IMPACT OF HEALTH EXPENDITURES AND HEALTH RESOURCES ON HEALTH STATUS IN THE EUROPEAN UNION MEMBER STATES

Pavla Jindrová

Abstract

Health of population is not only valuable in and of itself, but contributes to economic growth and social inclusion and so health status monitoring is important for EU policies. The health status of the population cannot be captured by a single metric and it is determined by many factors inside and outside of the health systems. The aim of this article is quantification of causal relationships among health status, health expenditures and health care resources in the European Union Member States. Health status and its determinants are multidimensional categories that are specified by a number of selected indicators accessible from Eurostat, OECD or WHO databases. Multidimensional statistical methods namely rank correlation, factor analysis, cluster analysis and linear ordering of countries using synthetic variables will be used to achieve the goal of the article. The results of the analysis also reveal some of the causes of inequalities in health status in the EU Member States.

Key words: Health Expenditure, Health resources, Health Status, Multidimensional Statistical Methods.

JEL Code: C38, I14, I15

Introduction

Health is important for the wellbeing of individuals and society, but a healthy population is also a prerequisite for economic productivity and prosperity. The European Commission promotes investing in health as a broader means of achieving smart sustainable and inclusive growth. This takes the form of:

- Promoting effective, accessible and resilient health systems
- Investing in health through disease prevention and health promotion
- Fostering health coverage as a way of reducing inequalities and tackling social exclusion.

Health policy defines health goals at the international, national or local level and specifies the decisions, plans and actions to be undertaken to achieve these goals. Health 2020 is the European health policy framework. It aims to support action across government and society to: "significantly improve the health and well-being of populations, reduce health inequalities, strengthen public health and ensure people-centred health systems that are universal, equitable, sustainable and of high quality" (WHO Regional Office for Europe, 2013).

1 Indicators, data and methods

The health status of the population cannot be captured by a single metric and it is determined by many factors inside and outside of the health systems. Fundamental determinants of state of health in each country include health expenditure and quality of health care. Health status and its determinants are multidimensional categories that are specified by a number of selected indicators accessible from Eurostat, OECD or WHO databases.

The objective of the article is to reduce the dimension of large-scale data sets of health indicators in European Union member states by using selected multidimensional methods, assessing health inequalities and identifying and quantifying some of its determinants.

The Eurostat database (2019) offers the most comprehensive source of comparable statistics of health and health systems across the EU countries. As the basis of a multivariate statistical analysis, the following indicators have been selected:

Health status

H1 – Life expectancy at birth, total, 2016 (or nearest year)

H2 – Healthy life years, men, 2016 (or nearest year)

H3 – Healthy life years, women, 2016 (or nearest year)

H4 – Healthy life years at 65, men, 2016 (or nearest year)

H5 – Healthy life years at 65, women, 2016 (or nearest year)

Health expenditures

E1 – All financing schemes (Percentage of GDP), 2016

E2 – Curative care and rehabilitative care (Percentage of GDP), 2016

E3 – Preventive care (Percentage of GDP), 2016

E4 – Long-term care (Percentage of GDP), 2016

Health care and recourses

R1 – Practising doctors per 1 000 population, 2016 (or nearest year)

R2 – Practising nurses per 1 000 population, 2016 (or nearest year)

R3 – Computed Tomography Scanners (per hundred thousand inhabitants), 2016

R4 – Magnetic Resonance Imaging Units (per hundred thousand inhabitants), 2016 (or nearest year)

R5 – Preventable mortality rates, three-years average (2013-15)

R6 – Amenable mortality rates, three-years average (2013-15)

The data matrix of the values of the 15 indicators has been completed for the 27 EU Member States, except Malta, due to the lack of data. According to the above mentioned goals we have used the correlation analysis, factor analysis, cluster analysis and multidimensional comparative analysis. Application of these methods can be found in Pacáková (2008), Pacáková et al. (2016), Pacáková & Kopecká (2018), Pacáková & Jindrová (2019) or Provazníková et al. (2015).

