Relationship between socio-demographic and economic determinants of cause-specific mortality in the EU countries in the period 2011 – 2014

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Abstract: *The article focuses on determinants of mortality and evaluates selected socio-demographic and economic sets of indicators. Our data matrix includes 112 observations for the EU28 countries in the period 2011 – 2014 (5 indicators of socio-demographic and economic determinants of health and 5 indicators of standardized cause-specific mortality). The data is calculated using canonical correlation analysis, composite indicator and multiple regressions. Computed cause-specific mortality index shows most favourable mortality structures in Finland and France and unfavourable in Hungary. The correlations between socio-demographic, economic determinants and cause-specific mortality in the EU countries exist on the following levels. In the countries with very high GDP per capita generally people less often die of circulation disorders (e.g., Finland, France, Germany) and with lower GDP per capita it shows higher mortality rates relate to circulation system disorders and diabetes (e.g., Estonia, Lithuania, Hungary). In the countries with lower levels of educational attainment, people generally most often die of circulation disorders (e.g., Czech Republic, Slovakia, Italy) and people with higher educational attainment more often die of disease of nervous system (e.g., Finland, Belgium, Denmark). The levels of socio-demographic and economic determinants and the mortality structures correlate in the EU countries, but show different quality. The regional disparities in cause-specific mortality still persist between the countries of the northern, the western and the southern Europe. An unfavourable rate mortality was further affirmed in eastern and south-eastern Europe.*

Keywords: *socio-demographic determinants, economic determinants, cause-specific mortality, public health, EU countries*

Introduction

The aim of this article is to compare the incidence and development of selected causes of death with the socio-demographic and economic determinants that affect life in the EU countries. The intention is also to determine regional differences of these determinants and mortality index, which is created as a composite indicator composed of selected causes of death.

The strong effect of socio-demographic and economic factors on population health, morbidity and mortality is currently considered objectively proven (Marmot et al. 2008, Marmot, Bell 2012). Socio-demographic and economic determinants are used for rating the population health and health condition by several large national and international comparative studies, such as the Survey of Health, Ageing and Retirement in Europe (SHARE 2018), the European Health Interview Survey a European Community Health Indicators (EC 2012, Börsch-Supan et al. 2013, Minicuci et al. 2016). These determinants are also in the focus of attention of some longitudinal studies, including the Study of Global Ageing and Adult Health, English Longitudinal Study of Ageing or the Health and Retirement Study (Minicuci et al. 2016).

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These studies mention predictors including indicators of sex and age structure, educational attainment or GDP (Meara et al. 2008, Khang et al. 2010 etc.). In epidemiology studies demographic factors (sex, age, education, unemployment rate etc.) as well as economic effects (occupation and social position of the individual, economic situation, healthcare availability etc.) and linked with the socioeconomic status (Glazier et al. 2009, Fraser, George 2015 etc.).

Individuals with a lower socioeconomic status show higher rates of morbidity, invalidity, premature deaths and mortality in general (Alter et al. 1999, Glazier et al. 2000, Wilkins et al. 2002, Frank et al. 2003, Matthews et al. 2005). Wealthier and educated individuals enjoy better health than poor and less educated persons (Veugelers et al. 2001, Veugelers 2003). Negative lifestyles including smoking, unhealthy food and physical inactivity occur more often in the worse socioeconomic conditions and lower socioeconomic groups (Whitehead, Dahlgren 1991, Lynch et al. 1997). Similarly, the trend towards preventive healthcare such as periodic medical examinations and participation in population screening programmes is more often observed among higher socioeconomic status groups (Davis et al. 1981, Whitehead, Dahlgren 1991). Subjective views of human health are contextualised in a social-structural framework also: lower education levels (Leinsalu 2002, Leinsalu et al. 2003) and poor economic situation increase the probability of poor (self) evaluation of health (Aittomäki et al. 2010). For these reasons we include socio-demographic and economic indicators in our mortality structure analyses as strong determinants of health, morbidity and mortality.

Knowledge of the state, quality and level of socio-demographic and economic determinants as well as the mortality structure can identify territorial differentiation and understand their correlation in the EU countries. The use of statistical methods for processing of publicly available data enables a comparison of developments in different periods and the results of the analyses can help to specify regions with less favourable situation within targeted preventive programs, legislative measures, etc.

