Problemy Zarządzania – Management Issues, vol. 16, no. 5(78): 22–34
ISSN 1644-9584, © Wydział Zarządzania UW
DOI 10.7172/1644-9584.78.2

Efficiency of Health Care in the EU28 Countries with the Innovation Factor Taken Into Account

Submitted: 06.09.18 | Accepted: 16.10.18

Mariola Zalewska*

The article presents an attempt to analyse the efficiency of health care systems in sub-regions of Poland in comparison to sub-regions of EU countries, using the indicator of average life expectancy and an innovation indicator developed on the basis of the European Innovation Scoreboard. The basic source of data presented in the article is commonly available data from databases of countries or international organisations: the Polish Central Statistical Office (GUS), Eurostat, WHO. Comparative methods were applied to the following indicators: the expenditure on health care, life expectancy and innovation at the country level. Life expectancy depends mainly on health expenditure, but also on access to innovative therapies. Countries referred to as "modest innovators", to which Poland belongs, have a lower indicator of life expectancy than innovation leaders. Innovation is becoming the main engine of progress in health care.

Keywords: health care system, efficiency, European Innovation Scoreboard, life expectancy.

Efektywność systemów ochrony zdrowia w krajach UE28 z uwzględnieniem czynnika innowacyjności

Nadesłany: 06.09.18 | Zaakceptowany do druku: 16.10.18

Celem artykułu jest analiza efektywności systemów ochrony zdrowia w krajach UE28 w oparciu o wskaźnik średniego dalszego trwania życia i wskaźnik innowacyjności opracowany na podstawie *European Innovation Scoreboard*. Podstawowym źródłem danych prezentowanych w artykule są ogólnodostępne dane pozyskane z baz danych krajów lub organizacji międzynarodowych: Eurostat, WHO. Zastosowano metody porównawcze dla analizowanych zmiennych: wydatków na ochronę zdrowia, wskaźników średniego dalszego trwania życia i innowacyjności krajów. Zauważono, że dalsze trwanie życia w głównej mierze zależy od wydatków na ochronę zdrowia, ale również od dostępu do innowacyjnych terapii. Kraje określane jako „skromni innowatorzy" (*modest innovators*), do których należy Polska, mają niższy wskaźnik średniego dalszego trwania życia w porównaniu z liderami innowacji. Innowacje stają się głównym motorem postępu w ochronie zdrowia.

Słowa kluczowe: system ochrony zdrowia, efektywność, European Innovation Scoreboard, oczekiwana długość życia.

JEL: O3, I14, H75

* **Mariola Zalewska** – PhD, Faculty of Management, University of Warsaw. https://orcid.org/0000-0002-8474-671X.

Correspondence address: Faculty of Management, University of Warsaw; 1/3 Szturmowa Street; 02-678 Warsaw; e-mail: Zalewska@wz.uw.edu.pl.

1. Introduction

Civilisational Challenges

The operations of health care systems cover virtually all people. In the face of growing civilisational challenges directly related to health care such as population growth, population ageing, universal access to health services for all citizens without the risk of financial consequences, world leaders have taken joint action. The 2030 Agenda for Sustainable Development adopted by the United Nations General Assembly sets out an action plan for people, our planet and prosperity (UN, 2015, p. 1). The plan covers 17 Sustainable Development Goals (SDGs) with 169 associated targets that are integrated and indivisible (UN, 2015, p. 7). Goal 3 refers to health and well-being and is to "Ensure healthy lives and promote well-being for all at all ages" (UN, 2015, p. 15).

Policy makers from the global, through international, national, regional down to local levels are taking action to improve the efficiency of health care systems. The improvement of economic and social efficiency is aimed at achieving better input-output ratios (Frączkiewicz-Wronka, 2010, pp. 53–54; Zalewska, 2011, p. 43). Health care systems in the EU28 are managed in different ways. According to the service delivery and financing models, three different systems can be distinguished: Beveridge's system, Bismarck's system and a mixed system (Gaeta et al., 2017). Health care systems need and benefit from innovation. Innovation is a driving force in the pursuit of a balance between health care quality and cost reduction. Policy makers are simultaneously trying to provide the most effective access to innovative treatment methods, taking into account affordability, while maintaining incentives for innovation. Diffusion of innovation in health care systems contributes to greater access to new diagnostic and therapeutic possibilities, and thus to longer life and its improved quality. Information technologies also play an important role by contributing to the growth of innovation in health systems.

The article seeks to analyse the efficiency of health care systems in the EU28 countries, with the innovation factor taken into account.

