairwise Actions and Criterion comparisons) is described by Matarazzo (1991) as follows:

- design of the criteria data matrix,
- normalization of the criteria data matrix,
- the paired comparison of variants is processed (two relations are possible preference or indifference),
- preferences are aggregated, resulting in a final order

The row totals of the aggregated matrix π are calculated according to the equation (3):

$$\sigma^l(a_i) = \sum_{j=1}^{p} \pi(a_i, a_j),\ i \in J^l \quad (3)$$

Variants with the highest σ^l values are placed in the first place in the arrangement. The set of variants is reduced from these variants, new set of variants A^l is created, the set of indexes of variants from A^l are marked as J^l. The procedure is repeated for m steps where m is the number of indifference classes by the arrangement from above.

In a similar procedure is reached the value of $\tau^1, \tau^2, \ldots, \tau^n$, where n is the number of indifference classes in the arrangement from below, by the usage of equation (4):

$$\tau^t(a_i) = \sum_{j \in J^t} \pi(a_j, a_i),\ i \in J^t,\ t = 1, 2, \ldots n. \quad (4)$$

From the obtained arrangements from above and below, the resulting arrangement can be obtained according to the average sequence numbers of the variants.

Results and Interpretations

In this section of the paper, there are presented the application results of the research. They are divided into two parts:

- Calculation of Aggregated eHealth Deployment Index
- Creation of the order of EU countries using the synthesis of MCDM methods

Calculation of Aggregated eHealth Deployment Index

First, the synthesis of the results of the 2012 survey of eHealth Deployment in hospitals and the 2013 survey of the General Practitioners is based on the construction of the Aggregated eHealth Deployment Index. In Tab. 3, there are summarized the results of eHealth deployment in EU countries according to the Aggregated Index. Values were converted to a scale of 0 to 1.

Table 3. Evaluation of eHealth Deployment in EU countries by the usage of Aggregated Index

Order	Variant	Aggregated Index (0-1)	Order	Variant	Aggregated Index (0-1)
1	Denmark	0,641	15	Portugal	0,427
2	Estonia	0,580	16	Cyprus	0,423
3	Finland	0,572	17	Germany	0,420
4	Sweden	0,562	18	Czech Republic	0,414
5	Netherlands	0,551	19	Croatia	0,400
6	United Kingdom	0,547	20	Hungary	0,398
7	Malta	0,543	21	Romania	0,382
8	Spain	0,526	22	Bulgaria	0,358
9	Austria	0,499	23	Slovakia	0,341
10	Belgium	0,491	24	Latvia	0,334
11	Luxembourg	0,484	25	Slovenia	0,333
12	Italy	0,473	26	Greece	0,327
13	Ireland	0,464	27	Poland	0,314
14	France	0,437	28	Lithuania	0,302

Source: Own research

The values of the index range from 0.641 in case of Denmark to 0.302 (Lithuania). It follows that eHealth in Denmark is up to 33.9 % higher than in Lithuania. EU average is 0.448. The five top ranking countries are Denmark, Estonia, Finland, Sweden and Netherlands. The five worst ranking countries are Latvia, Slovenia, Greece, Poland and Lithuania.

Creation of the order of EU countries using the synthesis of MCDM methods

The results of the EU countries ranking (Tab. 3) obtained using the Aggregated Index were refined and validated by application of selected MCDM methods - TOPSIS, WSA, and MAPPAC. All criteria, see criteria data matrix in Tab. 4, processed by selected MCDM methods, were maximizing nature. In calculations, there are also considered the weights of individual criteria. All the criteria were the same weight as they are equally relevant to the assessment of the eHealth in the EU Member States, see Sabes-Figuera and Maghiros (2013).

