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Digital transformation in healthcare. The need for medical technologies

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Abstract *The analysis of the status of the healthcare system is vital for its development and for the digital transformation. Information and communication technology is now part of every field of society and supports essentially every aspect of human activity. In health, digital transformation is needed more than ever, in the context in which there is currently a global health crisis through the combination of lifestyle with age-related chronic diseases and multiple comorbidities. In this paper, we aim to depict the health status and the technological advancements for 27 European countries, by comparing a set of chosen indicators. The indicators refer to medical technologies available for the population through imaging examinations (CTs, MRIs, PETs scanners etc.), to medical resources in terms of human resources and to the coverage of basic health needs. The analyzed period differs depending on the latest available year for each indicator, which varies from 2017 to 2021. Future studies should, however, concentrate on how the indicators can be grouped and modeled to achieve a deeper understanding of the European health environment in the context of the technological transformation.*

Keywords*: healthcare, digital transformation, medical technology, universal coverage, accessibility, comorbidities*

JEL classification*: I12, I14, I18, O30, O33*

Introduction

The health status of the population is closely related to medical technology and digital health innovations. Technological progress brings with it an increase in the capacity to prevent

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diseases, the possibility of appropriate and effective treatments, as well as post-intervention follow-up and long-term monitoring, focused on the patient.

In the context of today's society, there is a multiplication and a multi-stratification of health problems, arising in the context of some combinations between the lifestyle (tobacco use, alcohol consumption, physical inactivity) with the spread of obesity, diabetes and depression on a large scale. On top of those listed, there is also the aging of the population. Therefore, this complex environment requires tailored solutions that are able to prevent the occurrence of such diseases, to quickly and accurately diagnose the disease that the patient is facing, to treat the various ailments efficiently and with the lowest possible costs, as well as to monitor the patient throughout the treatment, adjacent to monitoring the evolution of the disease.

AI, telemedicine and smart devices are only some of the engines that ensure progress in the medical world which constitute the basis for improving the health of the population. Both patients and providers are increasingly interested in using digital tools to improve the health of each individual and to help patients engage in the health process. Thus, consulting people about their care and giving everyone access to health data and information are key dimensions of people centered health systems.

Healthcare systems recognize that digital transformation is critical to improving healthcare and strengthening patient relationships. The impact of digital transformation is felt throughout the medical care process, facilitating access to care, improving quality, as well as increasing cost efficiency. However, a great disadvantage is the accessibility of such technologies and innovations, as there are large discrepancies between continents, among states, as well as between different regions within the same state.

The international literature in the area of medical technologies and digital transformation in healthcare addresses different specific aspects, using various indicators referring to health or innovation, but the existing studies do not include under one palette all the indicators gathered in the current paper. With the help of the indicators collected here, which focus both on essential medical aspects and on advanced medical performance, we can build a profile of the European countries regarding the available medical technologies, as well as their effect on the indexes regarding the state of health. By using descriptive statistics, we can compare the situation between different countries and make value judgments about the existing gaps and how certain countries must make critical changes in their health systems to close up the differences and provide the population with the necessary medical technologies for prevention, treatment and monitoring of diseases.

Regarding the existing reports conducted by the European Union, the United Nations or other international organizations, their proposed data and indicators do not intend to build country profiles, especially for the general European health environment, and they neither refer specifically to the situation of medical technologies in the context of digital transformation in health.

This paper aims to highlight the state of medical technology in Europe and how it is used for the purpose of health, having as a starting point the data regarding 27 European states, out of which 23 states are from the European Union and 4 states from outside the Union. It is also observed how the states that have a better economic situation, allocate more funds in the medical sector and medical innovation and thus have a better state of health, according to the Global Health Security Index.

1. Literature review

1.1. The need for digital innovation in society

We are dealing at a global level with a multi-stratification of population's health problems. Digital and technological changes in the medical system are necessary to support their ability to manage increasingly complex diseases. The growing burden of chronic disease is a problem of both volume and complexity. Tobacco use, excessive alcohol consumption, diets high in sodium and low in fruits and vegetables, physical inactivity, and uncontrolled high blood pressure have spread worldwide. Epidemics of obesity, diabetes, cardiovascular disease, depression and disability are now global in scale, and both their incidence and prevalence are expected to increase as a result of aging populations and exacerbating health disparities (Bauer, Briss, Goodman, & Bowman, 2014).

These risk factors and chronic diseases often occur in combination. For example, those with a poor diet and who are also physically inactive are at increased risk of diabetes, cardiovascular disease and mood disorders. Each disease is treated with several drugs and psychotherapies. In the United States, approximately 92% of older adults have at least one chronic condition and 62% have multiple conditions. Additionally to this, 87% of those over age 65 take medications. The same population sees seven different healthcare providers in four separate offices each year. Many people in the United States question the sustainability of current approaches to chronic disease, especially when medical costs exceed $3 trillion/year, with projections of higher than $5 trillion/year by 2023. Other approaches must be found, including care provided through digital interventions (Patrick, et al., 2016).

New methods of understanding health and disease are thus emerging that are based on objective data about genomes, behaviors, social networks, psychological factors, social and environmental determinants. For example, with respect to obesity, the recent discovery of the human microbiome and its potential relationship to obesity and obesity-related issues, such as physical activity and energy balance, demonstrates the need for a systemic approach to the problem that involves in the equation the environmental influences on health (Patrick, et al., 2016).

