DIGITAL INNOVATION IN THE HEALTH SECTOR – A DETERMINANT OF HEALTH STATUS. RECORDS IN THE EU

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Abstract

Financial risk represents one of the negative effects of the increase in life expectancy, generated especially by the increase in the number of long-term illnesses. The development of e-Health solutions is one of the main objectives of the European Union. Thus, the integration of digital innovations in the medical systems will lead to the acceleration of the medical prevention process, the determination of an early diagnosis offering the possibility of personalized care and treatment.

The main objective of this paper is to identify the beneficial aspects of the latest discoveries in the field of technology on the state of health. Thus, the result obtained by applying the methods of multidimensional data analysis offers a perspective on how public digitization, in addition to the other socio-economic factors included in the Cluster Analysis, influences the improvement of the health status. Estonia is noted as Europe's digital leader, offering digitization solutions such as e-Residency, e-Governance, Digital ID, I-Vote and e-Health, with revolutionary benefits for patients. At the same time, we can notice a direct correlation between the years lived with disability and the average expenditure on health per capita, as people living in countries with higher expenditure on healthcare tend to live longer. The need for digital and technological innovation has increased the pace of innovation, as well as the investments in the R&D sector, making digital innovation an important determinant of health status. At the same time, a healthy silver population means active participation in social life, and improving health through digital innovations leads to an increase in healthy life expectancy and a positive correlation with life expectancy at the age of 65.

Keywords: digital innovation; health; e-health; multivariate analysis

JEL Classification

O00, I15, I180, C38

Introduction

Health has always been a major concern for a considerable number of stakeholders, from governments, ministries, political leaders, to private partners, non-governmental organizations, health professionals or various business communities. We notice that people live longer, which in statistical terms translates into a higher life expectancy, at both global and European Union level. However, as life expectancy increases, the amount of long-term illnesses begins to increase too. Thus, from the general concept of life expectancy there are two important aspects regarding the health status of the population: the healthy life expectancy, as well as the years a person lives bearing the burden of disability. In this context, there is an inexorable increase in the demand for medical care and therefore an acute need for digital and technological innovation in health. A key question about digital innovation and its future refers to the health challenges that future innovations must address, as well as the types of progress that are on the horizon (Cornell University, INSEAD, and WIPO, 2019).

1. Life expectancy and the economic context

As defined by the World Health Organization[1] (WHO), *life expectancy at birth* is a summary measure of death rates at all ages, and all health programs contribute to it. At the same time, life expectancy is a representative measure for assessing the health of the population as well as the differences in health around the globe. This is more comprehensive than the infant mortality metric, which focuses exclusively on mortality at an early age, while life expectancy captures mortality throughout the life cycle. The average global life expectancy reached 72,6 years in 2019, according to United Nations estimates, and in the case of the European Union (EU) it is above average, reaching 80,9 years. Despite this, there are still large inequalities both between and within countries. Today, the populations of many of the richest countries in the world have reached a life expectancy of over 80 years. For example, life expectancy in Spain, Switzerland, Italy and Australia was over 83 years, and the highest value was recorded in Japan, reaching about 85 years. By contrast, for countries with poor health, life expectancy reaches between 50 and 60 years, with Central African Republic being the country with the lowest life expectancy in 2019, with only 53 years (Roser et al., 2020).

Similar to life expectancy at birth, *life expectancy at age 65* reflects the number of additional years that a 65-year-old can live, if exposed for the rest of his/her life to the age-specific mortality rates. In the European Union, life expectancy at 65 was estimated at 19,9 years, reaching 21,4 years for women and 18,1 years for men. Between countries, it varies between 14,1 years, in Bulgaria or Latvia, and 19,6 years in France for men, and as for women it varies from 17,8 years in Bulgaria to 23,6 years in France (Eurostat, 2019).

It is interesting to analyze whether the extra years of life gained through increased longevity are spent in good or bad health. As life expectancy at birth is not able to quantify this aspect, relevant indicators that reflect the health status of a population have been developed: *healthy life expectancy* and *years lived with disability* (Eurostat, 2020). We can notice that in most countries there has been an increase in both aspects: as life expectancy has increased worldwide, so healthcare, along with improved treatments, has contributed to the increase in the number of years lived on average with a certain disability (Roser et al., 2020).