Table 4 Criteria data matrix D

	CI_1	CI_2	CI_3	CI_4	CI_5	CI_6	CI_7	CI_8
Austria	2,868	1,776	1,284	1,09	0,727	0,653	0,378	0,483
Belgium	2,875	1,758	1,215	1,13	0,702	0,644	0,424	0,410
Bulgaria	2,746	1,313	1,138	1,109	0,422	0,398	0,112	0,359
Croatia	2,636	1,692	1,26	1,135	0,629	0,524	0,168	0,195
Cyprus	2,583	1,445	1,494	1,041	0,546	0,452	0,510	0,232
Czech Republic	2,816	1,743	1,567	1,259	0,422	0,501	0,274	0,269
Denmark	3,227	3,041	1,381	2,308	0,934	0,809	0,430	0,465
Estonia	3,034	2,75	1,251	1,478	0,761	0,793	0,464	0,493
Finland	3,041	2,395	1,676	1,242	0,907	0,728	0,302	0,549
France	3,093	1,886	1,312	1,175	0,611	0,487	0,198	0,331
Germany	2,894	1,646	1,239	1,289	0,529	0,502	0,187	0,375
Greece	2,047	1,275	1,528	1,229	0,338	0,544	0,078	0,133
Hungary	2,845	1,609	1,785	1,154	0,338	0,589	0,118	0,291
Ireland	3,132	1,716	1,443	1,081	0,773	0,501	0,202	0,393
Italy	3,140	2,032	1,476	1,223	0,599	0,603	0,178	0,439
Latvia	2,167	1,298	1,081	1,082	0,524	0,364	0,22	0,158
Lithuania	1,393	1,471	0,955	1,076	0,505	0,38	0,063	0,244
Luxembourg	2,756	1,355	1,232	1,088	0,895	0,631	0,28	0,461
Malta	2,126	1,255	1,452	1,048	1,000	0,749	0,607	0,521
Netherlands	3,329	2,190	1,537	1,426	0,866	0,686	0,346	0,393
Poland	2,181	1,259	1,35	1,194	0,277	0,438	0,082	0,216
Portugal	2,803	1,845	1,179	1,508	0,655	0,547	0,182	0,198
Romania	2,467	1,553	1,464	1,232	0,485	0,365	0,101	0,427
Slovakia	2,393	1,231	1,304	1,081	0,341	0,470	0,168	0,243
Slovenia	2,128	1,318	1,467	1,308	0,566	0,338	0,057	0,146
Spain	3,157	2,356	1,572	1,547	0,708	0,615	0,264	0,465
Sweden	2,855	2,305	1,322	1,555	0,899	0,715	0,381	0,492
United Kingdom	3,221	2,009	1,458	1,597	0,866	0,604	0,278	0,556
Wieghts	0,12500	0,12500	0,12500	0,12500	0,12500	0,12500	0,12500	0,12500

Source: Own research

Based on the results of selected MCDM methods, it was possible to determine the order of the EU Member States in terms of the eHealth deployment, from the best to the worst. The results of all methods were compared and synthesized in Tab. 5. The overall arrangement of variants was reached by averaging of the serial numbers of variants. As the best evaluated is the option that has the lowest overall serial number. The overall ranking is displayed in the table as an Overall Score. Some countries have the same Overall Score.

Table 5 Evaluation of eHealth in EU member states by MAPPAC method

Variant	TOPSIS	WSA	MAP-PAC	OVERALL SCORE	Variant	TOPSIS	WSA	MAP-PAC	OVERALL SCORE
Denmark	1	1	1	1	France	16	14	12	14
Estonia	2	3	3	2	Cyprus	11	17	15	15
Finland	5	2	2	3	Hungary	19	16	13	16
Sweden	3	4	5	4	Germany	17	19	14	17
Nether-lands	6	5	4	5	Portugal	18	18	14	17
United Kingdom	7	6	5	6	Romania	20	20	16	18
Malta	4	8	7	7	Croatia	21	21	16	19
Spain	10	7	6	8	Bulgaria	22	22	17	20
Austria	9	9	8	9	Slovakia	24	23	19	21
Belgium	8	11	9	10	Greece	26	24	18	22
Italy	13	10	8	11	Slovenia	25	25	18	22
Luxem-bourg	12	12	11	12	Latvia	23	27	21	23
Ireland	14	13	10	13	Poland	27	26	20	24
Czech Republic	15	15	12	14	Lithuania	28	28	22	25