The article presents variables and their relationships:

1. health care expenditure and life expectancy for 174 countries in 2016,
2. the innovation index for the EU28 countries and life expectancy for women and men in 2015,
3. a tree diagram of the European Innovation Scoreboard for the EU28 countries in 2015.

2. Health Determinants and the Impact of Interventions on Health

Health care (HC) systems are monitored and evaluated to improve their operation and efficiency. Countries and international organisations develop indicator systems in an effort to build a comparable health information and knowledge system. A good health care system provides high quality services to all people when and where they need them. Service configuration varies from country to country, yet it invariably requires: a robust funding mechanism; well-trained and adequately paid workforce; reliable information providing the basis for decisions and HC policy development; provision of high quality treatments and medicines (WHO, 2018).

The European Commission (European Commission, 2009) in the Joint Action for European Community Health Indicators and Monitoring proposed and implemented 88 European Community Health Indicators (ECHI) to monitor in all Member States. The indicators are divided into five subsets:

– demography and socioeconomic situation – 9 indicators,
– health status – 32 indicators (including life expectancy),
– health determinants – 14 indicators,
– health interventions: health services – 29 indicators,
– health interventions: health promotion – 4 indicators.

These subsets of indicators are not homogeneous. As regards the indicators in the subset of health determinants, they can be further divided, taking into account whether an increase in the indicator contributes to improvement or deterioration of health or whether there is the optimum indicator value termed the nominal value.

Table 1 presents the breakdown of ECHIs for health determinants, divided into destimulants/nominants/stimulants and individual/collective research.

Research	Destimulant	Stimulant	Nominant
Individual	regular smokers, pregnant women smoking, total alcohol consumption, hazardous alcohol consumption, use of illicit drugs, work-related health risks	consumption of fruit, consumption of vegetables, breastfeeding, physical activity	body mass index, blood pressure
Collective	PM10 (particulate matter) exposure	social support	

Tab. 1. Indicators for health determinants according to ECHIs, divided into destimulants/nominants/stimulants and individual/collective research. Source: Prepared by the author based on ECHI. https://webgate.ec.europa.eu/chafea_pdb/health/projects/20082391 (accessed on 8.07.2018).

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In this model of indicators, in particular health determinants, the weaknesses of this system of indicators can be indicated and the direction of changes can be suggested. Disadvantages may be said to include, first and foremost, the lack of headline indicators and the heterogeneity of this subset mentioned earlier in the case of a set of indicators for health determinants. It is also difficult to clearly assign indicators to one set, and indicators such as body mass index or blood pressure are performance indicators regarding the health status and should be included in the subset of health status. In addition, the entire set lacks, for example, indicators for innovation of health care systems. It can be assumed that what matters for HC assessment is whether patients have access to innovative diagnostic and therapeutic methods.

A more general model, the Health Impact Pyramid, was presented by T. Frieden (Frieden, 2010). The Health Impact Pyramid does not include any set of indicators, yet it is a proposal for developing an indicator system.

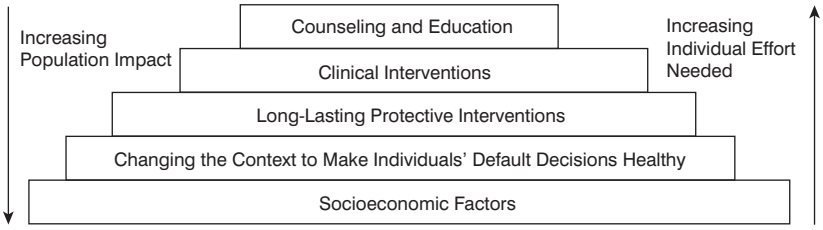

Fig. 1. Health Impact Pyramid. Source: Prepared by the author based on Frieden (2010).

The five-tier pyramid depicts the impact of various actions called in the original article public health interventions providing a framework for public health improvement. The bottom of the pyramid is formed by **Socioeconomic Factors**, interventions with the greatest potential impact. These are efforts to tackle socioeconomic health determinants (such as, for example, access to sanitation, improved education). The socioeconomic status is one of the most important determinants of health, both within and among individual countries (Mackenbach et al., 2008).

The second tier of the pyramid covers **Changing the Context to Make Individuals' Default Decisions Healthy**. These interventions change the environmental context to make healthy options the default choice, regardless of education, income, service provision, or other societal factors. These changes can lead to healthier default values including improvements in various aspects of life ranging from road and vehicle design to salt iodization, but also incentives to use public transport, facilitation of cycling, taxes on cigarettes or unhealthy food.