Healthy life expectancy provides an indication of the general health of a population, representing the equivalent of the average number of healthy years that a newborn is expected to live if he/she would go through life, being subject to age-specific death rates and health-specific levels for a given period. Thus, healthy life expectancy is focused on quality of life rather than quantity. Globally, healthy life expectancy was 63,3 years in 2016, and for the European Union it was estimated at 64 years for women and 63,5 years for men. Healthy years of life are an important measure of the relative health of the populations in the European

[1] https://www.who.int/gho/mortality_burden_disease/life_tables/situation_trends_life_expectancy/en/

Union. It is noteworthy that in higher income countries the inhabitants live more years with the burden of a disability or illness than in lower income countries. In this analysis, we chose to use the *health expenditure per capita*, which quantifies the economic resources dedicated to health functions and refers primarily to the health goods and services consumed by the resident units (Roser, et al., 2020).

The following graph Fig. no. 1) shows a positive correlation between the years lived with disability and the average expenditure for health per capita, as the people living in countries with higher expenditure for healthcare tend to live more years with disability. This results from increased funding in general care and treatment, which allows for an extension of life with a given disease or disability. At the same time, Latvia distinguishes itself as the EU state that allocates the smallest amount for health ($ 940/person) as well as the state with the lowest number of years lived with a certain disability (9,4 years), while Luxembourg is at the opposite pole, with the highest health expenditure ($ 6812/person) and the highest number of years that people live with disability (11,6 years). Romania occupies the second-last position out of the 28 countries in the study, from the point of view of the health expenditure per inhabitant, with $ 1079/cap, as well as with regard to the years lived with disability, with 9,7 years.

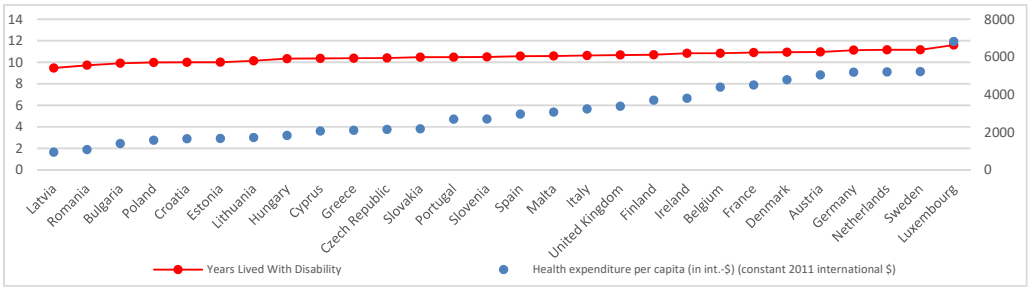

Fig. no. 1 Years lived with disability vs. Health expenditure, 2014

Source: Our world in data, 2019. Life Expectancy by Max Roser, Esteban Ortiz-Ospina and Hannah Ritchie https://ourworldindata.org/life-expectancy

In addition to *healthcare expenditure*, *Real Gross Domestic Product* (GDP) is another indicator that highlights the idea that countries with a more developed economy also have better health. By measuring the value of the total final output of goods and services produced by an economy over a certain period of time, GDP is used as a proxy for developing the standard of living for a country. In the study "Life Expectancy" (Roser et al., 2020) it has been observed that after analyzing the correlation between real GDP and life expectancy countries with higher GDP tend to have a higher life expectancy. However, economic development is not the only determinant of health, as scientific understanding and technological progress make effective public health interventions possible, such as vaccinations, hygiene measures, oral hydration therapy, and public health measures.