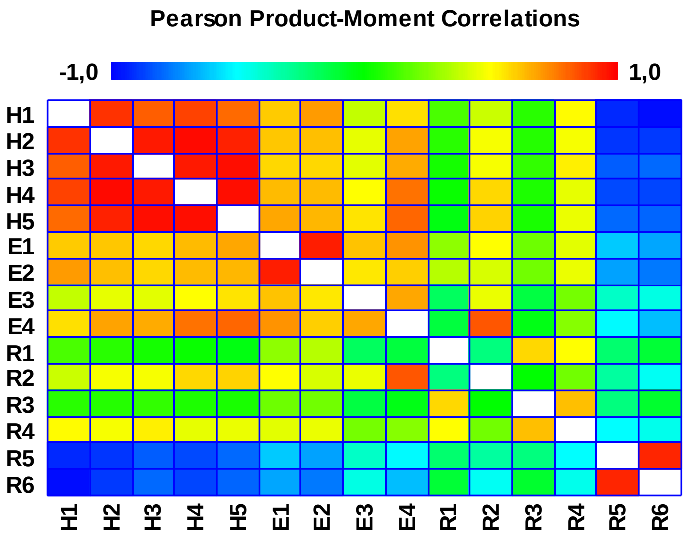
2 Results and discussion

Multidimensional statistical methods namely rank correlation, factor analysis, cluster analysis and linear ordering of countries using synthetic variables have been used to achieve the goal of the article. The results of the analysis also reveal some of the causes of inequalities in health status in the EU Member States.

2.1 Results of correlation analysis

Fig. 1 shows the correlation plot with results of correlation analysis, which makes it easy to assess the intensity of dependence of the indicators chosen. Surprisingly strong negative correlation of all health status indicators and indicators of preventable and amenable mortality.

Fig. 1: Correlation plot of selected health indicators



Source: Own processing using Statgraphics Centurion XVIII

2.2 Results of factor analysis

By application of factor analysis we have tried to obtain a small number of common factors which account for most of the variability in the 15 original variables. To assess the suitability of indicators for the factor analysis, we have applied the Kaiser-Meyer-Olkin measure (KMO). The KMO = 0.704776 shows suitability of the source variables for factor analysis. In our case, 3 factors have been extracted, since 3 factors had eigenvalues greater than or equal 1.0. Together they account for 83.54% of the variability in the original data.

Factor loadings present the correlation between the original variables and the factors and they are the key to understanding the nature of a particular factor. After varimax rotation we have obtained factor loadings shown in Tab. 2. Rotation is performed in order to simplify the explanation of the factors.

Tab. 2: Factor Loading Matrix After Varimax Rotation

	F1	*F2*	*F3*
H1	0.9098	0.2343	0.1643
H2	0.9292	0.3127	0.0780
H3	0.8874	0.3202	0.0762
H4	0.8873	0.4162	0.0322
H5	0.8232	0.4924	0.0146
E1	0.3807	0.7534	0.3884
E2	0.4626	0.6199	0.4425
E3	0.2208	0.7922	-0.0724
E4	0.4498	0.8243	-0.0827
R1	0.0322	-0.1348	0.8730
R2	0.2704	0.7591	-0.1407
R3	0.0102	-0.0295	0.8469
R4	0.4012	0.1709	0.7056
R5	-0.8936	-0.1903	-0.2607
R6	-0.8668	-0.3390	-0.1510

Source: Own processing using Statgraphics Centurion XVIII.

Based on factor loadings in Tab. 2 we found out that the 1st factor has strong positive correlation with five indicators of health status (H1-H5) and strong negative correlation with two indicators R5, R6 of health care. The 2nd factor has positive correlation with all four indicators of health expenditures (E1-E4) and with indicator R2 - number of practising nurses per 1 000 population. The 3rd factor has positive correlation with tree indicators of health personal and technical resources (R1, R3, R4). The high values of each extracted factor mean a high level the observed reality.