Data and Methods

The input matrix was populated with data for the EU28 and the period 2011 – 2014 (data are available from all present member states; the data are gradually added updated in the EC database and were complete at the time of the survey only for a given time period). The final data matrix included 112 observations for EU20. The decision was made to use 11 variables and eliminate non-standard quantitative data. Five indicators were chosen from the population health category to specify the most frequent cause-specific mortality with the help of standardised rates (per 100,000 inhabitants; the EU was the chosen standard) as follows: (1) Chapter II (C00-C97) malignant neoplasms (CAN); (2) Chapter IX (I00-I99) diseases of the circulatory system (CIR); (3) Chapter X (J00-J99) respiratory system (RES); (4) Chapter VI (G00-G99) nervous system (NS) and (5) Chapter IV (E10-E14) diabetes mellitus (DIA; WHO 2018). The selected causes of death were classified according to the tenth revision of the International Statistical Classification of Diseases and Associated Health Problems (ICD-10: version 2016; WHO 2018). These cause-specific mortality indicators were selected due to their high proportion of total mortality (neoplasms, circulatory system and respiratory diseases) and their dynamics of development (nervous system and diabetes; WHO 2017). Age standardization is one of the key methods to control for different age distributions among populations or over time. When comparing mortality patterns between countries, regions or periods, the differences in age and sex distribution are usually distracting, and standardization is in order. In the light of the European Standard Population (ESP) published in 1976 (Waterhouse et al. 1976) own calculation is based on the publication Revision of the European Standard Population (Eurostat 2013). Standard was the EU-level own indicator calculated for 2014.

Indicators that reflect the quality of life and health care, social and economic level, socio-economic status, etc. were chosen in the group of socio-demographic and economic determinants. The selected socio-demographic and economic determinants include 6 indicators: (1) index of old age dependency ratio, % (OAD); (2) share of university graduates in the 15 – 64 age group, % (EDU); (3) unemployment rate, % (UNE); (4) poverty threat rate, % (POV) and (5) the real GDP per capita, € (GDP). Data were taken from internet databases Echi Data Tools (EC, 2016) and Eurostat (2017) and processed by Statistica 12 software.

The canonical correlation analysis is a multidimensional statistical analysis generalising multiple linear regressions. We use it to determine whether the relationship between two groups of variables is significant or not (Hendl 2012). It enables investigating the relationships between two groups of variables without losing information on the overall structure of these files (Meloun, Militký 2012). The aim of canonical correlation analysis is to fit essential information into so-called canonical variables, which must be able to best represent the original variables. Therefore, they are designed to maximize the correlation between the groups and not the explained variance, as the whole calculation of the canonical correlation analysis is based on the correlation matrix. Compiled on the basis of the following model (Kubíková, Škop 2008):

$$I.\quad a_{11}X_1 + a_{12}X_2 + \ldots + a_{1p}X_p = U_1 \qquad V_1 = b_{11}Y_1 + b_{12}Y_2 + \ldots + b_{1q}Y_q$$

$$II.\quad a_{21}X_1 + a_{22}X_2 + \ldots + a_{2p}X_p = U_2 \qquad V_2 = b_{21}Y_1 + b_{22}Y_2 + \ldots + b_{2q}Y_q$$

$$p.\quad a_{p1}X_1 + a_{p2}X_2 + \ldots + a_{pp}X_p = U_p \qquad V_p = b_{p1}Y_1 + b_{p2}Y_2 + \ldots + b_{pq}Y_q$$

This canonical correlation analysis was used to study two sets of variables: (1) the left set represented standardized cause-specific mortality and included manifest variables X1 (CAN), X2 (CIR), X3 (RES), X4 (NS) and X5 (DIA; p =5; as canonical variability – variables U1 (CAN), U2 (CIR), U3 (RES), U4 (NS) and U5 (DIA), and (2) the right set represented the group of socio-demographic and economic determinants and included manifest variables Y1 (OAD), Y2 (EDU), Y3 (UNE), Y4 (POV) and Y5 (GDP; q =5; as canonical variability – variables V1 (OAD), V2 (EDU), V3 (UNE), V4 (POV and V5 (GDP).

