Spatial differentiation of selected health factors of the South Moravian Region population

Dana HÜBELOVÁ, Alice KOZUMPLÍKOVÁ,
Veronika JADCZAKOVÁ, Gabriela ROUSOVÁ

Abstract: *At present, the demographic, socioeconomic, and environmental determinants of health are considered to be among the main groups of factors influencing the level of health, morbidity and mortality, and also overall quality of life of the respective population. The goal of this paper is to assess the relation of selected population health determinants and their spatial differentiation at the level of districts (LAU 1) in the South Moravian Region (NUTS 3; Czech Republic). To fulfil this objective, a number of methods were applied: (1) construction of composite indicator and cluster analysis; (2) multiple regression; (3) canonical correlation analysis; (4) time series analysis, and (5) data visualization method. Confrontation of the situation in 2006 and 2015 showed improvement of all observed factors at the level of districts of the South Moravian Region and at the same time their greater differentiation. It became evident that the variables with the strongest impact on the mortality structure are of both demographic (weight at birth, aging index) and socioeconomic nature (housing allowances). Deepening knowledge of negative impacts of environmental pollution on human health in conjunction with proven influences of demographic and socioeconomic factors give rise to an increasing appeal to responsible environmental planning and socially and environmentally accountable policy.*

Keywords: *demographic, socioeconomic, environmental determinants, morbidity, mortality, emissions, air pollution, cluster analysis*

Introduction

Ideally, people and the environment in which they move about should be in perfect harmony. The present-day interest in health, health status, and pursuance of causes of diseases becomes more intense especially in relation to social, political, and economic transformations, but also to the changes in the quality of the environment (Tobiasz-Adamczyk 2011). Population health is generally considered one of the most important indicators of development of regions and of complex interdisciplinary relationships of demographic, socioeconomic, environmental, but also political processes (Fraser and George 2015). Health determinants represent indicators that influence the presence and the development of risk factors of diseases (Berman et al. 2012). Currently the concept of population health provides a wide spectrum of interpretations encountered not only in medical (with the healthcare aspect of health accentuating the bodily side of humanity) but also in psychological, sociological, or geographical literature (Seedhouse 1995, Anthamatten and Hazen 2011). The sociological aspect of health lays a stress primarily on the position of people within the society, which is related with their lifestyle and habits. The so-called environmental health discipline, which can be understood as a branch of public health dealing with all aspects of natural and man-made environment that can have some impact on human health, attracts more and more attention (Lakes et al. 2014). In an effort to make linkages among the selected aspects mentioned above, and applying statistical methods, the text of this article seeks the spatial differ-rentiations of health factors using the South Moravian Region (NUTS 3), Czech Republic divided into territorial units at the level of districts (LAU 1) as an example.

Theoretical starting points

Despite the apparent and primarily accepted unambiguousness of its content (a person either is, or is not healthy), the notion of health is undoubtedly a construct of a complex nature whose precise, apt definition to be accepted generally and without reservations does not exist thus far. According to the WHO, health (of an individual) is "*is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (WHO 2000). At the same time, the WHO dissociated itself from traditional axioms that defined health using "negative expressions". Although it accentuates also weaknesses, the organization integrated other aspects into the definition, including mental health and happiness: *"... health is the source of everyday life, not the goal of life…; it is a positive understanding that highlights social and personal resources and supplies, as well as physical prowess and capacity"* (WHO 2000). At present, the demographic, socioeconomic (SE), and environmental determinants of health are considered to be one of the main groups of factors influencing not only the level of health, morbidity, and mortality but also overall quality of life of the respective population (Hillemeier et al. 2004, Hübelová et al. 2017).

Most European studies that analyze demographic and SE determinants of health use data from international comparative studies, surveys or interviews. Study Eurobarometer presented data about SE inequality in clusters of health-related behaviours in 27 European Union (EU) states. Conclusions presented correlation with health and SE gradients (Kino et al. 2017). Existed also longitudinal study Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a multidisciplinary and cross-national panel database of data on health, SE status and social and family networks of more than 120,000 individuals aged 50 or older (more than 297,000 interviews). SHARE covers 27 European countries and Israel. Study applied health-related thematic domains (socio-demographic and economic, health states, overall self-report of health and mental state, health examinations, physical and mental performance tests, risk factors, chronic conditions, social network and subjective well-being; SHARE 2018). The European Health Interview Survey (EHIS) is being implemented at regular five-year intervals. Health indicators in Europe monitor the European Community Health Indicators (ECHI) project. The list of indicators includes 88 items in five categories (demographic and health indicators, health determinants, health support indicators (EC 2012). There are a number of European studies that investigate SE level differentiation but do not analyze the structure of mortality concurrently.

Are published diverse cluster analyzes of European countries in the literature (Křupka et al. 2013, Žmuk 2015, Aktaş 2017, etc.). Although these studies use different SE indicators, their results tend to be similar. An example is the results of the study by Aktaş (2017), in which EU countries and candidate countries are divided into 5 clusters (according to SE indicators related to the demographic situation). The first cluster included the economically weaker countries of Eastern Europe (e.g., Bulgaria, Romania, Latvia). Second of the clusters is formed mainly by the countries of Southern Europe. The other clusters were formed by the fusion of the Western and Northern European states, and a separate cluster is for developed Luxembourg.

Very strong impact of demographic and SE factors on health is currently considered to be objectively ascertained (Marmot and Bell 2012, Marmot 2017). Extensive national and international comparative studies of health and health status of population observe and assess these factors (e.g., EC 2012, Börsch-Supan et al. 2013, Minicuci et al. 2016, etc.). In the published studies, authors usually include indicators of sex and age structure, achieved level of education or gross national or domestic product (GNP/GDP; Shkolnikov et al. 2006, Meara et al. 2008, Khang et al. 2010, etc.) among demographic and SE factors. McNamara et al. (2017) provides the most up-to-date overview of SE inequalities for many non-communicable diseases (NCDs) in 20 European countries. The authors found significant differences between NCD with regard to social transitions and SE gaps (McNamara et al. 2017). It becomes evident that precisely income (in the given case the per capita GNP/GDP indicator) is a significant contextual determinant of health, but also of population morbidity in highly developed (e.g., European) countries (Brandt et al. 2012). An important question remains, however, when and how do incomes of individuals project into inequality of health during lifetime (Swift 2011). While most studies dealing with inequality of incomes focus on the currently observed situation, Subramanian and Kawachi (2004) pointed out there can also be delayed effects of income inequality.