The aforementioned new digital health ecosystem allows data to be extracted as needed from relevant areas and processed in real-time through techniques such as machine learning to generate predictions of health status and behavioral phenotypes (Sudharsan,

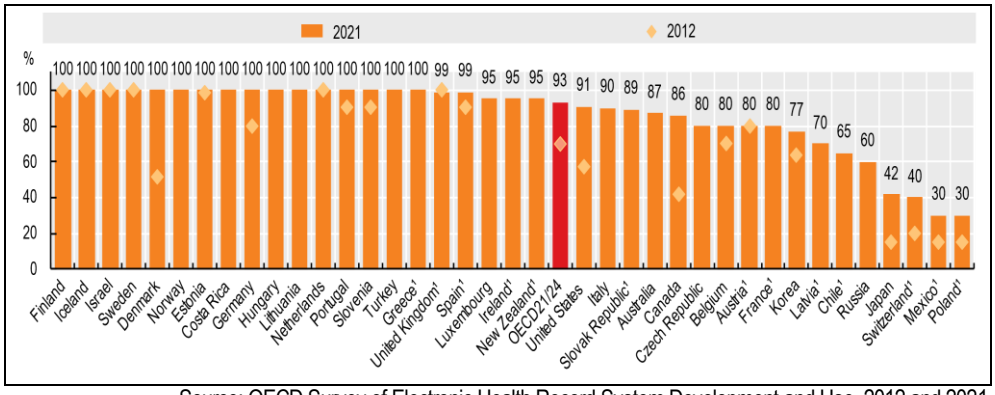
Peeples, & Shomali, 2015). Integrating these markers collected from people's everyday lives with genomic and clinical databases is the next step in digital transformation (Topol, Steinhubl, & Torkamani, 2015).

1.2. Population's access to medical technology. OECD states

From artificial intelligence to telehealth, digital health technologies and services can lead to better access to healthcare and greater patient satisfaction, especially among those who face barriers to traditional face to face healthcare services. This category includes, for example, patients from rural areas. The digital transformation in healthcare is currently taking place across the globe, accelerated especially by the COVID-19 pandemic and driven by the digitization of information infrastructure as well as by the increasing patient demand (OECD, 2021)

OECD countries have a high performance in terms of digital transformation; 93% of primary care practices in 24 OECD countries used Electronic Medical Records (EMR) in 2021, while in 15 countries all practices used EMR. The percentages can be viewed in the graphic below for 2021 OECD member states (OECD, 2021).

Figure 1. Proportion of primary care physician offices using electronic medical records, 2012 and 2021



Source: OECD Survey of Electronic Health Record System Development and Use, 2012 and 2021

An EMR is a computerized medical record created in a hospital or medical office, for the patients of that institution. They were created to be shared between providers and to provide a detailed history of contact with the healthcare system for individual patients attending multiple healthcare facilities. The above figures presented on EMR implementation come from a 2021 survey of OECD countries to which 25 OECD member countries and the Russian Federation (Russia) responded (OECD, 2021).

Consulting patients about their care and giving them access to health data and information are important elements in the development of patient-centered health systems. The use of digital tools facilitates this process, and within OECD countries there is an increase from 36% in 2010, to 59% in 2020, regarding the use of the Internet in order to search for health information in the last three months (the people surveyed had age between 16 and 74 years) (OECD, 2021).

However, there are significant demographic and socio-economic discrepancies in online health information seeking. Older adults, people with lower levels of education, and those from lower-income households were less likely to search for health information online. In general, people from these categories are mostly concentrated in rural areas. Health and digital literacy in healthcare are crucial to ensure that the digital transformation leaves no patient behind.

1.3. Digital innovation in health. World Index of Healthcare Innovation

World Index of Healthcare Innovation (WIHI) conducted by the Foundation for Research on Equal Opportunity (FREOPP) evaluates healthcare systems in 32 high-income countries based on four equally weighted dimensions: quality, choice, science and technology, and fiscal sustainability. Each dimension is composed of 3-4 elements, while each element further contains 3-4 other indicators. Together, each measure, element and dimension is weighted and aggregated to produce the standardized scores used to further rank the 32 countries in the Index. All measures, elements and dimensions use a standardized scoring method on a scale of 0 to 100 to assess each country's performance relative to the others (FREOPP.org, 2022).

The index highlights the importance of innovation in improving health outcomes. Advances in scientific development, healthcare delivery and personalized care are recognized as essential components of high-quality healthcare systems. The quality dimension consists of disease prevention (40%), pandemic preparedness (25%), patient-centered care (20%), and infrastructure (15%). The dimension of choice includes the accessibility of health insurance (35%), the freedom to choose medical care services (45%) and access to new treatments (20%). The science and technology dimension includes technological progress (35%), scientific discoveries (45%), and digitalization of health (20%). Finally, the last dimension refers to fiscal sustainability and includes national solvency (40%), public health expenditures (40%) and increased public health expenditures (20%) (FREOPP.org, 2022).

Following the results, the top five national healthcare systems in 2021 were Switzerland, the Netherlands, Germany, Ireland and Israel. All of these achieved universal health coverage. Out of these five, Switzerland, the Netherlands and Israel have universal private healthcare systems where all citizens are covered by compulsory private insurance. These countries offer patients multiple choices and allow private insurers to innovate without delays due to

political or regulatory inaction. Additionally, these systems tend to be more fiscally sustainable as subsidies are eliminated for wealthier patients (Roy, 2021).