The third tier of the pyramid, **Long-Lasting Protective Interventions**, includes one-off or multiple interventions that do not require permanent clinical care; these interventions generally have less impact than interventions represented by the two bottom tiers because they require reaching people who need them. Examples of such interventions may be vaccinations that, according to historical WHO data, have prevented 2.5 million deaths annually among children worldwide (WHO, UNICEF, World Bank, 2010) or treatment to stop smoking.

The fourth tier, **Clinical Interventions**, covers e.g. interventions to prevent cardiovascular diseases, diabetological treatment and others that have the greatest potential health impact but require continuous treatment. The fifth tier of the pyramid is **Counseling and Education** encompassing health education perceived by the author as actions for public health and assessed as the least effective type of interventions (Whitlock, Orleans, Pender, & Allan, 2002). At this tier, all interventions require the greatest individual involvement, are directed to individuals, and include dietary advice.

Implementing interventions at each tier can contribute to health benefits of the population. Depending on the tier of the pyramid, individual involvement in interventions and health effects on some part of the population vary. The actions at the lowest tier of the pyramid require the least individual efforts on the part of individuals and have an impact on the largest part of the population; they concern broader social groups. In an increasing order, higher tiers cover interventions that require more and more individual effort, while having an impact on a smaller part of the population.

The Health Impact Pyramid does not show any set of indicators; Frieden only gives examples of interventions at various tiers of the pyramid – interventions that have contributed to better health of the population.

In this model, indicators concerning the innovation of health care systems can be assigned to each tier and thus it is possible to recognise that innovation at the level of socioeconomic factors has the greatest impact on the health of society, with a gradually decreasing influence at subsequent tiers.

3. Life Expectancy – A Measure of the Condition of the Health Care System

Multiple measures have been developed that describe the performance of health care systems, including the most commonly used health results. These comprise, among others, life expectancy (LE), healthy life years (HLY), healthy life expectancy (HALE), potential years of life lost (PYLL), quality adjusted life years (QALY).

The most frequently used measure is still life expectancy (LE). It is calculated commonly, despite the awareness of its limitations, namely that it

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is based only on one type of data – regarding mortality (Ryć & Skrzypczak, 2011).

In spite of the similarity between challenges and undertaken actions, there are still significant differences between and within countries, indicating considerable disparities of the health status of populations. The apparent alignment of life expectancies in various countries is just an artefact (Oeppen & Vaupel, 2002). In 2016, the difference between the shortest and longest life expectancy for countries was 31.3 years; the shortest was for Lesotho, standing at 52.9 years, and the longest for Japan, at 84.2 years (WHO, 2018c).

Experts have repeatedly claimed that life expectancy is approaching the ceiling (Oeppen & Vaupel, 2002). If life expectancy is close to the maximum, its increase should slow down, yet life expectancy is growing (Oeppen & Vaupel, 2002).

The trend of life expectancy in the 20th century was characterised by slow, steady growth (Faber, 1982; World Bank, 2018), with fluctuations caused by epidemics and pandemic infectious diseases, hunger and war (World Bank, 2018; Olshansky et al., 2005).

Figure 2 presents life expectancy depending on health care expenditure. The figure is based on WHO data from 2016 for 174 countries.

It shows that for all countries, the best linear adjustment of the presented relationships is for the coefficient of determination R2 = 0.73, meaning that in 73% life expectancy counted in years can be explained by the variability of per capita health expenditure in the purchasing power parity.

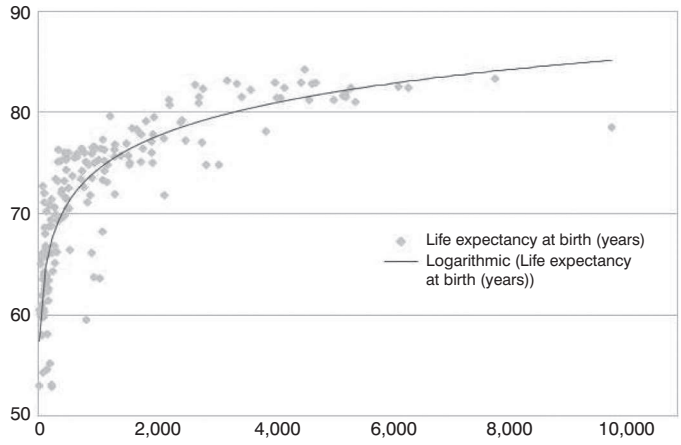

Fig. 2. Life expectancy in 174 countries around the world, depending on current per capita health expenditure in PPP in USD. Source: Prepared by the author based on WHO data for 174 countries for 2016. WHO. (2018c) accessed on 27.12.2018; WHO. (2018d) accessed on 27.12.2018.