Source: Own research

Assessment of the state of eHealth in the EU member states based on MCDM method refined the results obtained by assessment with the usage of Aggregated Indicator, by the design of the ranking of EU countries. All used methods showed similar results. On the best five places by Overall Score ranked Denmark, Estonia, Finland, Sweden, and the Netherlands. The worst state of eHealth was found out in Greece, Slovenia, Latvia, Poland, and Lithuania. From the values of the total relative distance indicator c_i in the TOPSIS method, it is obvious that the differences between the EU countries are significant. While the value of the best result (Denmark) reaches values of 0.77877, the worst result value (Lithuania) is 0.14555.

It is clear from the results that the eHealth deployment at primary care varies among EU countries. The implementation of EHR is often considered as a necessary condition for the further development of eHealth in primary and secondary care (European Commis-

sion, 2014). In 2013 EHR was the most widespread functionality of eHealth among General Practitioners – Composite Indicator CI_5 (value 0.678 of Aggregated Indicator). The adoption level of other functionalities (CI_6, CI_7, and CI_8) was much lower (HIE – 0.442, Telehealth – 0.343, and PHR – 0.319). The implementation of EHR, Telehealth, and PHR in Acute Hospitals was averaged (CI_2 - Applications), with a value of 0.558 of Aggregated Indicator. Electronic exchange of medical information in the case of hospitals (CI_3 - Integration), was the lowest value (0.252), which proves that the sharing of medical information electronically in hospitals was very limited. On the contrary, in the area of Infrastructure (CI_1), which includes the inter-connectivity, transfer of data, and mobile access, the value is above-average (0.637). The below-average value also reached the area of Security (CI_4), including the privacy of data (0.355).

The implementation differences between countries are also considerably. Nordic countries (Denmark, Finland, and Sweden) end Estonia are the overall leaders according to the assessment of eHealth indicators across the EU Member States. Conversely, the lesser performing are Eastern and Southern Countries.

Discussion

Based on the evaluation of eHealth in the EU Member States in the year 2013, it was found that Denmark, Finland, Estonia, Sweden, and the Netherlands are on the top among EU member states when evaluating the practical usage of eHealth. These countries are the countries with well-developed internet usage and advanced implementation of eGovernemnt (WHO, 2016a; OECD, 2019). Estonia is considered to be the leader among the Eastern European countries in eGovernment (European Commission, 2019). The citizens there are generally keen on the usage of internet, eGovernment and eHealth applications. In Denmark, for example, using the health and care services provided online at least once in the year 42 % of citizens (in Finland 49 % and in Estonia 49 %), see TNS opinion & social (2017). As stated by Raghavan et al (2015), the internet usage and literacy levels of a region are also often associated, for example, with higher levels of EHR adoption.

According to the study "Transforming eHealth into a political and economic advantage", see (Arak and Wójcik, 2017), the implementation of electronic health records, ePrescriptions, and national eHealth programmes varies significantly across EU member states. The best evaluated are Denmark, Finland, Spain, and Sweden that have the most developed eHealth solutions. The result is similar to the research presented in this article. A highly unsatisfactory state of eHealth was found in the case of Latvia, Poland, and Lithuania. According to Arak and Wójcik (2017), eHealth is the least developed in Bulgaria, Poland, and Cyprus. For example, in Poland, although there has been implemented various innovative projects of computerizing of the health system, there is a lack of principal rules necessary in the field of computerizing and incomplete coordination of IT actions between the health care units and governmental ones. Also, the on-line services lack the basic elements significant when it comes to contact with the patients; see Walczak and Pólkowski (2013). However, there are also countries ranked near the average among the EU Member States. In these countries, there are mainly serious shortcomings, particularly on the side of public digital services providers. Changing the attitude of government officials in the area of eHealth promotion is therefore required (Czech Republic, Hungary).