Figure 2. World Index of Healthcare Innovation, 2021 Rankings

Overall Rank ▲	Country	Overall Tier	Overall Score	Quality	Choice	Science & Technology	Fiscal Sustainability
1	**Switzerland**	Excellent	65.15	65.39	68.25	53.92	73.06
2	**Netherlands**	Excellent	62.99	62.65	73.31	42.56	73.43
3	**Germany**	Excellent	59.79	52.73	70.25	37.69	78.48
4	**Ireland**	Excellent	56.67	58.16	61.48	32.52	74.50
5	**Israel**	Excellent	55.72	63.21	59.67	38.38	61.62
6	**United States**	Excellent	54.78	56.33	54.53	73.93	34.35
7	**Australia**	Good	50.76	60.07	65.44	25.27	52.25
8	**Hong Kong**	Good	50.72	40.56	61.58	24.96	75.77
9	**Belgium**	Good	50.51	48.84	56.23	35.43	61.53
10	**United Kingdom**	Good	50.21	52.15	57.04	47.18	44.46
11	**Denmark**	Good	49.87	49.20	52.20	45.37	52.70
12	**Singapore**	Good	49.71	46.83	66.44	32.63	52.95
13	**Taiwan**	Good	49.26	50.22	60.10	17.75	68.96
14	**South Korea**	Good	48.36	51.81	63.35	18.14	60.16
15	**New Zealand**	Good	48.28	58.47	54.61	25.47	54.56
16	**Czech Republic**	Good	47.58	38.84	56.84	15.58	79.06
17	**Portugal**	Good	46.92	63.15	58.83	15.78	49.93
18	**Sweden**	Moderate	45.35	48.72	53.87	40.99	37.82
19	**Austria**	Moderate	45.33	50.86	55.45	29.84	45.16
20	**United Arab Emirates**	Moderate	45.19	46.72	45.86	22.41	65.79
21	**Finland**	Moderate	44.64	50.45	42.34	36.99	48.78
22	**Spain**	Moderate	44.53	47.13	56.85	23.52	50.63
23	**Canada**	Moderate	44.31	53.26	54.05	27.63	42.29
24	**Norway**	Moderate	44.17	57.10	48.59	33.76	37.22
25	**France**	Moderate	42.60	53.25	54.04	32.79	30.34
26	**Greece**	Moderate	41.55	38.72	58.67	19.66	49.14
27	**Hungary**	Moderate	40.31	32.34	48.82	17.72	62.34
28	**Italy**	Poor	37.90	44.22	44.21	19.37	43.80
29	**Slovakia**	Poor	37.70	28.75	48.66	14.32	59.06
30	**Japan**	Poor	37.52	57.20	56.09	36.76	0.04
31	**Poland**	Poor	35.52	25.23	44.01	8.40	64.45

Source: FREOPP World Index of Healthcare Innovation (Roy, 2021)

Switzerland, in addition to being 1st in the general ranking, also ranked first for Quality. The Netherlands took first place for Choice, while the Czech Republic ranked first for fiscal sustainability. In contrast, the USA is at the bottom of the ranking in terms of fiscal sustainability, ahead of only Japan and France. Instead, the US compensated according to

the 2021 results by placing well ahead of others in the field of Science and Technology. Overall, the United States ranked 6th, as a result of excellent scientific progress (1st place), good quality (10th place), moderate choice (20th place), and poor fiscal sustainability (29th place). Such rankings hint at the nation's relative strength in research and development, along with its struggle to control rising government spending on healthcare (Peter G. Peterson Foundation, 2022).

Four countries acquired a poor overall ranking: Italy, Slovakia, Japan and Poland. Poland ranked last for Quality and also for Science and Technology, while Finland, a single-payer country, ranked last for Choice. Japan, which has the highest debt-to-GDP ratio in the industrialized world, ranked last for fiscal sustainability.

2. Research Methodology

In the case study of this paper, we have chosen data regarding the resources of the health sector, in this case the medical technology available to the population, the universal health coverage, and also the security and the state of health. Thus, the situation of the 27 selected European states (23 EU states and 4 non-EU states) will be analyzed, taking into account a series of indicators, and making a comparison from the point of view of their performance. It will be possible to see which are the most performing European states, as well as which are the states that still have to work to rise to the standards imposed by the European average.

The indicators referred to are the Universal Health Coverage legislation, the Biomedical engineers, Immunization, Medical technology (Computed Tomography Scanners, Magnetic Resonance Imaging Units, Gamma cameras, Positron Emission Tomography scanners, Radiation therapy equipment, Mammographs), Medical technology examinations (Computed Tomography Scanners, Magnetic Resonance Imaging Units, PET scanners), Global Health Security Index and Bloomberg Global Health Index. The analyzed period differs depending on the latest available year for each indicator, which varies from 2017 for Biomedical engineers and UHC legislation, to 2020 for Medical technology and Medical technology examinations. For the Global Health Security Index we considered the year 2021 and for the Bloomberg Index the year 2019.

The Universal Health Coverage specifies if the countries have passed the legislation regarding the universal health coverage and can be either affirmative or negative.