The remaining 27% can be explained by other factors. For 30 countries, total life expectancy in excess of 80 years was recorded, and the expenditure of these countries significantly varied from USD 1,249 for Costa Rica to USD 7,867 for Switzerland (measured as current spending per capita in PPP in USD).

Data for Poland is marked with a circle; life expectancy was 77.8 years, with per capita spending in PPP of USD 1,774. Life expectancy depends on many factors including health care expenditure, yet other factors are also important.

4. Innovation of EU28 Countries – EIS Indicators

Innovation in general is the implementation of a new or significantly improved product (good or service) or process, a new marketing method or a new organisational method in business practices, workplace organisation or external relations (OECD, 2005). *Health innovation identifies new or improved health policies, systems, products and technologies, and services and delivery methods that improve people's health and wellbeing. Health innovation responds to unmet public health needs by creating new ways of thinking and working with a focus on the needs of vulnerable populations. It aims to add value in the form of improved efficiency, effectiveness, quality, sustainability, safety and/or affordability. Health innovation can be preventive, promotive, curative and rehabilitative and/or assistive care* (WHO, 2018a).

According to the authors of the OECD report, innovation is entering health care systems on an unprecedented scale: remote sensors, robotics, stem cells, artificial intelligence, 3D printing used for the production of implants will soon become a regular part of medical care (OECD, 2017). Commonly collected health data is used to develop and improve health care systems, from clinical care to the health of populations.

As part of the Lisbon Strategy, the European Commission and the EU member states introduced the European Innovation Scoreboard (EIS), which measures member states' innovation performance on an annual basis by means of statistics from different sources. Innovation performance is measured by a composite indicator comprising four main types of indicators: framework conditions, investments, innovation activities, and impacts, and ten dimensions of innovation that encompass 27 indicators in total. These indicators are included in the Summary Innovation Index.

For the development of the European Innovation Scoreboard presented in Table 2, collective results for sub-indices are used without distinguishing innovation performance in industries. In particular, sub-indicators for the health care area have not been distinguished so far. In all dimensions, the indicators include aggregated data, for example the share of public expenditure on R&D includes all expenditures in total in a country.

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Dimensions of innovation	Indicators
Framework Conditions	
Human resources	1.1.1 New doctorate graduates
	1.1.2 Population completed tertiary education
	1.1.3 Lifelong learning
Attractive research systems	1.2.1 International scientific co-publications
	1.2.2 Scientific publications among top 10% most cited
	1.2.3 Foreign doctorate students
Innovation-friendly environment	1.3.1 Broadband penetration
	1.3.2 Opportunity-driven entrepreneurship
Investments	
Finance and support	2.1.1 R&D expenditure in the public sector
	2.1.2 Venture capital investments
Firm investments	2.2.1 R&D expenditure in the business sector
	2.2.2 Non-R&D innovation expenditure
	2.2.3 Enterprises providing ICT training
Innovation activities	
Innovators	3.1.1 SMEs with product or process innovations
	3.1.2 SMEs with marketing or organisational innovations
	3.1.3 SMEs innovating in-house
Linkages	3.2.1 Innovative SMEs collaborating with others
	3.2.2 Public-private co-publications
	3.2.3 Private co-funding of public R&D expenditures
Intellectual assets	3.3.1 PCT patent applications
	3.3.2 Trademark applications
	3.3.3 Design applications
Impacts	
Employment impacts	4.1.1 Employment in knowledge-intensive activities
	4.1.2 Employment fast-growing firms innovative sectors
Sales impacts	4.2.1 Medium & high tech product exports
	4.2.2 Knowledge-intensive services exports
	4.2.3 Sales of new-to-market and new-to-firm innovations

Tab. 2. Dimensions of the European Innovation Scoreboard and individual innovation indicators of EU countries calculated in EIS. Source: Prepared by the author based on Eurostat data http://ec.europa.eu/DocsRoom/documents/24016, accessed on 10.07.2018.