The level of population health is also kept under review in epidemiological studies by means of demographic and SE factors (sex, age, education, type of employment, unemployment, family status, social standing of an individual at work and in the society, economic situation, income level, health literacy, healthcare availability, etc.). The given factors are presented to be tied with the socioeconomic status (SES, Glazier et al. 2000, Fraser and George 2015, etc.). The current SES of an individual is a significant prerequisite of the further development of his/her health and health status in the future and the subsequent successful ageing. The studies describing current SE characteristics and circumstances of the SES especially in seniors attest to that (Haveman-Nies et al. 2003, McLaughlin et al. 2010). Other researches also suggest that even SES factors from the past (e.g., family background and the SES in childhood, work status in the past, etc.) have a significant and long-term effect on the health of individuals (Haas 2008, Britton et al. 2008, Brandt et al. 2012). Due to SES it is possible to observe a certain so-called social transition, for which it is evident that the lower the SE position, the worse the health (Marmot et al. 2008, Marmot 2017). Numerous research reports and studies ascertain that persons with a lower SES have a higher degree of morbidity, invalidity, premature fatality rate and death rate in general; during their life they suffer from diseases more often, which is again reflected in shorter healthy life expectancy and overall lower life expectancy (Marmot et al. 1991, Glazier et al. 2000, NIPH 2015). Contrariwise, richer and more educated people enjoy better health than poorer and less educated people (Wilkins et al. 2002, Frank et al. 2003, Matthews et al. 2005). In this respect, we speak about SE gradient in health that has been well documented in many countries (e.g., Veugelers et al. 2001, Veugelers 2003).

Simultaneously, population health is very strongly determined by the quality of the environment. The danger of environmental factors impact lies in their long-term effect on the population (asthma, allergic reactions, etc.; Berman et al. 2012). The developed countries have monitoring systems, thanks to which e.g., the influence of air quality on human health can be documented. Many studies have proven that exposure to air pollution negatively affects human health including increased risk of death and occurrence of respiratory and cardiovascular diseases (Dockery et al. 1993). Many authors corroborate the impact of long-term exposure to particulate matter PM (Levy et al. 2000, Pope III et al. 2002, Pope III 2007, Janke et al. 2009, Kiesewetter et al. 2015, Sram et al. 2013).

Influence of short-term population exposure to PM, carcinogenic polycyclic aromatic hydrocarbons (c-PAH) and e.g., benzo(a)pyrene (BaP) is evidenced especially in studies focusing on children (Brauer et al. 2002, Svecova et al. 2009, Weinmayr et al. 2010, Zhu et al. 2017). The production of these dangerous substances is primarily related to solid fuel (coal, wood) combustion, especially during incomplete combustion in domestic furnaces (Sram et al. 1996, Guerreiro et al. 2016). Inhabitants of cities, where especially transport affects the air, are exposed to further burden. According to Peters et al. (2004), transitional exposure to transport can increase the risk of myocardial infarction in sensitive individuals. The study by Tonne et al. (2016) also demonstrated adverse impact of long-term exposure to traffic pollution.

Research objective, area of interest, methods and selection of indicators

The goal of this contribution is to establish the relation of selected population health determinants and their spatial differentiation at the level of districts (LAU 1) in the South Moravian Region (SMR; NUTS 3). Districts of the South Moravian Region were chosen as the model region for the study. The area of the SMR is 7,188 km^2; it consists of altogether seven districts

(Blansko, Brno-City, Brno-Country, Breclav, Hodonin, Vyskov, Znojmo). In the east, the SMR borders on Slovakia and in the south on Austria, and within the Czech Republic it neighbours on the South Bohemian Region, the Vysocina Region, and the Pardubice, Olomouc, and Zlin Regions starting from the western to the north-eastern boundary of the region (Fig. 1)

Fig. 1. *Situation and administrative division (districts) of the South Moravian Region, CR; Source: authors' own elaboration*

To fulfil this objective, a number of methods were applied: (1) construction of composite indicator and cluster analysis; (2) multiple regression; (3) canonical correlation analysis; (4) time series analysis, and (5) data visualization method. (1) To construct a composite indicator involving sub-indicators (described above) to capture a collective demographic and SE mind-set of South Moravian districts using the min-max method of standardization with range of values <0; 100> and the simple average approach for aggregation and further to establish groupings of districts in year 2006 and 2015 with respect to the cause-specific mortality and the demographic and SE profile by means of both hierarchical (based on Ward's method using squared Euclidean distance) and non-hierarchical (based on k-means) cluster analysis. More specifically, the Ward's method was carried out first to determine the number of clusters which served then as seed points for the k-means method generating the final cluster solution. (2) The influence of demographic and SE determinants was analysed applying multiple regression (ENTER method) that enters all variables into the model at once with statistical significance ($p < 0.05$). The primary objective of this method is to find out, to what extent can the dependent variable (mortality by causes) be explained by means of several independent variables (demographic and SE determinants; multiple coefficient of correlation), or how great is the relative influence of each of independent variables on the studied variable (standardized beta regression coefficients). (3) Canonical correlation analysis is a multivariate method that is used to investigate the dependence between two groups of variables. The first of the two groups is considered a set of dependent variables, the second a set of independent variables. (4) For development of standardized mortality by causes in 2006–2015 were selected only most common causes captured by means of chronological average (the standard was chosen by the Czech Republic). Standardized mortality by the main causes is numbered according to the codes International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) WHO (version for 2016; WHO 2016). (5) Map chart and thematic map method in ArcGIS programme was used to illustrate territorial differences.

The intent was to select such demographic, SE (Tab. 1), and environmental factors (Tab. 4), which could be regarded as a complex of indicators that represents theoretical model determining population health.