Based on above-mentioned we have named the three common factors as:

F1 – *Factor of health status and health care*

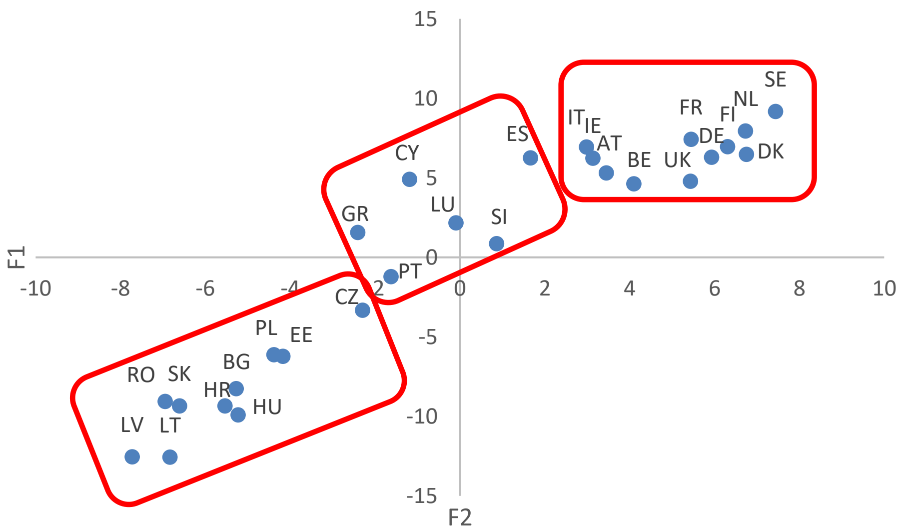
F2 – *Factor of health expenditures and nursing*

F3 – *Factor of personal and technical resources*

Graphical display of factor scores for monitored countries in a two-dimensional coordinate system allow us to evaluate and compare situation in these countries with respect to the extracted factors.

Fig. 2 shows the location of the EU countries in the coordinate system of factors F1 and F2. Monitored countries can be divided into three groups. First group consists of countries with low value of both factors F1 and F2. This group consists all post-socialist countries except Slovenia. Second group consists of countries with low or middle values of factor F2 and with middle to high values of factor F1. This group consists Slovenia, Greece, Portugal, Cyprus, Luxembourg and Spain. The third group with highest values of factor F2 and high level of health status and health care consists of the old EU member's countries. In Sweden the highest value of health expenditures and nursing leads to the highest values of health status and health care.

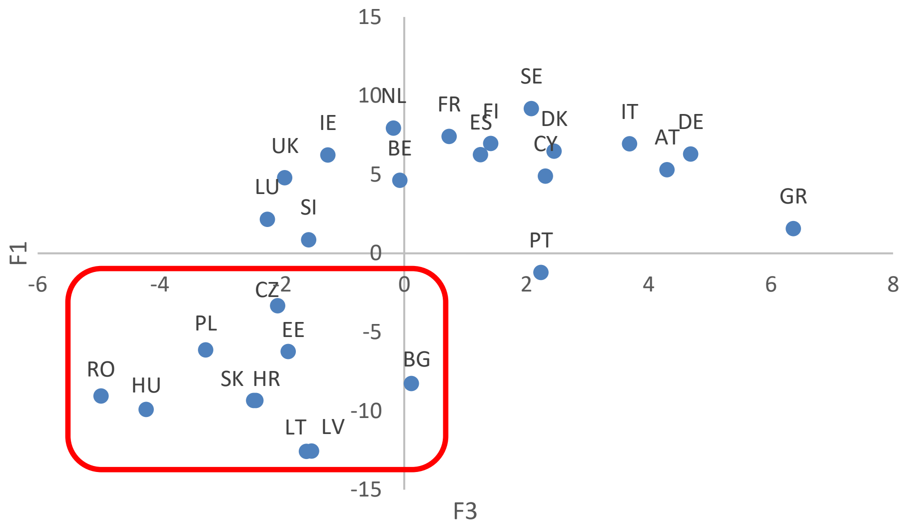
Fig. 2: Location of the EU countries in the coordinate system of factors F1 and F2



Source: Own processing

Fig. 3 shows location of the EU countries in the coordinate system of factors F1 and F3. In this figure it can be seen that the high value of the factor F1 corresponds to the high or middle value of the factor F3. But we can see that the highest value of factor F3 does not correspond with the highest value of factor F1 (see GR) and vice versa (see SE). In the Fig. 3 we can see that in post-socialist countries there are the lowest values of factor F1 and the lowest and middle values of factor F3.