5. Innovation of the EU28 Countries and Life Expectancy

As cited following the OECD, innovation is entering national economies, including health care systems, to various degrees. So, do innovation leaders achieve better results for HC systems, inclusive of life expectancy? In considering HC efficiency, Dubas (2011) mentions a general definition of *efficiency* used in various areas of life, meaning efficacy, effectiveness (Dubisz, 2003, p. 788). Therefore, in this respect, efficiency of the health care system implies its effectiveness (the degree to which the objectives of an action have been achieved) and efficacy. Taking the above into account, Figure 3 presents the relationships between the Summary Innovation Index of EU28 (countries ordered according to the index value) and life expectancy for women and men (data for 2015).

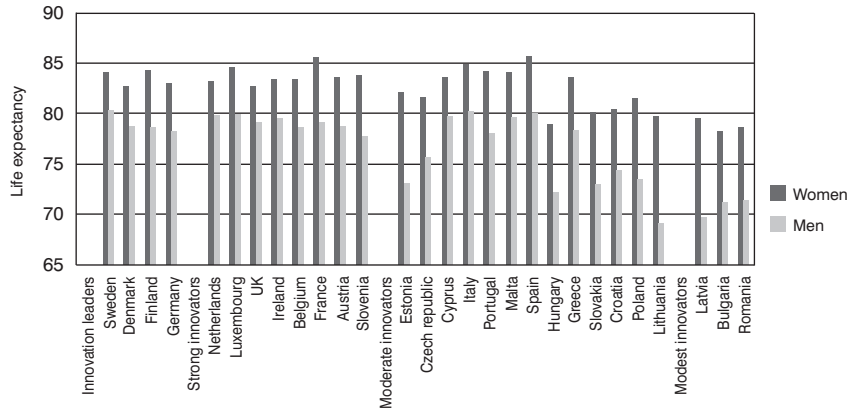

Fig. 3. Summary Innovation Index of the EU28 countries and life expectancy for women and men in 2015. Source: Prepared by the author based on Eurostat. Accessed on 8.07.2018.

On the basis of Figure 2, it can be seen that *innovation leaders* and *strong innovators* have similar life expectancies for women and men. There are no significant differences in life expectancy between these groups of countries in terms of the innovation criterion. The most divergent observations that have the shortest life expectancies were recorded for *modest innovators*, where the shortest life expectancies were noted for men and women. Among the EU28 countries, those that were assessed as more innovative have longer life expectancies for women and men.

As regards the diversity of LE, the shortest life expectancy for women was 78.2 years for Bulgaria; the longest was 85.7 years for Spain; for men, the shortest life expectancy was 69.2 years for Lithuania and the longest stood at 80.4 years for Sweden. The span between the longest and the

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shortest life expectancy for the EU28 countries is 7.5 years for women and 11.2 years for men.

The reduction of innovation gap is likely to contribute to increasing life expectancy. And this is more true for men than women.

The following Figure 4 illustrates the hierarchical structure of the EU28 countries, links between individual countries, based on the European Innovation Scoreboard indicators for the EU28 countries in 2015.

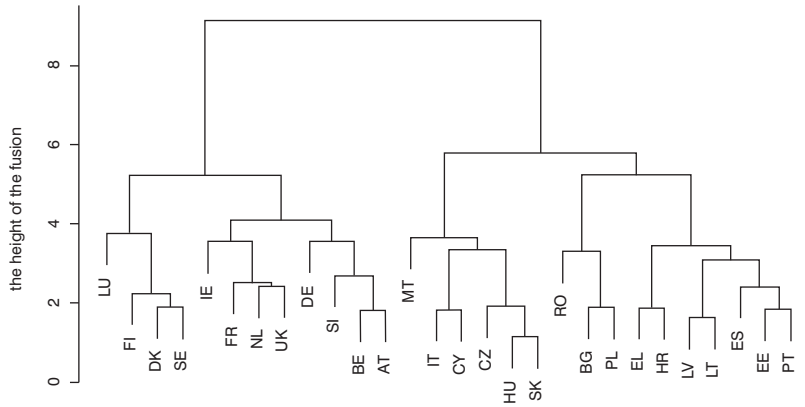

Fig. 4. A tree diagram of the European Innovation Scoreboard for the EU28 countries in 2015. Source: Prepared by the author based on Eurostat. Accessed on 8.07.2018.

Each country corresponds to one observation (27 ESI indicators). Moving up the tree, the similarity between observations decreases; similar observations are combined into branches (clusters) and further fused at the next level. Conclusions regarding the proximity of two observations can only be drawn on the basis of the height at which these observations are connected. No inference can be made on the basis of the proximity of two observations along the horizontal axis as a criterion for their similarity. The obtained results confirm the division of countries into two clusters: *innovation leaders* and *strong innovators* on the one hand and *moderate innovators* and *modest innovators* on the other. Poland is most similar to countries that are the least innovative of the EU28 countries.