Demographic factors:

- Most common mortality by causes of death by code ICD-10 (IX circulatory, X respiratory, and XI digestive system diseases, II neoplasms and XX external causes; %)
- Aging index (0-14 age group to age group 65+; %)
- Neonatal mortality (‰)
- Infant mortality (‰)
- Divorce rate (%)
- Percentage of children with weight at birth below 2.5 kg (%)
- Total abortions per 100 live born (%)
- Percentage of spontaneous abortions of total abortions (%)

SE factors:

- Percentage of unemployed persons aged 15-64 (%)
- Housing allowances in CZK/benefit

Environmental factors:

- Emissions of the basic pollutants to atmosphere (%)
- Air pollution of the atmosphere (%)
- Development of changes in the technical equipment of flats (% connected)

The source of data was the public database of the Czech Statistical Office (CSO 2016a, 2016b) and the data in time series 2006-2015. Only the data relating to the technical equipment of permanently occupied dwellings were taken from the databases of the Census of people, homes, and flats for 2001 and 2011 (CSO 2005, 2015), since these data are kept only within the census. The data on emissions of the principal air pollutants in 2006 and 2015 were taken from the database of the Czech Hydrometeorological Institute (CHMI), from the REZZO 1-3 and REZZO 1-4 registers (CHMI ISKO Graphic Yearbooks 2006 and 2015). Air pollution for 2006 is available in .shp format (ESRI) within the CHMI portal (areas with deteriorated air quality), and for 2015 (areas with exceeded air quality standards) from the CHMI ISKO portal in .shp format (ESRI) (CHMI, Air Quality Protection Department 2015).

As a demographic factor, mortality rate is an important indicator of demographic processes, and, at the same time, analyses of mortality by causes of death rank among the main values testifying to population health status (Ward 2012). Death rate is an indicator of success of the state; it reflects economic standard as a transformation into population health (Shkolnikov et al. 2004). Age structure of population expressed as index of aging is formed by a long-term development of fundamental demographic processes (Ďurček and Richter 2014). It is an important characteristic, and to a certain degree it also testifies to population education, lifestyle, needs and opportunities, using basic services, or requirements for social and healthcare infrastructure (Hübelová 2014a). Also divorce rate was considered as one of determinants of health, since mainly elderly persons living in couples are known for mutual support for instance at medical check-ups, in more active way of life etc. (Pienta et al. 2000). Neonatal and infant mortality are regarded indicators of advancement of a region, living standard and healthcare standard, similarly as the percentage of children with weight at birth below 2.5 kg (Galobardes et al. 2004). Abortion rate and percentage of miscarriages belong to the phenomena with a major share in population health (Norsker et al. 2012).

Tab. 1. *Input matrices (demographic and SE data)*

Districts in the South Moravian Region / year	Aging index (0-14 age group to age group 65+)	Divorce rate	Percentage of children with weight at birth below 2.5 kg	Percentage of spontaneous abortions of total abortions	Total abortions (per 100 live born)	Neonatal mortality	Infant mortality	Mortality by causes of death by code ICD-10 (%)					Percentage of unemployed (persons aged 15–64)	Housing allowances
	%					‰		IX circulatory	II neoplasms	X respiratory	XI digestive system diseases	XX external causes	%	CZK/ benefit
Blansko 2006	103,0	58,9	6,647	42,3	34,2	3,0	3,0	0,596	0,253	0,044	0,038	0,064	4,6	978,77
Blansko 2015	121,4	41,5	6,133	48,3	31,6	2,7	2,7	0,514	0,250	0,067	0,053	0,044	5,6	2837,11
Brno-City 2006	127,8	47,8	7,988	33,7	34,5	3,0	3,2	0,498	0,277	0,097	0,045	0,055	6,2	1414,04
Brno-City 2015	135,8	50,3	6,356	38,9	28,3	0,7	1,4	0,498	0,254	0,069	0,050	0,054	7,6	4025,24
Brno-Country 2006	96,9	53,8	7,552	37,1	26,2	2,9	4,3	0,470	0,245	0,081	0,038	0,054	4,3	975,68
Brno-Country 2015	101,6	52,7	5,803	44,3	24,8	0,4	1,6	0,465	0,251	0,059	0,032	0,044	5,2	3043,51
Breclav 2006	93,0	53,2	6,098	28,9	33,6	2,8	4,7	0,547	0,272	0,029	0,057	0,058	7,1	1014,18
Breclav 2015	122,1	67,8	4,783	50,1	33,4	1,8	2,7	0,444	0,217	0,049	0,049	0,058	6,5	2991,05
Hodonin 2006	100,6	56,2	5,467	37,6	36,9	4,2	4,2	0,624	0,268	0,036	0,046	0,064	9,2	979,86
Hodnonin 2015	132,1	43,0	7,059	45,7	31,7	0,7	0,7	0,529	0,256	0,050	0,055	0,058	9,0	2993,45
Vyskov 2006	98,0	59,2	10,234	33,7	32,9	4,9	6,2	0,571	0,263	0,031	0,033	0,057	5,1	985,16
Vyskov 2015	111,9	53,7	7,203	38,7	30,4	1,0	3,1	0,477	0,257	0,062	0,044	0,031	4,7	3090,01
Znojmo 2006	90,2	55,5	7,545	35,7	44,7	1,0	1,9	0,546	0,272	0,041	0,036	0,064	9,5	945,24
Znojmo 2015	117,5	54,7	7,185	36,0	33,9	0,8	1,7	0,428	0,235	0,096	0,046	0,054	9,4	3038,03
SMR average 2006	**101,4**	**54,9**	**7,362**	**35,6**	**34,7**	**3,1**	**3,9**	**0,550**	**0,264**	**0,051**	**0,042**	**0,059**	**6,6**	**1041,85**
SMR average 2015	**120,3**	**52,0**	**6,360**	**43,1**	**30,6**	**1,2**	**2,0**	**0,479**	**0,246**	**0,065**	**0,047**	**0,049**	**6,9**	**3145,48**

Source: authors' own calculations and elaboration; data by the CSO (2016a, 2016b)

A significant SE factor of health is the position in the labour market, since health consequences of unemployment are vast, ranging from psychic disorders to cardiovascular diseases (Shumaker et al. 2009). Negative effects of unemployment are direct, manifesting themselves as depression or loss of self-esteem related with worsened quality of life (Hübelová 2014b). The share of paid housing allowances is an indicator of scope and depth of poverty (Ouředníček et al. 2011). This indicator facilitates observing the regions with a higher concentration of population of poor SE status, referring to social deprivation of a territory (McGuinness et al. 2012), and judging about spatial differentiation in household incomes (Hübelová 2014a) with retroactive effects on morbidity and mortality.