Fig. 3: Location of the EU countries in the coordinate system of factors F1 and F3

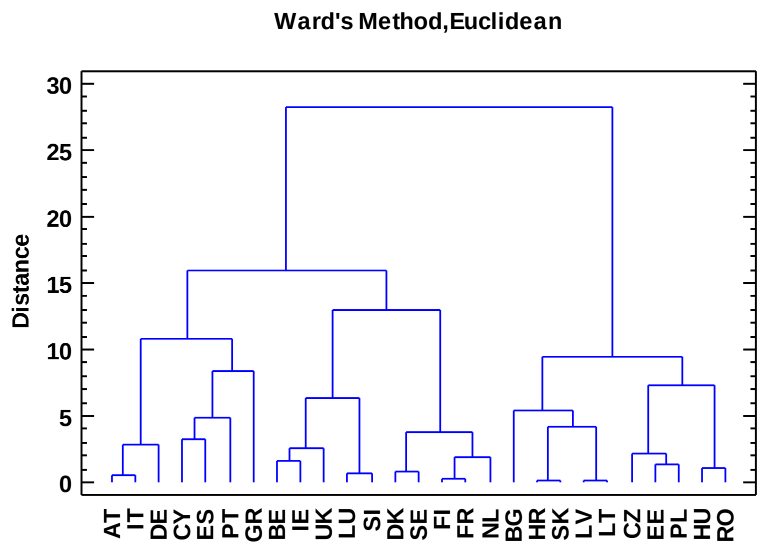


Source: Own processing.

2.3 Results of cluster analysis

The factor analysis based on principal component method resulted in 3 mutually independent factors, each representing one dimension of health situation. These factors are appropriate for the cluster analysis. Dendrogram (Fig. 4) presents the results in the visual form.

Fig. 4: Dendrogram



Source: Own processing using Statgraphics Centurion XVIII

According to the dendrogram of the Ward's method with Euclidean distances we have considered 3 different clusters. The cluster with the lowest values of the factor F1 of health status and health care and the lowest or very low values of factors F2 and F3 includes 10 former socialist countries (blue colour in Tab. 3). For the cluster which includes the countries Austria, Italy, Germany, Cyprus, Spain, Portugal and Greece the medium to high values of factor F2 and F3 and high to the highest values of factor F3 are typical (rose colour in Tab. 3). The cluster with high to the highest values of factors F1 and F2 and with moderate to high values of factor F3 consists of countries Belgium, Ireland, United Kingdom, Luxembourg, Slovenia, Denmark, Sweden, Finland, France and Netherlands (green colour in Tab. 3).