The number of Biomedical engineers per 10,000 population refer to the trained and qualified biomedical engineering professionals and biomedical engineering technicians[1]. They are required to design, evaluate, regulate, manage and maintain the safe use of healthcare medical technologies. These professionals have an important role in healthcare systems and

[1] www.who.int/data/gho/data/indicators/indicator-details/GHO/biomedical-engineers-density-(per-10-000-population)

should be considered as part of the health workforce as stated in the ILO report, ISCO-08 and the Global Strategy on Human Resources for Health: Workforce 2030 as they ensure access to and safe use of medical technology, essential for health service delivery. Data for this indicator were retrieved from the WHO data portal and refer to the year 2017 (most recent available).

The Immunization[1] indicator refers to the child immunization that measures the percentage of children aged between 12 and 23 months who received DPT vaccinations before 12 months or at any time before the survey. A child is considered adequately immunized against diphtheria, pertussis, and tetanus (DPT) after receiving three doses of vaccine. The data regarding Immunization were retrieved from the World Bank platform and refer to the year 2020.

Medical technology[2] refers to the healthcare facilities that include medical equipment in the hospital sector and providers of ambulatory healthcare. The equipment included here are Computed Tomography Scanners (CT), Magnetic Resonance Imaging Units (MRI), Gamma cameras, PET scanners, Radiation therapy equipment (RT) and Mammographs. These indicators are retrieved from Eurostat and refer to the year 2020. The medical technologies are expressed in the number of equipment per 100,000 population.

Medical technology examinations[3] refer to the medical imaging session to study one or more body parts that yield one or more views for diagnostic purposes. Data are collected for CT exams, MRI exams, and PET exams. These indicators are retrieved from Eurostat and refer to the year 2020. The medical technologies are expressed in the number of examinations per 100,000 population.

The Global Health Security (GHS) Index[4] refers to the year 2021 and assesses countries' health security and capabilities across six categories and 37 indicators. The findings are drawn from open-source information that answered 171 questions across the categories.

Bloomberg Global Health Index (GHI)[5] evaluates a country's health level, considering several parameters such as health risks (smoking, high blood pressure and obesity), availability of quality drinking water, average life expectancy, bad nutrition, causes of death. Bloomberg evaluates the quality of health every two years for those countries that have sufficient data to characterize their health status. In 2019, 169 states were taken into account.

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1 https://databank.worldbank.org/metadataglossary/gender-statistics/series/SH.IMM.IDPT

2 https://ec.europa.eu/eurostat/cache/metadata/en/hlth_res_esms.htm

3 https://ec.europa.eu/eurostat/databrowser/view/HLTH_CO_EXAM/default/table

4 www.ghsindex.org/

5 www.bloomberg.com/news/articles/2019-02-24/spain-tops-italy-as-world-s-healthiest-nation-while-u-s-slips

Through these indicators, we have chosen to carry out an analysis of the situation of the European states from the point of view of medical care and medical technology, depicting a performance profile for each country, as well as for Europe overall. The analysis is limited to descriptive statistics, as well as making comparisons between countries through graphs, or comparing several indicators to distinguish the health and medical situation of a country.

The study approaches a series of indicators starting from what is essential and general in terms of health to more complex and specific needs in terms of medical technologies. In the end, two comprehensive indexes illustrate, on the one hand, the health security for each country, and on the other hand, the country's health level. This will explain the discrepancies regarding the health status among countries, as well as the availability of medical equipment in relation to the needs of a country's population.

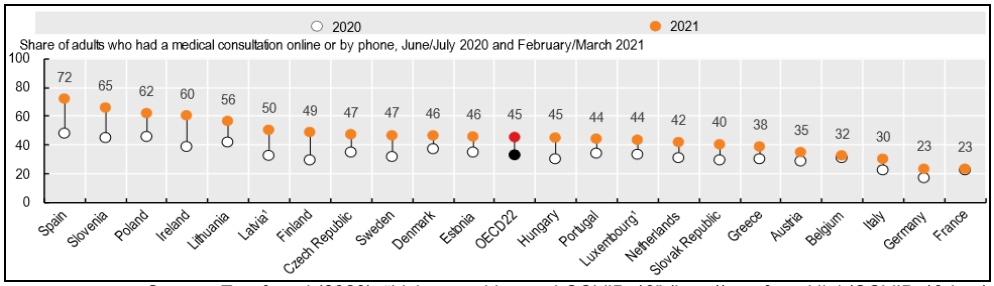
3. Analysis of the European healthcare environment. Medical technologies and transformation

3.1. Accelerated digital transformation after the COVID-19 pandemic

Digital transformation is needed more than ever, in the context of a global health crisis through the combination of lifestyle with age-related chronic diseases and multiple comorbidities. Computationally intensive behavioral health interventions may be one of the most powerful methods of reducing the consequences of this crisis, but new methods are needed for health research and practice, and evidence is needed to support their use widely (Patrick, et al., 2016).

Despite its negative effects, the COVID-19 pandemic also represented an opportunity for health systems to accelerate the digital transformation, which until 2019 was adopted slowly and fragmented by health providers. Thus, the pandemic has been a catalyst for changing consumer preferences and innovation in care delivery. The Deloitte Center for Health Solutions, in collaboration with the Scottsdale Institute, conducted a research project to better understand how health systems are using digital transformation to help their organizations future-proof (Appelby, Wurz, Chang, Hendricks, & Shudes, 2021).