Emissions are monitored, and the data are collected in the Register of Emissions and Sources of Air Pollution (REZZO). Pursuant to Act No. 201/2012 Coll. on Air Protection as amended, the REZZO records the sources of air pollutants. The sources are divided into stationary and mobile, and the stationary ones fall into categories according to their magnitude and importance. The REZZO 1-3 subsets include stationary sources, REZZO 4 the mobile sources (from transport). In 2006, areas with deteriorated air quality were defined according to the valid regulations, and in 2015 areas with exceeded air quality standards were newly added. Within the meaning of the Air Protection Act and according to air quality standards and tolerance limits, exceeding of average annual concentrations of PM_{10}, NO_2, lead, benzene, benzo(a)pyrene, cadmium, arsenic, and nickel is assessed for individual stations in order to mark out zones and agglomerations with deteriorated air quality. Additionally, the organization performs calculations of frequencies of exceeded daily limits for the PM_{10} and SO_2 fraction, frequencies of exceeded hourly air quality standards for SO_2 and NO_2, and frequencies of exceeded 8-hour limits of carbon monoxide and tropospheric ozone (CHMI.cz).

Results

Various approaches and methods were used for assessment of selected population health factors. (1) Prior to the construction of composite indicator proper, correlation matrix was inspected first to identify substantial correlations ($R > 0.8$) as these might distort the composite indicator. Owing to this, the neonatal mortality rate was eliminated as it highly correlated with infant mortality ($R = 0.84$). Furthermore, the variables were checked for possible skewness and kurtosis (as measured by corresponding coefficients), however, as these were rather low, the data were not submitted to any transformations.

Cluster analysis comprised all demographic and SE factors and facilitated capturing their change within the 2006 and 2015 confrontation. In 2006, the districts of the SMR formed two clusters (cluster No. 2 and 4), whereas in 2015 the districts divided into four clusters (clusters 1 to 4). The results obtained indicate that at lower regional levels (LAU 1) the studied factors become differentiated over time. It is clear this differentiation represents a positive tendency in the development of the examined health indicators. The only drop in the composite indicator value was recorded in the Breclav District (Tab. 2, highlighted in bold).

Tab. 2. *Composite indicator values for the SMR districts in 2006 and 2015*

Districts	Composite indicator		Clusters	
	2006	2015	2006	2015
Blansko	50.43	55.62	4	2
Brno-City	47.97	50.35	4	2
Brno-Country	59.63	67.76	2	3
Breclav	53.32	**45.51**	4	1
Hodonin	44.75	47.66	4	4
Vyskov	39.53	55.50	4	2
Znojmo	44.02	50.87	4	2

Source: authors' own calculations and elaboration; data by the CSO (2016a, 2016b)

Cluster 1 (Breclav District in 2015) is characterised by the lowest mortality rate by causes of death, but at the same time distinctively below-average demographic and SE profile. For this reason, worsening of morbidity is more likely to be expected in the future, and the cluster can be classified as "least favourable". Cluster 2 can be assessed as "average" (Districts Brno-Country in 2006; Blansko, Brno-City, Vyskov, and Znojmo in 2015) with a typical average demographic and SE profile and a slightly below-average mortality rate by causes. Cluster 3 (Brno-Country District in 2015) can be assessed as the "best" cluster with optimal values within the meaning of the most suitable demographic and SE situation and a slightly below-average mortality structure. Cluster 4 shows the attributes of a "below-average" cluster with a lower demographic and SE profile, and simultaneously the highest level of mortality by causes and morbidity (Fig. 2).

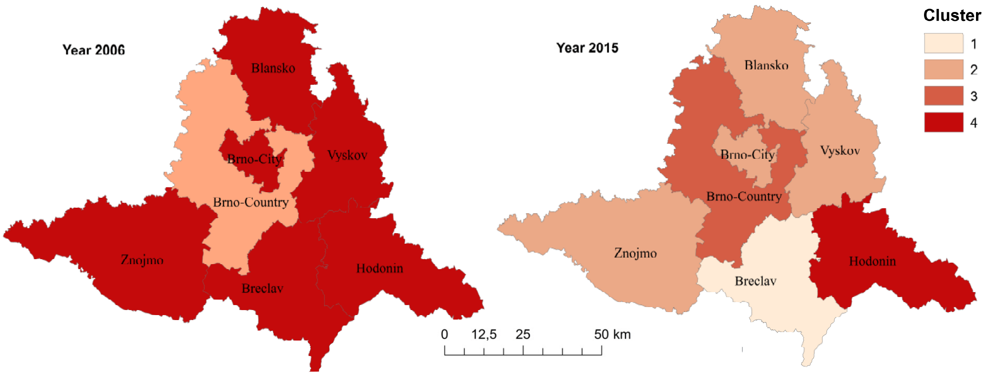

Fig. 2. *Clusters constructed on the grounds of demographic and SE factors of health in the SMR districts in 2006 (left) and 2015 (right); Source: authors' own elaboration; data by the CSO (2016a, 2016b)*

(2) Another evaluation approach consisted in the application of multiple regression method that ascertained the value of multiple coefficient of correlation R = 0.729. It adverted to the strength between the mortality rate by causes of death and all the other demographic and SE factors and proved that the strength of the relation is considerable and, moreover, significant. Nevertheless, adjusted $R^2 = 0.493$ refers to the percentage of explained variance; hence the model quality is more likely average. The variables significantly entering the model are represented by the following factors: (a) housing allowances (beta coefficient -0.895), (b) index of aging (beta coefficient 0.734), and (c) children with weight at birth below 2.5 kg (beta coefficient 0.152).

(3) The canonical correlation analysis method measured the strength of the relation between the left and right datasets (Tab. 3). With the R = 0.799 value obtained, we can talk about a high intensity of relations, which is moreover conclusive (attained $p < 0.001$). On the grounds of canonical correlation analysis, it is possible to state that the right set of variables (demographic and SE indicators) more likely casts light on the variability in the left set (diseases as the main causes of death), since the total redundancy is markedly higher for this set, namely amounting at 45.0%. Therefore, it is clear that demographic and SE factors of health explicate the 45.0% variability in mortality by causes of death, whereas individual deaths only explain 14.3% variability in demographic and SE factors. On the strength of the outcomes, the direction of dependence (causality), from which a marked influence of selected demographic and SE factors on the structure of mortality results is also undeniable, although canonical correlation analysis is primarily a symmetric method (Tab. 3).