X1 malignant neoplasms (CAN)	Y1 index of old age dependency ratio (OAD)
X2 diseases of the circulatory system (CIR)	Y2 university graduates (EDU)
X3 respiratory system (RES)	Y3 unemployment rate (UNE)
X4 nervous system (NS)	Y4 poverty threat rate (POV)
X5 diabetes mellitus (DIA)	Y5 real GDP per capita (GDP)

The process of creating canonical variables then undergoes individual steps. In the first step, two new variables are created: U1 representing the first group and V1 representing the second group. When creating groups, it is important to ensure that the correlation between them is as strong as possible. In the next step, a second pair of canonical variables U2 and V2 is created so that it does not correlate with the first pair, but the second pair must correlate with each other as much as possible (Kubíková, Škop 2008). All 28 EU countries data of which were processed over a four-year period entered into our analysis of canonical correlation and there were no missing values in the sample. Total 112 valid cases (N = 112) were analyzed. The outcome of canonical correlation analysis brings individual pairs of canonical variables beneficial for a particular model. A statistical significance was tested on the basis of the *Chi-quadratic test* based on the gradual removal of roots and then confirming or rejecting the null hypothesis. The significance level by test was expressed as *p-value* and set at 5%. If the *p-value* is less than 5%, the model is considered significant (Meloun, Militký 2012).

A composite indicator (referred to as the cause-specific mortality index) is composed of several sub-indicators, which are generally given in different units of measure, vary in level and variability, and have different degrees of interdependence. They are often used for measuring and comparing regions as they contain more information than individual sub-indicators. This creates a relatively comprehensive and complete view of the issue (Hudrlíková 2014). The main advantage of composite indicators is the ability to summarize multi-dimensional phenomena using sub-indicators. These are often contradictory aspects of reality that cannot be captured in a single indicator. Another advantage of CIs is their easy interpretation. This makes indicators easier to understand and they become attractive to the general public and the media. Another great advantage provided by CIs is the possibility of international comparison in space and time (OECD 2008).

A composite indicator is composed of sub-indicators, in our case five selected cause-specific mortality indicators. These are sub-indicators of the min type, as it is desirable to achieve their lowest values. All data from the period under review were checked by the correlation matrix before calculating the composite indicator, which made it possible to assess the interdependence between indicators. Based on the results of the correlation matrix, adequate weights were then assigned to the indicators (Minařík et al. 2013). The weights were assigned using a paired comparison method, which compares the indicators according to their importance. The weights were assigned using a paired comparison method, which compares the indicators according to their importance, where the sum of the weights must be equal to 1. Pair comparison results was: weights CAN 0.25; CIR 0.25; RES 0.2; NS 0.1; DIA 0.2.

The next step of the analysis is the standardized values were calculated by the *min-max* method. Due to the fact that all sub-indicators were of the min type, the calculation for the given type of sub-indicators was also used. The advantage of this method is that it adjusts the range of values. All indicators thus have values <0.1> (Hendl 2012):

$$b_j = \frac{X_j - \min\{X_j\}}{\max\{X_j\} - min\{X_j\}} * 100$$

The final step in the compilation of the composite indicator itself is weighing and aggregation. Weighing is based on the above weights and by multiplying the standardized data by the given weight. The values are then aggregated. Aggregation was performed by the weighted sum method. The result of this aggregation is a dimensionless composite indicator, on the basis of which we can determine the order of selected statistical units. This composite indicator was expressed by a percentage index calculated as the ratio of the composite indicator value of each region to the aggregate value of all composite indicators (Minařík et al. 2013). The composite indicator produced was termed the cause-specific mortality index.

For the multiple regression analysis, the created composite indicator – cause-specific mortality index was used as the dependent variable. The group of the independent variables included the 6 socio-demographic and economic determinants. Before the multiple regression analysis started the extreme observations were removed (especially for the UNE, POV and GDP variables; remote, respectively extreme values were evaluated using box graphs) by logarithmic transformation ($y_{ij} = log_c x_{ij}$). The dependent variable values were predicted for the individual cases. The selected model was the linear regression model based on the following equation (Minařík et al 2013):

$$y_i = b_0 + b_1 x_{1_i} + b_2 x_{2_i} + b_3 x_{3_i} + \ ... + \ b_p x_{p_i} + e_i$$
$$y'_i = b_0 + b_1 x_{1_i} + b_2 x_{2_i} + b_3 x_{3_i} + \ ... + \ b_p x_{p_i}$$

The intensity of correlation between the dependent variable and the group of the independent variables was specified by means of the multiple correlation coefficient, *"R"*. The determination coefficient, R^2, showing the explained dispersion %, was used to specify the created model quality. Adjusted R^2 is an adjusted determination coefficient taking into consideration the number of the independent variables included in the model. The correlation intensity is defined by the *beta-coefficient* (by non-standardised regression coefficients, *b* and standardised regression coefficients, *b**.