Figure 5 shows the relationship between the innovation index (in 2016) and life expectancy (in 2016) for the EU28 countries, according to the criterion of the HC management model (circles denote countries with Bismarck's model; triangles denote countries with Beveridge's model; rhombuses denote countries with a mixed model).

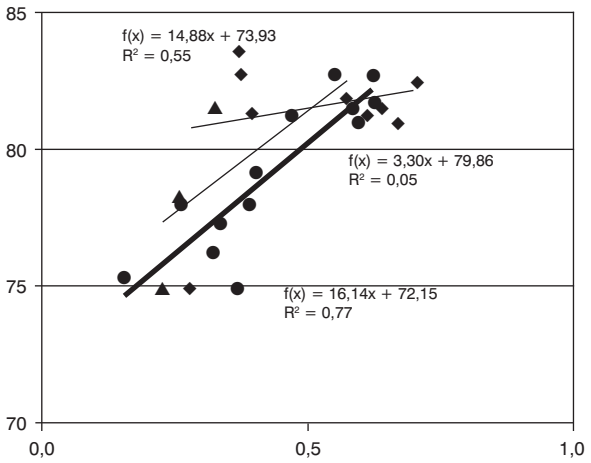

Fig. 5. Innovation index for the EU28 countries and total life expectancy, considering the HC system management model, 2015. Source: Prepared by the author based on Eurostat. Accessed on 8.07.2018.

Regression curves were adjusted for each group of countries and the coefficients of determination were calculated.

The conclusions from the figures are as follows:

1. in the group of 13 countries with Bismarck's model (marked with circles: Belgium, Estonia, France, Germany, Lithuania, Luxembourg, the Netherlands, Poland, the Czech Republic, Romania, Slovakia, Slovenia, Hungary), the higher the innovation index, the higher life expectancy, high R2 coefficient = 0.77;
2. in the group of 11 countries with Beveridge's model (marked as rhombuses: Cyprus, Denmark, Finland, Ireland, Italy, Latvia, Malta, Portugal, Spain, Sweden and the United Kingdom) except Latvia, all countries, despite different levels of innovation, achieve high life expectancies; low R2 coefficient = 0.05;
3. in the group of 4 countries with a mixed model (marked as triangles: Austria, Bulgaria, Greece and Croatia), the R2 coefficient = 0.55, i.e. it is lower than for those with Bismarck's model, yet a similarity occurs, namely the higher the coefficient, the longer life expectancy.

For all EU28 countries, the best linear adjustment of the presented dependences is for the coefficient of determination R2 = 0.41.

For Poland (values marked with a larger circle), the innovation index was 0.266 and life expectancy was 78[1], while for all EU28 the innovation index was 0.498 and life expectancy was 78.2. As regards the innovation index, Poland ranked 25th among the EU28 countries and, despite moderate values, it ranked 21st in the EU28 in terms of life expectancy.

 DOI 10.7172/1644-9584.78.2

6. Conclusion

In the light of civilisational challenges, studying the efficiency of the health care system is becoming very important. Decision-makers at all levels are undertaking joint actions: strategies, monitoring and evaluation systems (including indicator systems), programmes to ensure the highest quality of health care systems for the population in the most effective manner.

The importance of developing, monitoring and evaluating a set of indicators for the health care system is growing. The article points out weaknesses and gaps in the existing ECHI indicator system for the EU28 countries, heterogeneity of indicator groups, a lack of leading indicators, a lack of indicators regarding system innovation. Perhaps a better solution is to develop a pyramid of health care system indicators, starting with those that have the greatest impact on the efficiency of HC systems. The performed analyses make it possible to suppose that increased efficiency of HC systems of the EU28 countries can and should be sought. This can be achieved through actions with varying impact ranges. This article particularly highlights the role of innovation as a factor that penetrates all tiers of the health impact pyramid. It is reasonable to introduce indicators for HC innovation into the system. The article draws attention to the relationship between the innovation index and life expectancy in the EU28. In this ranking of countries according to the EIS indicator, especially *modest innovators* have significantly lower life expectancy values for both women and men. As regards the financing model of the HC system, for all countries, the dependence between the innovation index and life expectancy was positive and the strongest for countries with Bismarck's model.

Endnotes

[1] According to WHO data, life expectancy for Poland in 2017 was 77.8 years; according to Eurostat, it was 78.2 years.

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