The measurement of disability is based on the question of The Global Activity Limitation Indicator (GALI), which comes from the survey "The European Union Statistics on Income and Living Conditions" (EU-SILC)[2], where the answers to the question are quantified: "At least for the last six months, have you been prevented due to a health problem in the activities that people usually do? Yes, strongly limited / Yes, limited / No, not limited". Based on this survey, Eurostat calculates both the *share of people with good or very good perceived health*, as well *as the unmet need for self-reported medical examination and care*. Both indicators measure the weight of the population aged 16 and over, with the difference that the first

[2] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Activity_limitation

indicator refers to the population that is perceived as having "good" or "very good" health (subjectively judging the health on a scale from "very good" to "very bad"), and the second indicator refers to the population reporting unmet needs for medical care for one of the following reasons: "Financial reasons", "Waiting list" and "Too far to travel" (all three categories being cumulated). It has been found that indicators of general health status are a good predictor of future healthcare use and population mortality. It should be noted, however, that the result may be affected by the subjective perception of the respondents, as well as their environment of origin (Eurostat, 2014).

2. Digital innovation as a determinant of the health of the population

The difference between *life expectancy at birth* and *healthy life expectancy* is the equivalent of years lost due to disability (YLD). The main determinants of the loss of healthy years are musculoskeletal disorders, mental disorders (depression, anxiety), neurological disorders, hearing or sight loss, cardiovascular disease or diabetes. Digital innovations in health are meant to combat these conditions, with a view to prolonging the healthy years, as well as life expectancy. Therefore, the increased need for digital innovation in the health sector has increased the pace of innovation as well, while allocating more funding for the Research & Development sector. This has made digital innovation an important determinant of health.

The Global Innovation Index 2019 (GII) explores the role of medical innovation, as it will shape the future of healthcare through artificial intelligence (AI), genomics or mobile health applications, which will transform the provision of healthcare in both developed and emerging countries (Cornell University, INSEAD, and WIPO, 2019).

The adoption of digital solutions in health is one of the main objectives of the European Union. This necessity is stimulated by the aging process of the population, as well as by the sustainability of the quality of provided care. Furthermore, the European Commission has recognized that promoting innovation in the field of e-Health in Europe is the way forward to ensure better and more sustainable health, as well as safer care for EU citizens. In addition, innovation in the field of health ensures a more qualified workforce, more efficient and more sustainable care systems, more responsive public administrations, but also new business opportunities and a more competitive European economy (Imbrişcă and Neaţu, 2015).

The Digital Economy and Society Index (DESI)[3] is a composite index that summarizes relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness. Over the last year, all EU countries have improved their digital performance: Finland, Sweden, the Netherlands and Denmark achieved the highest scores for DESI 2019 and are among the world leaders in digitization, followed by the United Kingdom, Luxembourg, Ireland, Estonia and Belgium. However, there are also countries that have a long way to go, with Romania having the second lowest DESI score after Bulgaria, and with EU as a whole needing improvement in order to compete on the global stage. Although DESI index has five dimensions, in our study we focus on the one dedicated to *digital public services*, having *e-Health* as a sub-dimension of interest, with a weight of 20%. The e-Health sub-dimension comes also from the weighted average of three standardized indicators, each one of them with a weight of 33% (European Commission, 2019): *e-Health* measures the percentage of people who have used the healthcare services provided online, without having to go to the hospital (for example, receiving an e-prescription or online consultation); *The exchange of medical data* refers to general practitioners who exchange medical data with hospitals and doctors; *e-Prescription* refers to general practitioners who use electronic prescriptions.

A number of emerging technologies for healthcare, including telemedicine, smartphone applications, biosensors for remote diagnosis and monitoring, speech recognition and

[3] https://ec.europa.eu/digital-single-market/en/desi

automatic image interpretation, will be particularly important for the healthcare workforce. Digital healthcare technologies have the potential to speed up the process of getting closer to the patient's home and offer the opportunity for people to be more informed about their care, allowing them to work along with healthcare staff in order to make treatment decisions.
As we move toward complete genome sequencing, genomics will expand beyond rare diseases and cancers, producing benefits in the prevention and management of common diseases. It is now possible to make corrections in a person's DNA, which could lead to remedies for previously untreatable diseases, as well as the delivery of targeted therapies. Such an intervention will be able to replace some palliative therapies in the next 10-20 years, with the potential to reduce the costs of chronic treatments.
Completing the digitization and integration of medical records will result in the full benefits of digital medicine, such as early diagnosis, personalized care and treatment. However, it is essential for the healthcare system to be prepared to adopt any new technologies, in a spirit of equality and equity. A number of social factors affect health outcomes and digital health technologies should remedy this in order not to consolidate inequalities, paying particular attention to vulnerable and marginalized groups.