Results

The summary results of the canonical correlation analysis of socio-demographic and economic determinants and cause-specific mortality can be described as follows: the left set representing cause-specific mortality explained 37.74% of the right set variability, the right set representing the socio-demographic and economic condition of the EU countries. On the other hand, the right set explained in total 36.18% of the left set variability (tab. 1). The obtained dispersion demonstrates the left set canonical variability (variables U1, U2, U3, U4 and U5) and the right set canonical variability (variables V1, V2, V3, V4, and V5) and its own set of variables X1–X5 and Y1–Y5. The left set canonical variables explained 100% of their own set dispersion by manifest variables X1–X5. The right set canonical variables explained 100.0% of their own set dispersion with the help of six manifest variables Y1–Y5 (the disproportion between the results was caused by the lower number of variables of the left set ($p<q$). The most important value revealed by the summary results was the "*Canonical R"*. Its value is crucial for further progress of the analysis as it defines the strength of correlation between the first pair of canonical variables. In our case the value of the "*Canonical R"* is 0.915, showing a very tight correlation. Since it is also the highest found correlation, it can be considered as a measure of the overall correlation between the two groups of original variables. The value of *p-value* represents the probability of the risk of a false rejection of a true hypothesis. In our case, *p-value* is equal to zero. The risk of a false acceptance of the hypothesis is therefore zero and we can safely reject the hypothesis that there is no relationship between the groups (tab. 1).

Tab. 1. *Summary results of canonical correlation analysis of cause-specific mortality and socio-demographic and economic determinants of health in EU countries (period 2011 – 2014)*

N = 112	**Summary of canonical analysis Canonical R: 0.91482171 Chi²(25) = 352.48 p = 0.0000**	
	Left set	**Right set**
Number of variables	5	5
Obtained dispersion	80.00%	100.00%
Total redundancy	**36.18%**	**37.74%**
Variables 1	CAN	OAD
2	CIR	EDU
3	RES	UNE
4	NS	POV
5	DIA	GDP

Source: own work and calculations, data EC (2012)

The summary results of the canonical correlation analysis were subsequently analysed in detail, especially to explain how the individual roots (canonical variables U and V) contribute to explanations of variability of their own and the opposite set. The column entitled "Obtained dispersion" shows the calculated dispersion values for own set. The "Redundancy" column, on the other hand, explains the shares of canonical variables in explanation of the opposite set variability. Within the left set the highest contribution to own set explanation is provided by canonical variable U1 (CAN; 33.47%). This variable also explains the greatest percentage of the right set variability (28.01%). Within the right set the highest contribution to own set variability explanation is provided by canonical variable V1 (OAD; 34.63%). This variable also explains the greatest part of the left set variability (28.98%; tab. 2).

Tab. 2. *Obtained dispersion and redundancy in the right and the left set of the canonical correlation analysis of cause-specific mortality and socio-demographic and economic determinants of human health in EU countries (period 2011 – 2014)*

Factor	**Obtained dispersion (left set)**		**Variable**	**Obtained dispersion (right set)**	
	Obtained dispersion	Redundancy		Obtained dispersion	Redundancy
Root 1	**0.3347**	**0.2801**	Root 1	**0.3463**	**0.2898**
Root 2	0.1654	0.0501	Root 2	0.1350	0.0409
Root 3	0.1052	0.0194	Root 3	0.1334	0.0246
Root 4	0.1199	0.0118	Root 4	0.2142	0.0210
Root 5	0.0748	0.0004	Root 5	0.1710	0.0010

Source: own work and calculations, data EC (2012)