Tab. 3. *Relation of mortality by causes of death and demographic and SE factors in the SMR districts in 2006-2015*

	Left set	Right set
No. of variables	5	9
Obtained variance	100.000%	32.5978%
Total redundancy	45.0324%	14.2873%
Variables:	Circulatory diseases	Percentage of unemployed (%; aged 15–64)
	Neoplasms	Housing allowances in CZK/benefit
	Respiratory diseases	Aging index (%)
	Digestive system diseases	Divorces per 100 marriages (%)
	External mortality causes	Children w. weight at birth below 2.5 kg (%)
		Share of spontaneous abortions of total abortions (%)
		Total abortions per 100 born (%)
		Neonatal mortality rate (‰)
		Infant mortality rate (‰)

Source: authors' own elaboration; data by the CSO (2016a, 2016b)

(4) Within the monitoring of the development of the state of the environment in the SMR districts in 2006-2015 the interest was to capture the quantity of total emissions of the main pollutants (Tab. 4).

Tab. 4. *Total emissions of the main pollutants from the sources, proportions by categories of air pollution sources (t.year^{-1}) in the territory of the SMR in 2006 and 2015*

SMR 2006	PP	SO_2	NO_x	CO	VOC	NH_3
Total*	**3,899.5**	**3,855.3**	**18,109.5**	**38,723.4**	**16,761.8**	**7,788.2**
REZZO 1	418.8	3,243.2	2,836.7	2,711.6	841.7	50.4
REZZO 2	257.8	150.8	379.6	357.6	400.9	29.6
REZZO 3	2,012.8	393,7	659,8	11,314.6	9,518.4	7,459.8
REZZO 4**	1,210.1	67.6	14,233.4	24,339.7	6,000.8	248.4
SMR 2015	PP	SO_2	NO_x	CO	VOC	NH_3
Total*	**2,914.0**	**1,732.0**	**11,853.9**	**28,571.6**	**12,335.7**	**6,072.8**
REZZO 1	525.5	1,299.2	3,246.1	5,171.3	948.9	9.4
REZZO 2	1.9	1.1	97.4	24.0	4.8	0.0
REZZO 3	1,637.6	415.7	670.4	13,214.8	8,884.0	5,841.2
REZZO 4**	749.0	16.1	7,840.8	10,163.0	2,498.2	222.1

* Emissions of PP, VOC and NH_3 from area sources calculated per regions applying appraisal

** Transport emissions calculated per regions according to the methodology by the TRC Brno

Source: CHMI portal, REZZO, Department of Emissions and Sources (CHMI 2015, 2017)

During the 2006-2015 period, emissions of the main pollutants in the SMR decreased in all of the examined indicators. The most significant decrease is evident in NO_x emissions (by 55%) and SO_2 emissions (by 35%). Emissions of CO (45%), NO_x (19%), and VOC (19%) had the greatest share in total emissions of pollutants in the SMR both in 2006 and 2015.

Sources of CO emissions are both local heating of households and the transport. NO_x emissions are mainly produced by transport. The dominant sources of emissions of particulate pollutants (PP) are local heating and also transport. In case of SO_2 emissions the main producers within the SMR in 2000–2015 were major pollution sources aimed at the production of electric power and heat and also heating of households (Kratina et al. 2015).

It is evident that the Districts Brno-City and Brno-Country that exceed the regional average have the greatest share in air pollution in the SMR in 2006 and 2015. Despite this, there is a decreasing trend in the quantity of released emissions of pollutants. In 2015, the Blansko District exceeded the regional average, as between 2006 and 2015 emissions in this area increased by 4.2% as against the SMR average. Between the mentioned years, increase in emissions occurred also in the Breclav and Znojmo Districts. A reverse trend was noted in the Hodonin District; in 2015 the emissions decreased to -2.3% of the regional average, although in 2006 emissions amounted to +17%. In the Vyskov District a slight decrease in the share in emissions was noted (Fig. 3).

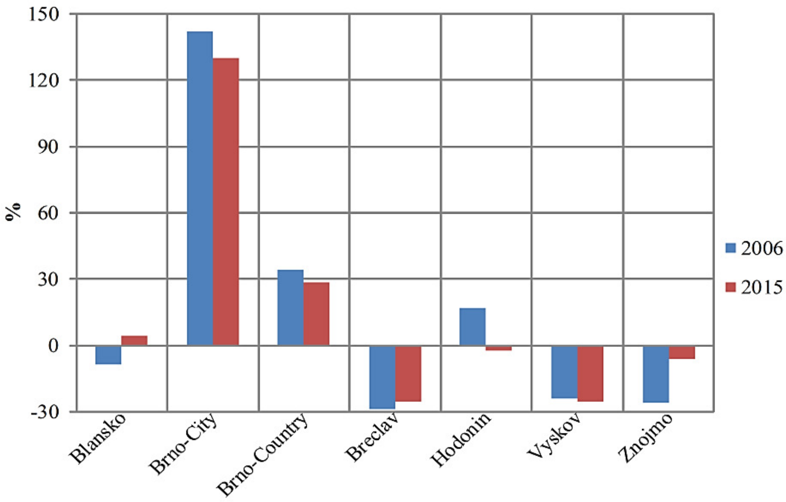

Fig. 3. *Share in emission burden of the districts (%) in relation to the SMR average in 2006 and 2015; Source: authors' own elaboration; data from the CHMI REZZO, Department of Emissions and Sources (CHMI 2015, 2017)*

As mentioned above, local heating of households also has a major share in emissions of pollutants (PP, NO_x, SO_2, CO). Tab. 5 shows the details pertaining to shares of flats by the type of heating in the SMR districts in 2001 and 2011. During this period, a positive change in the ratio of solid fuels and electric power/gas used for heating occurred in the majority of the districts. A marked change can be observed in the districts of Hodonin (72% change in favour of electric power/gas, Brno-City with 16%, and Znojmo with 13%). The lowest proportion of flats heated by electric power/gas was recorded in the districts of Blansko, Znojmo, Vyskov, and Brno-Country).

Tab. 5. *Shares of flats by types of heating (%) in the SMR districts in 2001 and 2011*

	Total	Blansko	Brno-City	Brno-Coun.	Breclav	Hodonin	Vyskov	Znojmo
				2001 (%)				
Solid fuels	**17**	18	16	13	7	80	23	30
El. power/gas	**83**	82	84	87	93	20	77	70
				2011 (%)				
Solid fuels	**8**	17	1	12	7	8	12	17
El. power/gas	**92**	83	99	88	93	92	88	83
Difference 2001–2011	**9**	**2**	**16**	**1**	**0**	**72**	**10**	**13**

Source: CSO (2012a, 2012b)

The territorial change in emission burden expressed in percentages between 2006 and 2015 and the change in the level of standardized death of respiratory diseases rate captured by means of chronological mean values in 2006-2015 suggests the possible connections already at the (micro)level of the SMR districts. Simultaneously, the districts with the highest emission load (esp. Znojmo, Blansko, and Breclav) show the largest change in the death of respiratory diseases rate (Fig. 4).