3. Results and discussions

In order to analyze the effects of digital innovation on the health of the population, it is necessary to know, besides the healthcare needs of a population and its state of health (quantified using traditional indicators), the economic resources dedicated to health systems as well as the openness of the population to use the latest digital innovations in the field. The indicators used in the study have as sources primary indicators used in the calculation of DESI and EUROSTAT data (Eurostat, 2017), data processing being performed with XLSTAT.[4]
Thus, using Cluster Analysis, we will obtain a segmentation of the 28 countries of the European Union in 5 clusters (Fig. no. 2), based on the indicators used in the analysis: *Healthy life years and life expectation at birth, by sex; Healthy life years and life expectation at age 65 by sex; Share of people with good or very good perceived health by sex; Self-reported unmet need for medical examination and care by sex; Individuals using the internet for seeking health-related information; Real GDP per capita; 5b1 e-Health; 5b2 Medical data exchange; 5b3 e-Prescription; Health care expenditures by provider*.
Cluster 1 includes Austria and Luxembourg. Although it is characterized by the highest average values in terms of *GDP* and *Healthcare expenditure by provider*, we observe a low average value of *life expectancy at birth* (~ 57 years). It is worth noting that in terms of *GDP*, Luxembourg ranks at the top of the EU countries and in terms of *health expenditure* it ranks the third in the same ranking. In 2017, The Legatum Institute Foundation published the report on the Global Prosperity Index, and Luxembourg is considered the healthiest nation in the world with a life expectancy of 82 years. This pillar of the index is composed of three components: the mental and physical health of a country, the infrastructure of the health systems and the availability of preventive care.
Cluster 2 made up of Belgium, Denmark, Finland, Netherlands, Spain, Sweden and United Kingdom differentiates itself by the highest average of the indicators *Healthy life years and life expectancy at birth*; *Healthy life years and life expectancy at age 65*; *Share of people with good or very good perceived health*. On the other hand, start-ups in Sweden are focused on creating digital healthcare and developing digital technology in the field of health. For example, the KRY medical service that allows physicians and psychologists to meet patients through the video interface, it is encountered in the publicly funded national health systems in Sweden, Norway and Spain. The countries included in this cluster are in the first 25

[4] Addinsoft, (2020). XLSTAT statistical and data analysis solution. New York, USA. https://www.xlstat.com.

positions *of the Global Prosperity Index* and are in general developed economies with resources which makes them rank as the healthiest in the world.
At the same time, in a recent study on the digital transformation of 17 integrated health programs from 8 European countries, including the Netherlands, Spain and the United Kingdom (Baltaxe, et al., 2019), it shows that all states included in the analysis have at least a partial implementation of Electronic Medical Record (EMR) and intend to improve the implementation of EMR in the future.