Figure 3. Share of adults who received services from a doctor via telemedicine since the start of the pandemic, 2020 and 2021



Source: Eurofound (2020), "Living, working and COVID-19" (http://eurofound.link/COVID-19data)

There are major changes in the healthcare industry related to the digitization of patients, healthcare clinics, devices and medicines (Bhavnani, Narula, & Sengupta, 2016). In the study conducted by M.H. van Velthoven, C. Cordon, G. Challagalla, they described several ways to facilitate digital transformation and innovation in health. A first way is for a company to develop new capabilities more quickly on its own compared to competitors. IBM did this by developing its AI platform and naming it after its first CEO, Thomas Watson, through which IBM hoped to develop AI faster than their competitors. Another way is for a company to partner with technology companies to gain access to their research and development facilities and capabilities. For example, pharmaceutical company Otsuka, the creator of the psychiatric drug Abilify, jointly developed with medical device company Proteus Digital Health a digital ingestion tracking system, for which the latter developed the sensor (Velthoven, Cordon, & Challagalla, 2019).

3.2. Analysis and discussion

First of all, we begin with analyzing which are the countries that have passed the Universal Health Coverage (UHC) legislation. Universal health coverage refers to the fact that all people have access to the full range of quality health services, when and where they need them, without financial hardship. Coverage means the full range of essential health services, from health promotion to prevention, treatment, rehabilitation and palliative care. The only three countries out of the 27 that didn't pass the UHC are Lithuania, Malta and Poland, according to the World Health Organization.

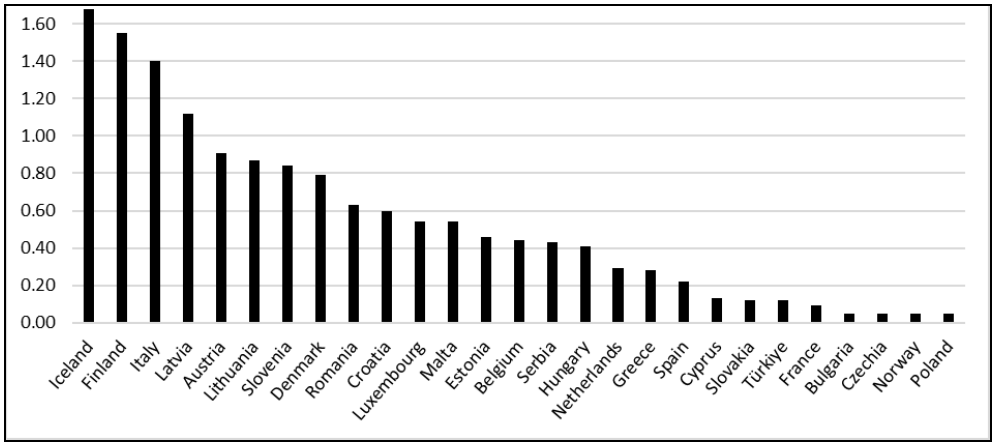
In the Adam Wagstaff and Sven Neelsen study for The Lancet Global Health Journal it is observed that the UHC index scores are usually higher in higher-income countries, but even so there are variations within the same income groups. Their UHC indicators are significantly and positively associated with GDP (Gross domestic product) per capita, and most of them are correlated with the share of health spending channeled through social health insurance and government schemes.

If we look at the healthcare facilities, in particular the biomedical engineer's density, Iceland, Finland and Italy are in top 3 with more than 1.4 biomedical engineers per 10,000

inhabitants, while Poland, Norway, Czech Republic and Bulgaria have the smallest densities with 0.05 biomedical engineers per 10,000 inhabitants.

Biomedical engineering is a comprehensive field that can change healthcare and open doors to new technologies in operating equipment, diagnostics, imaging and more. Individuals are continuously looking for biomedical treatments whenever they anticipate a more convenient or advanced therapy. According to a study by Javaid, Mohdm, Haleem, Abid and Ravi, Singh, the healthcare system's need for biomedical equipment and procedures is projected to increase.

Figure 4. Biomedical engineers density, 2017



Source: own processing using data retrieved from WHO (www.who.int/data)

On the part of immunizing the children of ages 12-23 months against DPT, the percentages do not vary very much. Iceland is again in the top with the highest immunization rate (99%) and Luxembourg, Malta and Greece having the same rate. In fact, we observe that half of the countries have a rate greater than 95%. The lowest rate is 85% corresponding to Austria, slightly exceeded by Serbia (87%), these being the only two countries with an immunization rate below 90%.

Table 1. Immunization against DPT (%), 2020

Immunization	
Mean	94.44
Median	95
Mode	97
Range	14

Minimum	85
Maximum	99
Count	27

Source: own processing using data retrieved from World Bank

It is also worth noting that the countries with the highest vaccination rates are high-income countries. The only two exceptions would be Türkiye, which had a 98% immunization rate although it is an upper-middle-income country, and Austria, which has the lowest rate (85%) even though it is a high-income country. The other upper-middle-income countries are Bulgaria, Romania and Serbia.

Table 2. Immunization percentage in relation to Income, 2020

Country	Income	Immunization %
Türkiye	Upper middle	98
Bulgaria	Upper middle	91
Romania	Upper middle	90
Serbia	Upper middle	87

Source: own processing using data retrieved from World Bank

Regarding the Medical technologies, we can see that there are on average 2.53 CT scanners per hundred thousand inhabitants, 2.37 Mammographs, while in a considerably lower number per hundred thousand inhabitants are the MRIs (1.60), RT equipment (0.81), Gamma cameras (0.76) and PET scanners (only 0.21).