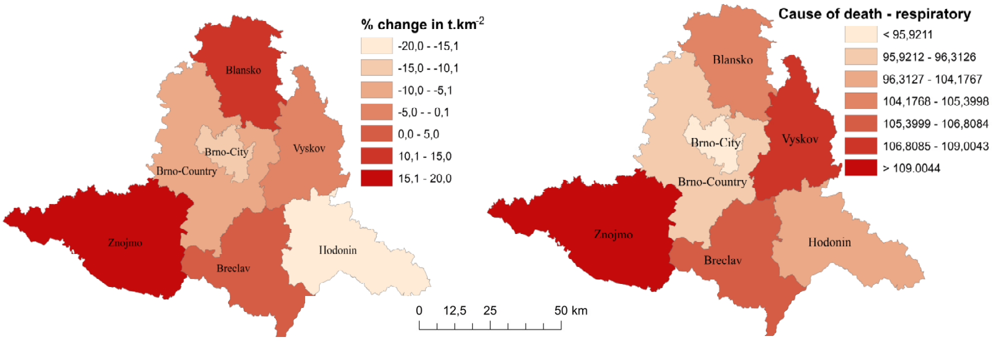

Fig. 4. *Change in emission load between 2006 and 2015 (left) and change in standardized death of respiratory diseases rate in 2006-2015 (right) in the SMR districts; Source: authors' own elaboration; data by the CSO (2016a) and CHMI (2015, 2017)*

(5) Fig. 5 determinates the areas, in which exceeding of air quality standards of at least one of the pollutants occurred. It is clear from the comparison of the areas with exceeded air quality standards that have been specified since 2006 that a fair portion of the SMR territory is being exposed to over-standards concentration of pollutants, and this pertains to areas of high population density. In a clear majority of cases, classifying of zones and agglomerations within these areas is caused by exceeding of the daily air quality standards for suspended solid particles PM_{10} and exceeding of the annual immission limit for $PM_{2,5}$ and benzo[a]pyrene (shp format, CHMI ISKO 2011, 2015). It has to be noted that the air quality of a territory is influenced not only by the quantity of pollutants in the atmosphere released from various sources, but also the dispersion conditions that prevail in a particular year and period to either improve or worsen the situation. A significant phenomenon is also uncontrolled transfer of pollution from the surrounding regions.

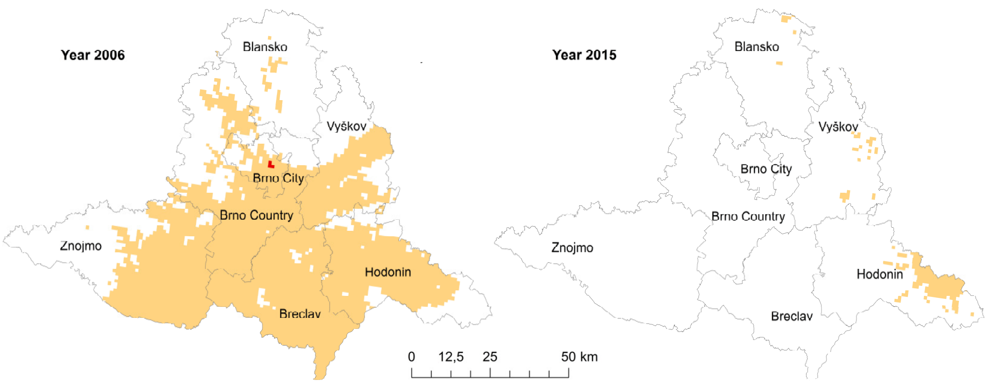

Fig. 5. *Air quality of the SMR districts in 2006 (left) and 2015 (right); Source: authors' own elaboration; data from the CHMI ISKO (2011, 2015)*

Summary of results and discussion

Cluster analysis and multiple regression method involved all selected demographic and SE factors that were considered as a complex of indicators representing a theoretical model determining population health. Confrontation of the situation in 2006 and 2015 showed improvement of all observed factors at the level of districts of the SMR and at the same time their greater spatial differentiation. Spatial differentiation is evident in compare years 2006 and 2015. The districts of Blansko, Brno-City, Breclav, Vyskov and Znojmo had similar demographics and SE factors, and the district Brno-Country had the best results in 2006 year (two clusters). The spatial distancing of district characteristics occurs in 2015, when are formed four clusters. These studied factors indicate distancing districts and increase in regional disparities. Best value at the demographics and the indicator in the cluster was formed again Brno-Country in 2015. Average values amounted district Brno-City, Blansko, Vyškov and Znojmo, Breclav below average and the worst was evaluated district Hodonin. The composite indicator has increased almost at all SMR districts.

The highest improvement occurred in the district of Vyskov (composite indicator grew by almost 16) and Brno-Country (by more than 7). In the district Vyskov there is a slow rate of growth of the ageing index, the values of neonatal and infant mortality, abortion rate and number of children with weight at birth below 2.5 kg. The least improved the district Brno-City (about 2.4) and Hodonin (about 2.9). It the district Hodonin is decreasing the rate and number of abortions and percentage of children with weight at birth below 2.5 kg, unemployment and the aging of the population. Only district Breclav worsened the demographic and the SE profile at the time, as it reduced composite indicator scores from 53.3 in 2006 to 45.5 in 2015. The most significant decline in indicators was reflected in the rate of population aging and the increase in abortion rates. Below-average demographic and SE profile will be prerequisites of deterioration of mortality structure (Goovaerts 2010, Fraser and George 2015). One of the factors increasing regional disparities in the observed time can be geographic location of districts. The improvement of the situation exists in the SMR districts, which are influenced by the trend of suburbanization. Here is the slowdown of aging population and the improvement in mortality rates. In the peripheral districts of the socio-economic situation deteriorates by contrast.