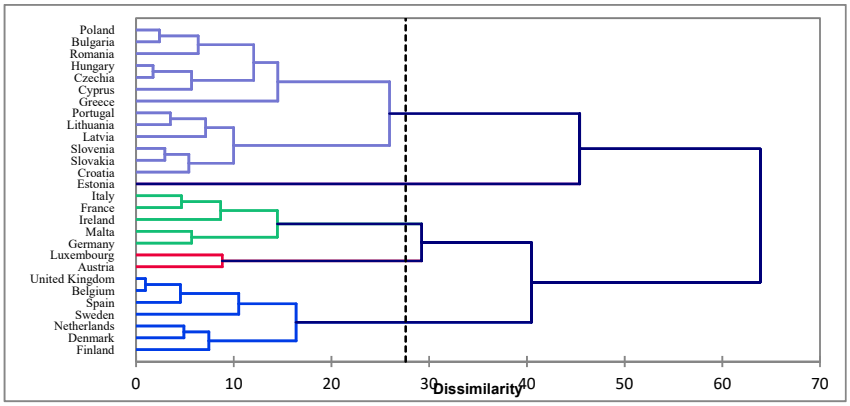

Fig. no. 2 Dendograma
Source: Own processing with XLSTAT

Cluster 3 is composed of: Bulgaria; Croatia; Cyprus; Czechia; Greece; Hungary; Latvia; Lithuania; Poland; Portugal; Romania; Slovakia; Slovenia. It is the largest grouping and it is distinguished by the lowest average values of the indicators *Real GDP per capita*, *5b2 Medical data exchange* (DESI) and *Healthcare expenditure by provider* and through the most modest developments in digital innovation. In Lithuania, IT companies have developed a HUB for innovation (Digital-Lithuania) that offers a multitude of innovative solutions in the public sector. Among the digital healthcare services offered we can name the patient e-mail services portal, electronic health services (with development of the electronic prescription service for patients); the information system on compulsory health insurance.
In Romania, at the beginning of April 2020, it was launched 9SOS, the first integrated private telemedicine system offering assistance and support services to people affected by COVID-19. This is a complex and complete solution that has the functions of registering, sorting, evaluating and monitoring those affected by COVID-19 as well as helping to reduce the load of the medical system by systemizing and automating the contact with infected persons.
Cluster 4 is represented by Estonia. Nearly three decades after regaining its independence, Estonia had the courage to invest in IT solutions, reaching the point that it can now be considered Europe's digital leader. Starting with the first step in digitization in 1995, when all Estonian schools were connected to the internet and culminating with the e-residency service (2014) which allows entrepreneurs, regardless of nationality or area in which they live, to obtain a transnational digital ID for access to public services, so e-residents can set up/manage a remote business in EU.
Other milestones in Estonia's digitization process: *e-Government* (1997) – 99% of public services are available as electronic services; *Digital ID* (2002) – launch of a mandatory national identity card that offers digital access to all secure electronic services; *I-Vote* (2005) – Estonia becomes the first nation in history to offer online voting at national elections; *e-Health* (2008) – patient health data available online; 95% of the data generated by hospitals/doctors are digitized. All this led to Estonia's 25th place in the GII 2019 ranking and

obtaining Europe's leading position for providing online public services in the DESI hierarchy 2017. At the same time, according to the results of the global cyber security index determined by the International Telecommunication Union (ITU), Estonia was designated the most important European nation.

Noteworthy it is also the revolution of the health system with the help of digital solutions: e-Health Records, e-Ambulance and e-Prescription[5]. Currently, 99% of the health data are digitized, 99% of prescriptions are digital, about 2,3 million monthly queries related to medical information are identified, and the billing of healthcare services is 100% electronic. However, paradoxically, for the indicators of *life expectancy* at the *birth and life expectancy at age 65*, Estonia is below the EU average.

Cluster 5: France; Germany; Ireland; Italy; Malta. Considered the fourth world health market in 2018 and one of the top ten countries in terms of health expenditure per capita (measured as a percentage of GDP), Germany has a relatively low degree of digitization of the health system. The first electronic health law in German history was approved in 2015. Subsequently, in 2017 were initiated electronic medical services, the possibility of fast and safe transmission of medical information and the provision of video consultations. Starting with 2018, it is possible to store emergency medical data such as blood group, allergies, history of previous illnesses etc. on an electronic health card.

Regarding Italy, at the end of 2019 Paolo Romolo Locatelli – scientific officer at the Politecnico Di Milano's Digital Innovation in Healthcare Observatory, declares "There is a delay in the digital transformation process, and the healthcare sector needs to speed up the transformation to reach the real impact on digital services for patients and citizens"(Postelnicu, 2019). He also underlined the use of the Electronic Medical Records (EMR) due to relevant regional projects (for example, in Lombardy and Veneto). Of maximum interest, but with a slower evolution, is also considered telemedicine, due to the services requested by patients and doctors alike. Research on the impact of digital innovation on health aims at a better understanding of how the latest discoveries in technology lead to improved health. This gives an overview of the integration of digital innovation in health systems and provides a perspective on how socio-economic factors and public digitization influence or correlate with *healthy life expectancy* and *years lived with disability*. Considering that the final solution is not always the optimal solution, the validity of the results of the Cluster Analysis is given either by the confirmation of the grouping solution used or by the interpretative methods of graphical representations.