While EHR was the most advanced eHealth functionality across EU Member States (CI_5), the greatest shortcomings were monitored in the area of electronic sharing medical information (CI_3). Sabes-Figuera and Maghiros (2013) state also that only about half of the monitored hospitals share medical information electronically with other care providers (general practitioners, external specialists). European Commission (2014) state, that above all, the sharing of medical information with health care providers located in other EU countries remains a challenge because less than 8 % of the hospitals reported the sharing of some medical information with other EU countries.

In 2018 the European Commission performed benchmarking in the area of General Practitioners, see European Commission (2018). As a result, the Composite Index of EU countries was compared. It was found out that the state o eHealth in the area of General Practitioners has improved since 2013. The EU countries average score increased from 1.876 in 2013 to 2.131 in 2018 (max value is 4). The countries with the highest level of eHealth adoption were Denmark, Estonia, Finland, Sweden, and the United Kingdom (scores between 2.517 and 2.862), while Lithuania, Malta, Slovakia, Luxembourg, and Greece had the lowest level of adoption (scores between 1.647 and 1.785). There were found increases in the adoption of EHR since 2013 across all EU countries (European Commission, 2018). The implementation in the other eHealth fields – HIE, Telehealth, and PHR has also increased since 2013, however remains much lower than the adoption of EHR.

For the future implementation of eHealth in the EU, it is expected the higher effort of the European Commission in the field of eHealth harmonisation and standardisation (European Commission, 2011). It is expected the creation of common European registers of chronic diseases and actions to improve research data exchange between EU member states (Mair et al. 2012). The Commission is working with the member states to start exchanging e-prescriptions across borders in 2018 (European Commission, 2019). Cross-border telemedicine is a cornerstone of the "European Reference Networks" which will connect close to 1.000 clinics in Europe to diagnose and treat complex and rare diseases. Both schemes are supported by the "Connecting Europe Facility" and the system for the exchange of prescriptions is based on a successful CIP project "epSOS" (Europa, 2018).

Limitations of the Research

In connection with this research, there are several limits. The eHealth Deployment evaluation is carried out for 2013, as it is based on the available benchmarking activities in the field of eHealth of the European Commission. The research results, therefore, correspond to this time. Currently, results may vary. In 2018, a follow-up study was carried out in the field of General Practitioners, where it is possible to compare partial results. However, a follow-up study in the field of hospitals has not been carried out yet, and relevant data are available only for 2013. The conducting of up-to-date eHealth Deployment research, as proposed in the presented article, is limited now for this reason. In the presented research, an Aggregated Index is constructed, which is the subject of other limits. There are number of advantages and disadvantages associated with creating composite indexes. In the case of complex policy issues, as eHealth deployment, there exist a large number of indicators. The summarization of them in the form of a compo-

site index is a convenient tool to receive a more unified and compact policy message. The disadvantage is that their use can distort reality in certain respects.

Conclusion

The adoption of eHealth in primary care is a crucial task on both national and international levels. The interest of the EU and EU Member States policy is to measure progress and assess the extent of the implementation so that shortcomings can be explained and reduced. In the presented article, a procedure for evaluating eHealth deployment at primary care using an Aggregate Indicator was proposed. The results were verified and improved by the usage of MCDM methods. The ranking of EU countries was specified on the basis of the application of TOPSIS, WSA, and MAPPAC methods.

The benefit is that in the presented study, both areas of eHealth are evaluated within one evaluation model, and the ranking of EU countries assessing the position of eHealth deployment is specified by the application of MCDM methods, so it is not just an arithmetic average of variants.

It was acknowledged that the best ranking in this area obtained Denmark, Finland, Estonia, and Sweden. The worst state of eHealth was reported in Slovenia, Poland, and Lithuania. The research showed that access to and use of ICT become almost universal in primary care in all EU countries. However, in the case of more advanced functionalities as EHR, HIE, Telehealth, and PHR, more progress across EU countries is needed. Also, the area of sharing electronic medical information and privacy and security of data should be improved. The results of eHealth deployment evaluation in EU countries pointed out that the reaching of the target and objectives defined for eHealth both in the Digital Agenda for Europe and in the 2012 eHealth Action Plan they remain a challenge for future and that more policy efforts are needed to enable more improvements.

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