The strength of the relation among demographic and SE factors and mortality by causes measured by means of canonical correlation analysis proved to be conspicuous and significant (Pearce et al. 2011, Lakes et al. 2014). It became evident that the variables with the strongest impact on the mortality structure are of both demographic (weight at birth, aging index) and SE nature (housing allowances; Glazier et al. 2009, Ward 2012). A significant influence of demographic and SE factors on mortality structure rated by the most common diseases as the main mortality by causes of death (redundancy in excess of 44 %) follows from causality direction, whereas conversely the individual deaths account only for 14.3% of variability in demographic and SE factors.

There is a relationship between the change in emission load between 2006 and 2015 and the change in the standardized death rate of the respiratory disease rate in 2006–2015 in SMR districts (especially Blansko, Breclav and Znojmo). The statistical methods applied and the visualization of data facilitated capturing of the development of demographic, SE, and environmental influences on the population health in the districts (LAU 1) of the SMR (NUTS 3). In the literature mostly examine the relative position of some countries (EU, candidate countries of EU, other European countries) in terms of SE development indicators, but lower territorial units are not usually analysed. They are only interested in selected populations or questionnaire surveys and do not analyse secondary data.

This article presents the possibilities of using secondary data from publicly available databases and some statistical methods for evaluating demographic and SE factors determining population health. We are aware of the limitations given by the low number of (micro) regions evaluated. However, the study may be a pilot analysis for the assessment of larger spatial areas.

Conclusion

Outcomes of analysis facilitate: (a) estimate of future risks for the quality of population health (e.g., an adverse impact of age structure), (b) localization of areas with significantly higher risks (esp. in the case of the Breclav district), and (c) analysing of relations with presumed risk factors. Deepening knowledge of negative impacts of environmental pollution on human health in conjunction with proven influences of demographic and SE factors give rise to an increasing appeal to responsible environmental planning and socially and environmentally accountable policy (Dahlgren and Whitehead 2006, Khreis et al. 2016, Marmot 2017). Models and methodologies that make use of multidisciplinary approach encompassing epidemiological, SE, demographic, and environmental indicators become source materials for complex environmental planning. The linkages are mentioned for instance by Riedel et al. (2015) elaborating the example of population exposure to traffic noise. According to the author, environmental planning has to be transformed from the traditionally sectoral environmental planning to planning based on models of multiple stressors from socio-environ-mental epidemiology.

In their study, Lakes, Brückner, Krämer (2014) use Berlin as the example for calculating an environmental justice index; the authors assess the SE disparity in relation to noise pollution and distribution of green areas. The study by Braniš, Linhartová (2012) performed in 39 cities of the CR corroborate the relationships among SE, demographic, and environmental factors. Their conclusions corroborate the relationship of unfavourable SES of population and dwelling place in smaller towns with a higher level of concentration of air pollutants. Šlachtová et al. (2016) evaluated environmental and SE health inequalities on the example of the Ostrava region.

The text of this article also presented some of the possible methods that serve for health factors assessment. The contribution presents primarily the analyses of selected. The quality assessment of environmental indicators is based on publicly available data. In the next stage of our work we will deal with the proposal to determine environmental health index for the territory of the CR that will interconnect the indicators of SE, environmental (air pollution is particularly important as a disease-causing syndrome), and epidemiological factors.

References

AKTAŞ M. T. 2017: Comparing EU Countries, Turkey and Macedonia via Clustering Analysis for Quality of Life Indicators. In KOÇ et al. (Ed.) *Economic Issues: Crises, Finance and Agriculture*, London: IJOPEC Publication (76-104).

ANTHAMATTEN, P., HAZEN, H. 2011: *An introduction to the geography of health*. London (Routledge).

BERMAN, J. D., FANN, N., HOLLINGSWORTH, J. W., PINKERTON, K. E., ROM, W. N., SZEMA, A. M. et al. 2012: Health Benefits from Large-Scale Ozone Reduction in the United States. *Environmental Health Perspectives*, 120(10), 1404-1410. DOI: http://dx.doi.org/10.1289/ehp.1104851.

BÖRSCH-SUPAN, A., BRANDT, M., HUNKLER, C., KNEIP, T., KORBMACHER, J., MALTER, F. et al. 2013: Data Resource Profile: The Survey of Health, Ageing and Retirement in Europe (SHARE). *International Journal of Epidemiology*, 42(4), 992-1001. DOI: https://doi.org/10.1093/ije/dyt088.

BRANDT, M., DEINDL, C., HANK, K. 2012: Tracing the origins of successful aging: The role of childhood conditions and social inequality in explaining later life health. *Social Science & Medicine*, 74(9), 1418-1425. DOI: https://doi.org/10.1016/j.soc-scimed.2012.01.004.

BRANIŠ, M., LINHARTOVÁ, M. 2012: Association between unemployment, income, education level, population size and air pollution in Czech cities: Evidence for environmental inequality? A pilot national scale analysis. *Health & Place Journal*, 18, 1110-1114. DOI: https://doi.org/10.1016/j.healthplace.2012.04.011.

BRAUER, M., HOEK, G., Van VLIET, P., MELIEFSTE, K., FISCHER, P. H., WIJGA, A. et al. 2002: Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. *American Journal of Respiratory and Critical Care Medicine*, 166(8), 1092-1098. DOI: https://doi.org/10.1164/rccm.200108-007OC.

BRITTON, A., SHIPLEY, M., SINGH-MANNOUX, A., MARMOT, M. G. 2008: Successful aging: the contribution of early-life and midlife risk factors. *Journal of the American Geriatrics Society*, 56, 1098-1105. DOI: https://doi.org/10.1111/j.15325415.2008.01740.x.

CSO 2005: *Data 2001 - Census of people, homes and flats*. [cit. 24.05.2017]. Retrieved from: https://www.czso.cz/staticke/sldb/sldb2001.nsf/index.

CSO 2015: *Data 2011 - Census of people, homes and flats*. [cit. 02.06.2017]. Retrieved from: https://www.czso.cz/csu/czso/otevrena_data_pro_vysledky_scitani_lidu_domu_a_bytu_2011_sldb_2011.

CSO 2016a: *Statistical Yearbook of the South Moravian Region*. [cit. 28.03.2017]. Retrieved from: https://www.czso.cz/csu/xb/casove_rady.

CSO 2016b: *Selected demographic data by district*. [cit. 25.02.2017]. Retrieved from: https://www.czso.cz/csu/xb/okresy.

CHMI 2015: *Emisní bilance České republiky 2006*. [cit. 02.08.2017]. Retrieved from: http://portal.chmi.cz/files/portal/docs/uoco/oez/embil/06embil/index_CZ.html.