Conclusions

The evolution of medical technologies, as well as a greater focus on prevention, health and well-being, will bring major improvements in patient outcomes. High quality, affordable healthcare for all is important for sustainable economic growth, as well as for the overall quality of citizen's life. While significant progress has been made over the last decades on several dimensions, there are gaps in access to quality health care for a large part of the global population.

With the evolution of digital and biological technologies, the importance of data integration and management in the medical system also increases. Health innovation is now evolving massively around the Internet of Things, Big Data and Artificial Intelligence, which involves huge power changes within the health sector. Emerging markets have a unique opportunity to capitalize on medical innovations and invest in new healthcare models in order to reduce the gap to more developed markets. However, it must be taken into account that new health innovations as well as their costs can increase the health gap between the rich and the poor.

As previously mentioned, Estonia's health system has been revolutionized by innovative

[5] https://e-estonia.com/solutions/healthcare/e-health-record/

electronic solutions and the benefits of accessing electronic health services have not only been just for patients and physicians, as these government policies have also led to economic benefits for hospitals.

In the future, we want to include in the analysis the impact of blockchain technology on the medical systems and on the pharmaceutical industry, as well as the study of 5G mobile technology use in instant healthcare. Another factor that will be included in a future research will refer to the implementation of digital medical solutions for the disadvantaged and the elderly, which is difficult to manage under the current conditions generated by the coronavirus pandemic.

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References

Baltaxe, E., Czypionka, T., Kraus, M., Reiss, M., Askildsen, J.E., Grenkovic, R., Lindén, T.S., Pitter, J.G., Rutten-van Molken, M., Solans, O., Stokes, J., Struckmann, V., Roca, J. and Cano, I., 2019. Digital Health Transformation of Integrated Care in Europe: Overarching Analysis of 17 Integrated Care Programs. *Journal of Medical Internet Research*, 21(9). Article Number: e14956.

Cornell University, INSEAD, and WIPO, 2019. *The Global Innovation Index 2019: Creating Healthy Lives - The Future of Medical Innovation,* Ithaca, Fontainebleau, and Geneva. [pdf] Available at: <https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2019.pdf> [Accessed at 12 February 2020].

European Commission, 2019. *Digital Single Market,* [online] Available at: <https://digital-agenda-data.eu/> [Accessed at 1 February 2020].

Eurostat, 2014. *Statistics Explained,* [online] Available at: <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Health_glossary> [Accessed 18 February 2020].

Eurostat, 2019. *Mortality and life expectancy statistics,* [online] Available at: <https://ec.europa.eu/eurostat/statistics-explained/index.php/Mortality_and_life_expectancy_statistics> [Accessed at 03 February 2020].

Eurostat, 2020. *Healthy life years statistics,* [online] Available at: <https://ec.europa.eu/eurostat/statistics-explained/index.php/Healthy_life_years_statistics> [Accessed at 04 February 2020].

Imbrişcă, C.I. and Neaţu, A.M., 2015. *The implementation of e-Health solutions. A review of international solutions and their relevance for Romania.* Bucharest: Editura ASE.

INED, 2019. *Tous les pays du monde,* [online] Available at: <www.ined.fr> [Accessed at 5 April 2020].

Postelnicu, L., 2019. *Q&A: How Italy is working to digitise healthcare*. [online] Available at: https://www.healthcareitnews.com/news/europe/qa-how-italy-working-digitise-healthcare [Accessed at 23 March 2020].

Roser, M., Ortiz-Ospina, E. and Ritchie, H., 2020. *Life Expectancy,* [online] Available at: <https://ourworldindata.org/life-expectancy> [Accessed 12 February 2020].

UNFPA and HelpAge International, 2012. *Ageing in the Twenty-First Century: A Celebration and A Challenge,* New York, London: UNFPA and HelpAge International.