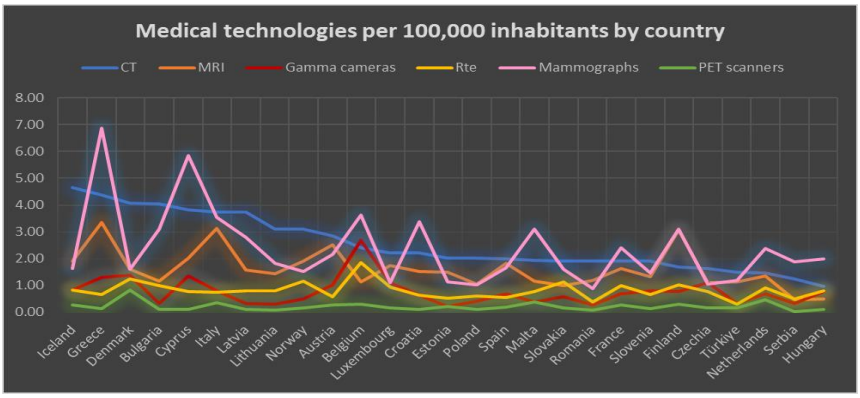
Table 3. Medical technologies, 2020

	CT	MRI	Gamma cameras	RT	Mammographs	PET scanners
Mean	2.53	1.60	0.76	0.81	2.37	0.21
Median	2.03	1.5	0.69	0.78	1.88	0.17
Mode	2.22	#N/A	0.69	0.78	1.61	0.17
Range	3.68	2.89	2.46	1.55	5.99	0.81
Minimum	0.96	0.46	0.23	0.29	0.89	0.03
Maximum	4.64	3.35	2.69	1.84	6.88	0.84
Count	27	27	27	27	27	27

Source: own processing using data retrieved from Eurostat

Looking at the countries, Iceland and Greece have the highest number of CT relative to the population, with 4.64 and 4.37. On the opposite side there are Hungary (0.96) and Serbia (1.23). The last two countries also have the lowest numbers when it comes to MRI, while the top countries in this technology are Greece (3.35), Italy (3.12) and Finland (3.06).

Figure 5. Medical technologies density, 2020



Source: own processing using data retrieved from Eurostat

Moving forward to Gamma cameras, the ranking changes. Belgium leads by far with 2.69 cameras per 100,000 inhabitants, followed by Denmark (1.37), Cyprus (1.35) and Greece (1.30). The least endowed countries are Lithuania (0.29), Romania (0.28) and Estonia (0.23). In RT equipment, Belgium is in the same position as detached leader with 1.84, followed again by Denmark (1.25), while at the other end of the ranking the last three countries are Serbia (0.49), Romania (0.39) and Turkiye (0.29).

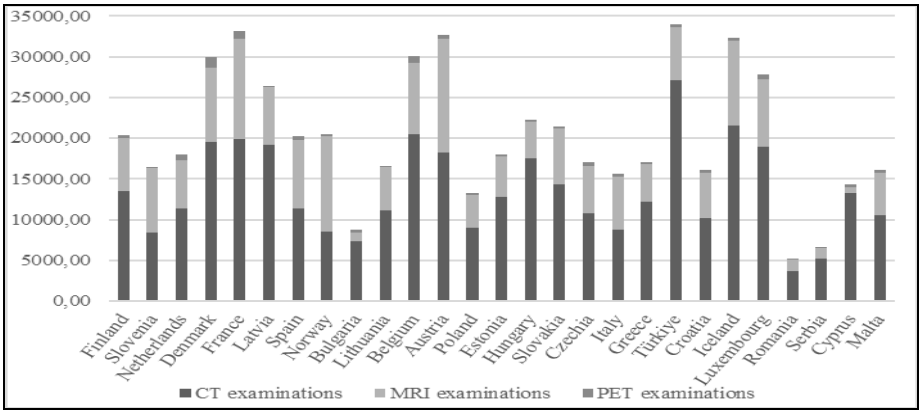
Concerning Mammographs, Greece and Cyprus have the highest density of equipment, with 6.88, respectively 5.83. In contrast, Romania is the only country with less than 1 mammograph per 100,000 inhabitants (0.89).

Romania is not doing better even in terms of PET scanners with 0.07 per 100,000 inhabitants, the same as Lithuania, surpassing only Serbia which has 0.03 scanners. Denmark leads the ranking a long way with 0.84 scanners, followed with a big gap by Netherlands (0.48).

Overall, taking into account the above rankings, the best performing countries in terms of the medical technologies related to the number of inhabitants, seem to be Belgium, Greece, Denmark, while the countries with the lowest density of medical equipment are Serbia, Hungary, Romania and Lithuania.

Perhaps more relevant than the density of medical technologies are the examinations by medical imaging techniques (CT, MRI and PET) expressed per hundred thousand population. Regarding CT examinations, Turkiye has the highest number, followed by Iceland and Belgium, all three having above 20,000 examinations per 100,000 inhabitants. For MRI, Austria and France are leading the ranking with more than 12,000 examinations and concerning the PET scanners examinations, Denmark and France are the best performers.