After testing the canonical pairs for statistical significance (by *Chi-square test*) only the fifth root was found statistically insignificant. The left set shows correlations between the socio-demographic and economic determinants and the left set of canonical variables and correlations between the cause-specific mortality and the right set of canonical variables. This structure allows for the conclusion that within the left set variable X2 (CIR) shows the highest correlation with the canonical variable U1: 0.960. This statement can be interpreted as follows: the countries with a high value of this canonical variable will show higher rates of mortality for circulation diseases. Another strong correlation within this group is represented by the correlation of variable X4 (NS): 0.816. The tightest correlation with the canonical variable U2 is shown by variable X5 (DIA): 0.649, the tightest correlation with the canonical variable U3 is shown by variable X3 (RES): 0.643, and the tightest correlation with the canonical variable U4 is shown by variable X5 (DIA): -0.558 (tab. 3). Within the right set with canonical variable V1 a very tight correlation is shown by variable Y5 (GDP): 0.954. A strong correlation with variable V1 is shown by variable Y4 (POV): -0.693, a strong correlation with variable V2 is shown by variable Y1 (OAD): -0.688; with V3 is variable Y4 (POV): 0.683 and a strong correlation with variable V4 is shown by variable Y1 (OAD): -0.696 and Y2 (EDU): 0.661 (tab. 3).

The created composite indicator (named cause-specific mortality index) shows favourable mortality structure values by cause-specific mortality in Finland (134.4%), France (126.5%) and Sweden (120.2%). Very good situation was also found in South European countries (Greece, Italy and Spain) and countries with strong economies (Luxembourg, Austria and Germany). Among countries that joined the EU later, above-average values of this index are shown in Estonia (109.7%), Lithuania (107.8%), Malta (105.2%) and Cyprus (103.8%). Unfavourable values of the index are shown by Hungary (63.8%), Slovakia (74.9%), and Croatia (76.4%; tab. 4).

Tab. 3. *Canonical burdens – correlations of socio-demographic and economic determinants and correlations of cause-specific mortality in EU countries (period 2011 – 2014)*

Root/variable	**Factor structure, left set (CCA)**			
	Root 1	Root 2	Root 3	Root 4
CAN	-0.3366	0.4383	-0.4600	0.0502
CIR	**0.9602**	-0.1118	-0.2422	0.0820
RES	0.2900	0.6267	**0.6433**	0.2480
NS	**0.8163**	-0.0201	-0.1986	0.4687
DIA	-0.0316	**0.6489**	-0.1193	**-0.5576**
Root/variable	**Factor structure, right set (CCA)**			
	Root 1	Root 2	Root 3	Root 4
OAD	0.1456	**-0.6875**	0.0036	**-0.6961**
EDU	0.5384	-0.4293	0.1802	**0.6613**
UNE	-0.1716	0.0400	0.4096	-0.3048
POV	**-0.6943**	-0.1066	**0.6826**	-0.1628
GDP	**0.9535**	0.0703	0.0287	0.1726

Source: own work and calculations, data EC (2012)

Tab. 4. *Ranking of EU countries pursuant to the composite index of cause-specific mortality (period 2011 – 2014)*

Rank	Country	Index	Index (%)	Rank	Country	Index	Index (%)
1.	Finland	81.484	**134.4**	15.	Slovenia	60.861	100.4
2.	France	76.730	**126.5**	16.	Netherlands	59.672	98.4
3.	Sweden	72.871	**120.2**	17.	UK	59.198	97.6
4.	Greece	71.795	118.4	18.	Poland	56.372	93.0
5.	Luxembourg	68.600	113.1	19.	Bulgaria	55.700	91.9
6.	Italy	68.031	112.2	20.	Rumania	55.581	91.7
7.	Spain	67.535	111.4	21.	Latvia	55.231	91.1
8.	Estonia	66.491	109.7	22.	Portugal	54.600	90.0
9.	Germany	65.745	108.4	23.	Ireland	51.468	84.9
10.	Austria	65.587	108.2	24.	CR	48.953	80.7
11.	Lithuania	65.361	107.8	25.	Denmark	48.445	79.9
12.	Belgium	64.377	106.2	26.	Croatia	46.347	**76.4**
13.	Malta	63.821	105.2	27.	Slovakia	45.429	**74.9**
14.	Cyprus	62.967	103.8	28.	Hungary	38.708	**63.8**

Source: own work and calculations, data EC (2012)

The multiple regression analysis using point diagrams confirmed linear correlations between the individual predictors and the dependent variable (linearity can be seen in all bivariate correlations although the UNE variable will probably show a lower influence on the cause-specific mortality index in comparison to the other variables, fig. 1).