Tab. 3: Table of results of cluster analysis

Country		*F1*	Country		*F2*	Country		*F3*
Lithuania	LT	-12.57	Latvia	LV	-7.72	Romania	RO	-4.96
Latvia	LV	-12.54	Romania	RO	-6.95	Hungary	HU	-4.22
Hungary	HU	-9.91	Lithuania	LT	-6.83	Poland	PL	-3.25
Croatia	HR	-9.34	Slovakia	SK	-6.61	Slovakia	SK	-2.46
Slovakia	SK	-9.34	Croatia	HR	-5.53	Croatia	HR	-2.43
Romania	RO	-9.06	Bulgaria	BG	-5.27	Luxembourg	LU	-2.24
Bulgaria	BG	-8.26	Hungary	HU	-5.23	Czechia	CZ	-2.07
Estonia	EE	-6.23	Poland	PL	-4.38	United Kingdom	UK	-1.95
Poland	PL	-6.12	Estonia	EE	-4.17	Estonia	EE	-1.90
Czechia	CZ	-3.33	Greece	GR	-2.41	Lithuania	LT	-1.60
Portugal	PT	-1.21	Czechia	CZ	-2.29	Slovenia	SI	-1.56
Slovenia	SI	0.86	Portugal	PT	-1.62	Latvia	LV	-1.52
Greece	GR	1.56	Cyprus	CY	-1.18	Ireland	IE	-1.25
Luxembourg	LU	2.16	Luxembourg	LU	-0.09	Netherlands	NL	-0.17
Belgium	BE	4.63	Slovenia	SI	0.87	Belgium	BE	-0.07
United Kingdom	UK	4.79	Spain	ES	1.67	Bulgaria	BG	0.12
Cyprus	CY	4.90	Germany	IT	2.99	France	FR	0.73
Austria	AT	5.31	Ireland	IE	3.13	Spain	ES	1.25
Ireland	IE	6.23	Austria	AT	3.45	Finland	FI	1.42
Spain	ES	6.26	Belgium	BE	4.10	Sweden	SE	2.08
Germany	DE	6.29	United Kingdom	UK	5.44	Portugal	PT	2.24
Denmark	DK	6.49	France	FR	5.45	Cyprus	CY	2.31
Italy	IT	6.94	Germany	DE	5.93	Denmark	DK	2.45
Finland	FI	6.96	Finland	FI	6.31	Germany	IT	3.69
France	FR	7.42	Netherlands	NL	6.73	Austria	AT	4.30
Netherlands	NL	7.94	Denmark	DK	6.76	Germany	DE	4.69
Sweden	SE	9.18	Sweden	SE	7.45	Greece	GR	6.37

Source: Own processing.

2.4 Results of multidimensional comparative analysis

Multidimensional comparative analysis methods provide techniques for comparing multidimensional objects according to the observed complex property, characterized by several variables in order to linear ordering of them (Barnett, 1976; Kuc, 2012).

In the first step the type of each variable should be defined. It is necessary to identify whether the high values of a variable positively influence the analysed processes (such variables are called stimulants) or whether their low values are favourable (these are called destimulants). The original variables are usually measured in different units. The aim of normalisation in second step is to bring them to comparability. Normalisation have been performed according to the formulas

$$b_{ij} = \frac{x_{max} - x_{ij}}{x_{max} - x_{min}}, \tag{1}$$

$$b_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}}. \tag{2}$$

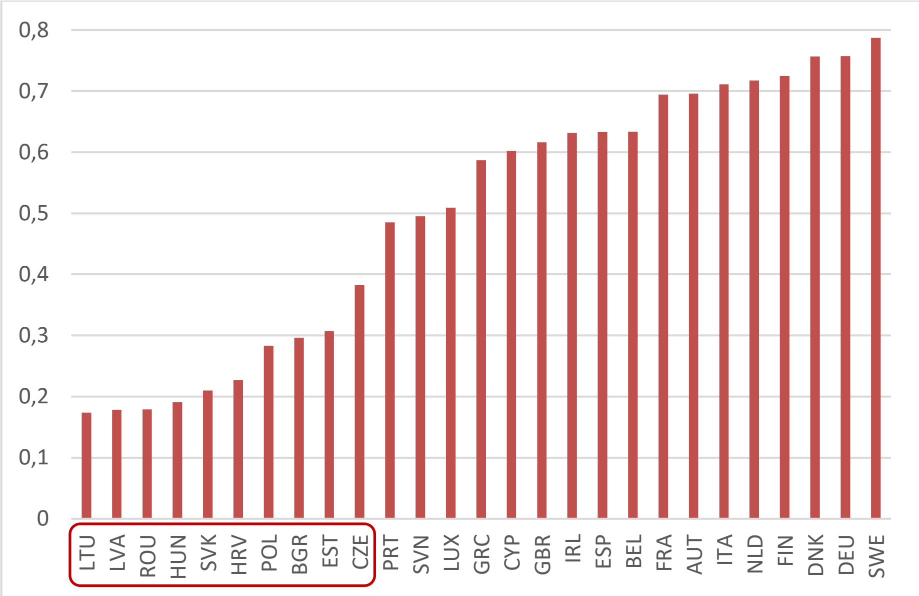
The formula (1) is convenient for stimulants and formula (2) for destimulants.