Figure 6. Examinations by imaging techniques (CT, MRI, PET), 2020



Source: own processing using data retrieved from Eurostat

As we can see in Figure 6, the lowest numbers in examinations and, therefore, the least performing countries are Bulgaria, Serbia and Romania, although Cyprus has the lowest number in MRI examinations and Slovenia is last in terms of PET scanners examinations.

In a study conducted by Dosanjh Ristova & Gershan in 2022 it was observed that the Southeast European (SEE) region differs from Western Europe as the most SEE countries lack active cancer registries and have less diagnostic imaging devices and radiotherapy (RT) facilities. Based on a questionnaire, the authors found that cancer incidence rates are higher in those SEE countries that have greater access to diagnostic imaging equipment, while cancer incidence-mortality rates are higher in those countries lacking RT equipment.

By combining information from the SEE region with data available on global databases, they demonstrated that the availability of diagnostic imaging and RT equipment in SEE countries is related to their economic development. Immediate development of diagnostic imaging and radiotherapy capacity is needed, but it is also essential to develop cancer registries at both national and SEE regional levels to understand the heterogeneity of each country's needs and to set as well regional collaboration strategies to fight cancer.

However, conventional monitoring approaches that include imaging modalities such as ultrasound, CT, MRI, and X-ray may be limited. According to a study from Trends in Biotechnology Journal (Ho, Quake, & McCabe, 2020), emerging technologies will open the door to biomarker surveillance with higher sensitivity and higher frequency than conventional monitoring approaches. Wearable technologies can overcome the challenges of measurements to improve the accuracy of the treatment response assessment, therefore improving the personalized interventions. AI is also being leveraged to improve diagnostic imaging capabilities to further guide patient-specific treatment.

Further, we will discuss the 2021 Global Health Security (GHS) Index measures the capacities of 195 countries to prepare for epidemics and pandemics. The GHS Index aims to spur measurable changes in national health security and improve international capability to

address one of the world's most omnipresent risks: infectious disease outbreaks that can lead to international epidemics and pandemics. All countries remain dangerously unprepared for future epidemic and pandemic threats, including threats potentially more devastating than COVID-19.

Looking at the top 10 countries at the global level, we see that the United States has the highest index (75.9), followed by Australia (71.1.) and Finland (70.9), the latter being as well among the countries of interest in this paper. Moving to the European ranking, we notice that after Finland, Slovenia comes close by (67.8), while other six countries have the index over 60: Netherlands, Denmark, France, Latvia and Spain, including Norway that is on the 11th position.

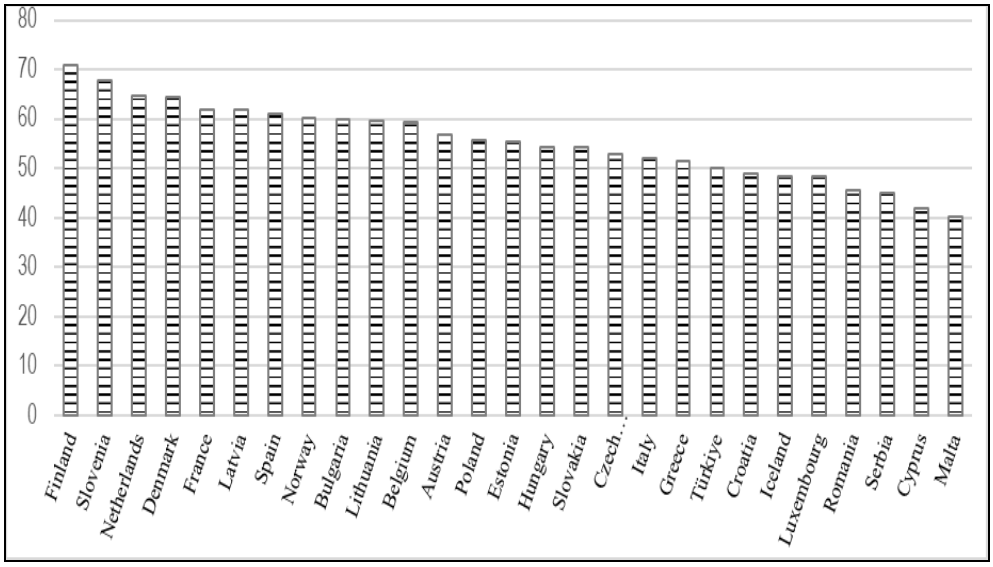
Table 4. 2021 Global Health Security Index, by country

Top 10 World			Top 10 Europe	
country	***HSI***		***country***	***HSI***
United States	75.9		Finland	70.9
Australia	71.1		Slovenia	67.8
Finland	70.9		United Kingdom	67.2
Canada	69.8		Germany	65.5
Thailand	68.2		Sweden	64.9
Slovenia	67.8		Netherlands	64.7
United Kingdom	67.2		Denmark	64.4
Germany	65.5		France	61.9
South Korea	65.4		Latvia	61.9
Sweden	64.9		Spain	60.9

Source: own processing using data retrieved from https://www.ghsindex.org/about/

As it is illustrated in the graphic below, the least performing countries are Romania (45.7), Serbia (45), Cyprus (41.9) and Malta (40.2). Bulgaria is the only upper-middle country in terms of income that is among the first 10 ranked countries, in contrast with Cyprus and Malta who are less secured in terms of health, but have a high income.