The value of multiple correlation coefficient "*R*" was 0.631, showing a relatively high-intensity correlation. The determination coefficient $R^2 = 0.398$, meaning that 39.8% of dispersion of the cause-specific mortality index is explained by the selected variables. The "*Adjusted* R^2" is an adjusted determination coefficient with its value close to R^2, hence the model can be seen as not over-dimensioned. At the same time the model can be seen as very significant, as shown by the *p-value* which has a value significantly below the determined limit of 5%.

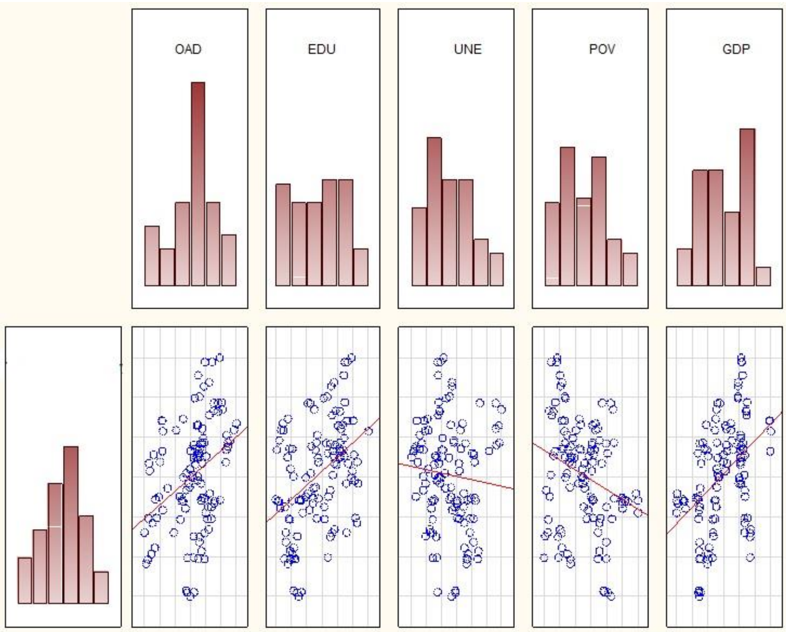

Fig. 1. *Point diagrams for multiple regression analysis of cause-specific mortality index and socio-demographic and economic predictors in EU countries (period 2011 – 2014); Matrix diagram, Multiple regression); Source: own work and calculations, data EC (2012)*

The standard estimation error is the standard deviation of the residues and underlines quality of the created model. The P-*values* show the levels of statistical significance of the individual predictors, therefore the predictors that can be considered statistically significant are OAD, EDU and GDP ($p < 0.05$). Variable UNE, although not reaching the significance level of 5%, shows a relatively stable low value, which suggest that there is still some effect of this variable on the dependent variable. Variable UNE ($p = 0.695$) was excluded from the prediction due to its nearly 70% risk of non-confirmation (tab. 5).

Tab. 5. *Basic results of multiple regression analysis of cause-specific mortality index and socio-demographic and economic predictors in the EU countries (period 2011 – 2014)*

N=112	Regression with dependent variable: composite indicator cause-specific mortality index					
	R = 0.6307932		**R^2 = 0.3979497**		**Adjusted R^2=0.46280696**	
	F(5,106) = 14.01		**p < 0.00000**		**Standard estimate deviation: 7,959**	
	*b**	Standard deviation (of *b**)	*b*	Standard deviation (of *b*)	T (105)	*p-value*
Absolute member			-8.3662	27.2490	-0.3070	0.0759
OAD	0.405100	0.076930	1.0669	0.2026	5.266	**0.0000**
EDU	0.327100	0.094360	0.4661	0.1345	3.466	**0.0007**
UNE	0.036030	0.091490	1.9664	4.9936	0.394	0.6945
POV	-0.067320	0.117500	-5.1908	9.0601	-0.573	0.5679
GDP	0.224900	0.126100	8.1025	4.5427	1.784	**0.0773**