The aggregate measure of health state and health determinants, called as *synthetic variable* for each monitored country i = 1, 2, …, 27 has been calculated as the average of values b_{ij}, j = 1, 2, ..., 15. According to the formulas (1), (2) obviously implies that the higher the value of synthetic variable, the higher the level of the multidimensional object.

The synthetic variable allows to replace the set of variables into one aggregated variable. By this it allow to transform multidimensional problem to one dimensional. The synthetic variable made up of all 15 indicators of health status, health expenditures and personal and technical resources will make it possible to compare the monitored countries and arrange them from the best to the worst health status and its determinants. The group of stimulants contain almost all variables except R5 and R6, which are destimulants. The synthetic variable S has been created from all 15 indicators by formulas (1) and (2).

The Fig. 5 shows the values of the synthetic variable *S* in ascending order. The group with the smallest value of the variable *S* contains the group of post-socialistic countries. The worst situation in monitored health status and its determinants is in Lithuania, Latvia and Romania. The Czech Republic we can see on the tenth place before Portugal and Slovenia. The best situation we can see in Sweden, Germany and Denmark.

Fig. 5: Linear ordering the EU countries by synthetic variable S



Source: Own processing.

Conclusion

The results of the selected multidimensional methods confirmed their usefulness to reduce the dimension. The application of factor analysis allowed to replace the 15 original variables with three common factors explaining above 80% of the variability of the original variables. Identifying these factors by factor loadings has made possible to assess the impact of health expenditures and personnel and technical resources on health status in EU member states. The results of factor and cluster analysis confirm the significant inequalities in health status and its determinants in the monitored countries and especially bad health situation in the new EU members. This fact have been confirmed by results of multidimensional comparisons of health situation and so despite the efforts and actions of the European Commission the health inequalities in countries of EU are considerable.

References

Barnett, V. (1976). The Ordering of Multivariate Data. *Journal of Royal Statistical Society*, Ser. A, 139, 318–354.

Eurostat Statistics Explained (2019). *Health in the European Union – facts and figures*. https://ec.europa.eu/eurostat/statistics-explained/index.php/Health_in_the_European_Union_%E2%80%93_facts_and_figures

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. (2007). *Multivariate Data Analysis*. Sixth Edition. New Jersey: Pearson Education, Inc.

Kuc, M. (2012). The implementation of synthetic variable for constructing the standard of living measure in European Union countries. Oeconomia Copernicana, 3(3), 5-19. https://doi.org/10.12775/OeC.2012.012

OECD/EU (2018). *Health at a Glance: Europe 2018: State of Health in the EU Cycle,* OECD Publishing, Paris. *https://doi.org/10.1787/health_glance_eur-2018-en*

Pacáková, V. (2008). Multidimensional statistical methods and applications. *Ekonomický časopis*, *56(2)*, 218-219.

Pacáková, V., Jindrová, P. & Zapletal, D. (2016). Comparison of Health Care Results in Public health Systems of European Countries. *In: European Financial Systems* 2016, Brno: Masaryk University, 534-541.

Pacáková, V. & Kopecká, L. (2018). Inequalities in Health Status Depending on Socio-economic Situation in the European Countries. *E+M Economics and Management,* XXI (2).

Pacáková, V. & Jindrová, P. (2019) Determinants of Health Inequalities in European Countries. In: *Wseas Transactions on Business and Economics, 16*, 25-38.

Provazníková, R., Kašparová, M. & Křupka, J. (2015). Comparison of Regional Competitiveness Models on the Basis of Cluster Analysis. In: *13th International Scientific Conference on Hradec Economic Days.* University of Hradec Kralove, Hradec Kralove, 5, 123-130.

WHO Regional Office for Europe (2013). *Health 2020. A European policy framework and strategy for the 21st century.*

Contact

Pavla Jindrová

University of Pardubice. Faculty of Economics and Administration. Institute of Mathematics and Quantitative methods

Studentská 95

532 10 Pardubice

Czech Republic

Mail: pavla.jindrova@upce.cz