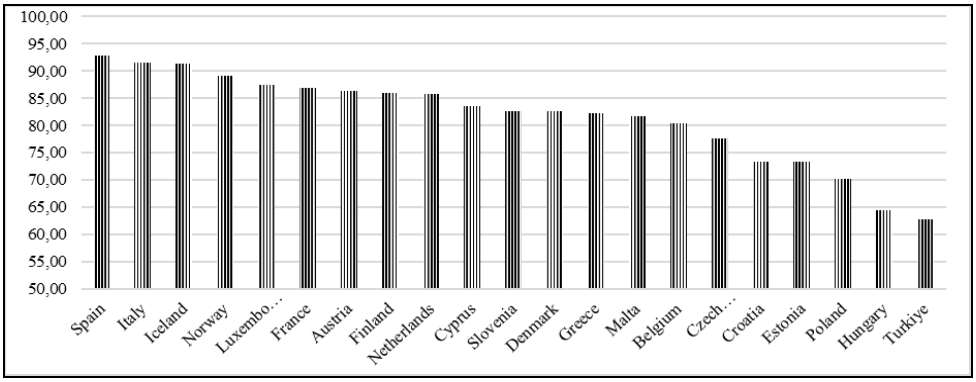
Figure 7. 2021 Global Health Security Index



Source: own processing using data retrieved from https://www.ghsindex.org/about/

The Bloomberg ranking for Global Health Index 2019 is also interesting to approach. Unfortunately, we found public data only for the first 50 with the best health indicators. The highest scores globally are obtained by three European countries, Spain (92.75), Italy (91.59) and Iceland (91.44), followed by Japan with 91.38. Also, in the top 10 globally there are Australia, Singapore and Israel with scores above 88.

Figure 8. Global Health Index by country, 2019



Source: own processing based on indicators retrieved from www.passaronoombro.com/en/science/health-indicators-in-the-world/

Hungary and Turkiye have the lowest scores with 64.43, respectively 62.81. However, only 21 out of 27 European countries studied in this paper are included in this top 50 ranking; Bulgaria, Romania, Serbia, Latvia, Lithuania and Slovakia were not among the selected countries for 2019 Bloomberg's Index.

According to Bloomberg, more developed countries tend to be healthier than developing or less developed countries. In fact, developed countries have a better quality of life, including lower levels of pollution, better infrastructure, better health and education systems, healthier food, better quality water for human consumption as well as adequate work.

Conclusions and limitations

The current epidemics of non-communicable diseases do not originate only in the living behavior of individuals. This means that the solution lies not only in more and better ways to change these lifestyle behaviors, but in addition to digital technologies, health education methods are also needed for wider progress. Therefore, for research purposes, it is imperative to take into account both the individual and social levels of public health analysis, with their different knowledge assumptions, when thinking about the digital landscape as it might look in 30 years time (Michael P. Kelly, 2016).

Organizations and medical care institutions realize the need for digital transformation regarding the way of working and health services. However, significant uncertainties persist about how to digitize processes and what are the best options to capitalize on their potential. There are cultural differences regarding the development approach between traditional and start-up health organizations.

The impact of digital transformation will be felt in all aspects of healthcare, helping to facilitate access to care, improve the quality of services and lower their cost. In addition to operational and financial advantages, digital transformation helps especially in building stronger and more sustainable relationships with patients.

It is clear from our analyzed indicators that the more medical resources are allocated to the population, the more countries will have a better health overall. By medical resources we understand both human resources (treating patients, working with medical equipment, or in research and innovation), as well as technological resources in terms of medical equipment and devices (especially imaging techniques), pharmaceutical products (e.g. vaccines) and many others. Through a better allocation of these resources, adequate prevention, treatment and monitoring can be ensured for the population, leading to an improved state of health.

The UHC is a must to achieve for Lithuania, Malta and Poland from our analyzed countries, while some countries need to increase their number of biomedical engineers and close up the gap compared to the average density. As it is also included in the 2030 United National Agenda for Sustainable Development, attaining 100% immunization of 12-23 against DPT should be a key priority in European health systems.

Following Turkiye's example, which has the best performance regarding the examinations by imaging techniques even if it is not among the high-income countries, the other European countries should increase the imaging sessions for the good of the population and supplement the number of medical technologies, especially CTs and MRIs.

The current European medical environment faces several and transversal technological challenges that need to be addressed and solved through investments and a higher GDP percentage allocation. Therefore, European countries need to increase their capacities in order to be better prepared for possible upcoming pandemics and outbreaks of infectious diseases.

A problem for all organizations is the challenge of successfully innovating in healthcare. Digitization has the potential to disrupt healthcare and solve long-standing problems related to quality and cyclical costs (Kane, 2017). However, there are many promising digital health innovations without widespread adoption, and many digital health interventions are abandoned when organizations fail to sustain their use over time (Greenhalgh, 2017).

As a disclaimer, threats to cybersecurity remain one of the biggest current challenges of the health systems, in the context of accelerated digitalization in recent years (since the pandemic) and perhaps not always in the safest conditions. Medical care units are the main

targets of cyber-attacks in the context of the large amount of sensitive personal data. In this context, the confidentiality of information belonging to patients must be a top digital priority for health systems. The cyber security units must cooperate with the digital transformation teams to ensure better transparency and better control.

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