Source: own work and calculations, data EC (2012)

The correlations between the individual predictors and the dependent variable are defined by the Beta-coefficient. Its values are part of the regression model equation:

Cause-specific mortality index = b0 + b1OADi + b2EDUi + b3UNEi + b4POVi + b5GDPi

Cause-specific mortality index = -8.366 + (1.067 OADi) + (0.466 EDUi) + (1.966 UNEi) + (-5.191 POVi) + (8.103 GDPi)

The standard deviation of cause-specific mortality index is 10.024. In our case the cause-specific mortality index affected by variable of variable OAD (beta-coefficient is 0.405), representing mean positive correlation (tab. 5). If OAD increases by one standard deviation value, i.e. by 3.81, the index will rise by 4.060% (10.024 x 0.405) and vice versa. Also variable EDU represents a medium-strong positive correlation to the cause-specific mortality index. Beta-coefficient in this case equals 0.327. In the case of its increase by one standard deviation value, i.e. by 7.03, the index value will increase by 3.278% and vice versa. Beta-coefficient of variable UNE is 0.036, representing weaker positive correlation to the cause-specific mortality index. If UNE increases by one standard deviation value, i.e. by 0.18, the index value will drop by 0.361% and vice versa. Beta-coefficient of variable GDP is 0.225. If GDP increases by a single standard deviation value of 0.28, the index value will decrease by 2.341%. This interpretation of the variables will however apply only if the other variables remain constant. Based on the results of this analysis, we can say that the chosen independent variables affect the cause-specific mortality index in rates, especially in the case of variables OAD and EDU.

Discussion

A WHO study conducted by the Commission on Social Determinants led by M. Marmot provides evidence of the impact of social determinants on the health status of people from different parts of the world and states that different mortality rates are influenced by the social, economic and demographic situation of states (Janatová, Uličná 2008). At present there is still limited evidence of socio-demographic and economic distribution of non-infectious diseases, or the most frequent causes of cause-specific mortality across Europe (McNamara et al. 2017). The results of the multiple regression analysis suggest that the selected socio-demographic and economic determinants – independent variables – do affect the value of the cause-specific mortality index, with the statistically most significant effect of the index of old age dependency ratio and the level of education achieved. Old age dependency ratio is not only economic indicator burden the productive part of the population, but also indirectly reflects the potential economic pressure e.g., for health and social systems.

Our results are confirmed by other studies proving the effect of the level of education on the risk of morbidity and mortality caused by cardiovascular diseases (Dalstra et al. 2005, Volkers et al. 2007), high blood pressure (hypertension; Caulhoun et al. 2008) or respiratory system disorders (Gershon et al. 2012, Khang et al. 2010) and diabetes (Connolly et al. 2000, Dalstra et al. 2005, Volkers et al. 2007, Agardh et al. 2011). The evaluation of the relationship of education and mortality was discussed by Michelozzi who found connections mainly with mortality from circulatory diseases, chronic lung disease and smoking-related cancer (Michelozzi et al. 1999). There is also a correlation between education levels and cardiovascular mortality and higher circulatory mortality among people with lower education (Davey Smith et al. 1998). The risk of a first heart attack is exacerbated in connection with lower education (Macintyre 2001). Diabetes mortality has been addressed by Espelt, who also demonstrates a correlation in the European Union between higher mortality due to the disease and lower levels of education (Espelt et al. 2015). Also a case study of the relationship between education and mortality performed in 11 developed EU countries confirms the positive correlation between these two variables, especially in the case of tertiary education (Albert, Davia 2011). A statistically significant effect on morbidity and mortality is also shown by the GDP value. There is a general consensus about existence of a positive correlation between income and health but this effect may rather be observed across a longer period of time (Niu, Melenberg 2014).

The unemployment rate is also considered a key socio-economic determinant of mortality structures. Due to particularly long-term unemployment, there is a higher probability of death due to heart disease, respiratory problems and nervous system dysfunctions, but also changes in biochemical values, causing diabetes and problems with hypertension (Kebza 2010). This statement is supported by a study showing that the risk of cardiovascular problems is increased by up to 35.1% when jobs are lost (Dupre et al. 2012).

In particular, the outcome of multiple regression analysis can be the subject of discussion, concluding that the cause-specific mortality index is decreasing in relation to GDP/capita growth, but the effect has also been reversed, which may be in contrast to the claim that GDP growth results in a reduction in mortality. The reason for such results may be the relatively short evaluated period of time. Indeed, many authors agree on a positive correlation between income levels and mortality rates, but state that this effect is more likely to be observed over a longer period of time (Niu, Melenberg 2014). Last but not least, the growth of consumer society is also linked to GDP growth, with mortality rising in developed countries in connection with the growing cycles in the economy. This statement is explained by greater spending on food, cigarettes or alcohol (Morin 2013).

Conclusion

The EU27 is a developed world, but there are still relatively large differences in demographic, social and economic terms. These differences are particularly evident between Western and Northern European countries, which are considered to be the engine of European integration, and Central and Eastern European countries, which in some respects are lagging behind.

Our results of the canonical correlation analysis suggest that the set representing the socio-demographic and economic determinants explains just a little larger part of variability within the cause-specific mortality set (tab. 1). Therefore, one can say that in the EU countries the mortality structure is more strongly affected by the socio-demographic and economic determinants (which are considered as indicators of quality of life and health care, social and economic level, socio-economic status, etc.). On the basis of these study findings one can safely say that the strongest correlations between socio-demographic and economic determinants of cause-specific mortality in EU countries exist on the following levels (tab. 3):

(1) In the countries with very high GDP per capita people generally less often die of circulation disorders. This statement is particularly true for Finland, France, Germany, the Netherlands, Sweden or Great Britain.

(2) In the countries with lower levels of population education people generally most often die of circulation disorders. Examples include the Czech Republic, Croatia, Hungary, Bulgaria, Romania, Latvia, Slovakia or Italy.

(3) In the countries with high education levels people more often die of disease of nervous system. This statement is best represented by Finland and similar situations can also be observed in Belgium, Denmark, France, Ireland, Luxembourg, Spain, Sweden or Great Britain.

(4) The countries with lower GDP per capita show higher mortality rates related to circulation system disorders and diabetes. The most typical examples are Bulgaria, Estonia, Croatia, Lithuania, Hungary or Romania.

(5) The countries with lower senior rates (people over 65) generally show lower rates of mortality of respiratory diseases. This phenomenon is typical for Ireland, Cyprus, Luxembourg, Hungary, Malta, the Netherlands, Poland, Slovakia and Slovenia.

The created cause-specific mortality index presents the best mortality rates in Finland (134.4%), France (126.5%) and Sweden (120.2%). Southern European countries (Greece, Italy and Spain) and economically strong EU countries (Luxembourg, Austria and Germany) also performed well. Some of the countries that joined the EU later have above-average index values (Estonia, Lithuania, Malta and Cyprus (tab. 4). The countries of Central and Eastern Europe have a below-average index. The lowest index was reported by Hungary (63.8%), Slovakia (74.9%), Croatia (76.4%) and the Czech Republic (80.7%; tab. 4). These are countries that became EU Member States only in the 21st century. Not very good situation of mortality rates has started to improve in the countries of Central Europe since the 1990s. The main factors include improving health care (modern treatment methods, expanding health practices and technologies), healthy lifestyles, expanding food supply, moving the population from industry to services, improving the quality of the environment, etc. Mortality rates in Eastern European countries improve even more to a lesser extent. The economic transformation, which reduced the quality of life, had a significant effect here.

Our study presents the use of some statistical methods to evaluate the correlations and levels of socio-demographic determinants of health and mortality in the EU countries. The benefits of selecting indicators with the data available for all current EU Member States have eliminated the need to address missing data. We are aware of the risk of some generalization of results in relation to socio-demographic and economic data analysis using large data sets. The results would be more accurate if we looked at a lower number of countries or focused on micro-regional case studies in specific countries (Hübelová et al. 2018). Despite these limitations, our analyses declare intense correlations between determinants of health and mortality, as well as illustrate the persistent territorial differentiation of cause-specific mortality rates in Europe. The levels of socio-demographic and economic determinants and mortality structures strongly correlate in EU countries, but there is a different quality that divides the EU region into specific places. The regional disparities in cause-specific mortality still persist between the countries of the northern, the western and the southern Europe. An unfavourable rate mortality was further affirmed in eastern and south-eastern Europe.

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