CHMI 2017: *Emisní bilance České republiky 2015*. [cit. 02.08.2017]. Retrieved from: http://portal.chmi.cz/files/portal/docs/uoco/oez/embil/15embil/index_CZ.html.

CHMI ISKO 2011: *Kraje s překročenými imisními limity v roce 2011*. [cit. 02.08.2017]. Retrieved from: http://portal.chmi.cz/files/portal/docs/uoco/isko/ozko/11nadlimit/11nad-limit.html.

CHMI ISKO 2015: *Kraje s překročenými imisními limity v roce 2015*. [cit. 02.08.2017]. Retrieved from: http://portal.chmi.cz/files/portal/docs/uoco/isko/ozko/15nadlimit/15nad-limit.html.

CSO 2012a: *Technické vybavení trvale obydlených bytů podle okresů*. [cit. 16.08.2017]. Retrieved from: https://www.czso.cz/documents/11280/26211413/620pb06.pdf/ad333-8c2-80a8-43118507-fbc5230ee389?version=1.0.

CSO 2012b: *Obydlené byty podle způsobu vytápění a používané energie k vytápění 2011*. [cit. 16.08.2017]. Retrieved from: https://www.czso.cz/documents/10180/20534408/ cz064_zvkr026.pdf/7e7b797d-5970-48f2-a365-f8d216695a1f?version=1.0

DAHLGREN, G., WHITEHEAD, M. 2006: *European strategies for tackling social inequities in health: Levelling up part 2. Studies on social and economic determinants of population health*. WHO Geneva (Regional Office for Europe No 3.).

DOCKERY, D. W., POPE III, A., XU, X., SPENGLER, J. D., WARE, J. H., FAY, M. E. et al. 1993: An association between air pollution and mortality in six U.S. cities. *The New England Journal of Medicine*, 329(24), 1753-1759. DOI: https://doi.org/10.1056/NEJM-199312093292401.

ĎURČEK, P., RICHTER, M. 2014: Development of Selected Demographic Indicators in the Context of Urban Shrinkage Phenomenon in the Urban Space of Slovakia. *Geographia Cassoviensis*, 8(2), 127-140.

EC 2012: *European Commission - ECHI European Core Health Indicators*. Brussels: EC. [cit. 25.02.2017]. Retrieved from: http://ec.europa.eu/health/indicators/echi/list/.

EHIS, 2018: *Eurostat - EHIS European Health Interview Survey*. [cit. 18.02.2018]. Retrieved from: http://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey.

FRANK, J. W., COHEN, R., YEN, I., BALFOUR, J., SMITH, M. 2003: Socioeconomic gradients in health status over 29 years of follow-up after midlife: the Alameda county study. *Social Science & Medicine*, 57(12), 2305-2323. DOI: https://doi.org/10.1016/-j.socscimed.2003.08.003.

FRASER, S. D. S., GEORGE, S. 2015: Perspectives on differing health outcomes by city: Accounting for Glasgow´s excess mortality. *Risk Management and Healthcare Policy*, 8, 99-110. DOI: https://doi.org/10.2147/RMHP.S68925.

GALOBARDES, B., LYNCH, J. W., SMITH, G. D. 2004: Childhood socioeconomic circumstances and cause-specific mortality in adulthood: Systematic review and interpretation. *Epidemiologic Reviews*, 26, 7-21. DOI: https://doi.org/10.1093/epi-rev/mxh008.

GLAZIER R. H., BADLEY E. M., GILBERT J. E., ROTHMAN L. 2000: The nature of increased hospital use in poor neighbourhoods: findings from a Canadian inner city. *Canadian Journal*, 91, 268-273. DOI: http://dx.doi.org/10.17269/cjph.91.258.

GLAZIER, R. H., AGHA, M. M., MOINEDDIN, R., SIBLEY, L. M. 2009: Universal health insurance and equity in primary care and specialist office visits: A population-based study. *Annals of Family Medicine*, 7(5), 396–405. DOI: https://doi.org/10.1370/afm.994.

GOOVAERTS, P. 2010: Combining areal and point data in geostatistical interpolation: applications to soil science and medical geography. *Mathematical Geosciences*, 42(5), 535-554. DOI: https://doi.org/10.1007/s11004-010-9286-5.

GUERREIRO, C. B. B., HORÁLEK, J., DE LEEUW, F. et al. 2016: Benzo(a)pyrene in Europe: Ambient air concentrations, population exposure and health effects. *Environmental Pollution*, 214, 657-667. DOI: https://doi.org/10.1016/j.envpol.2016.04.081.

HAAS, S. A. 2008: Trajectories of functional health: the ‘long arm’ of childhood health and socioeconomic factors. *Social Science & Medicine*, 66, 849-861. DOI: https://doi.org/-10.1016/j.socscimed.2007.11.004.

HAVEMAN-NIES, A., DE GROOT, L., VAN STAVEREN, W. A. 2003: Dietary quality, lifestyle factors and healthy ageing in Europe: the SENECA study. *Age and Ageing*, 32, 427-434.

HILLEMEIER, M., LYNCH, J., HARPER, S., CASPER, M. 2004: *Data Set Directory of Social Determinants of Health at the Local Level*. Atlanta: U.S. Department of Health and Human Services, Centres for Disease Control and Prevention. [cit. 11.09.2017]. Retrieved from: http://www.cdc.gov/cvh.

HÜBELOVÁ, D. 2014a: Some results of comparison of the quality of human resources in the districts of the Czech Republic. *Geographical Journal*, 66(4), 383-400.

HÜBELOVÁ, D. 2014b: Regional Disparities of the Human Resources Quality of the Czech Republic in the Context of Demographic and Economic Development. *Geographia Cassoviensis*, 8(1), 34-49.

HÜBELOVÁ, D., JADCZAKOVÁ, V., ROUSOVÁ, G. 2017: Impact of demographic and socioeconomic determinants on mortality in districts of the South Moravian Region in 2006–2015. In Klímová, V., Žítek, V. (eds.) *20th International Colloquium on Regional Sciences. Conference Proceedings*. Brno: Masaryk University, pp. 396-405.

JANKE, K., PROPPER, C., HENDERSON, J. 2009: Do Current Levels of Air Pollution Kill? The Impact of Air Pollution on Population Mortality in England. *Health Economics*, 18(9), 1031-1055. DOI: https://doi.org/10.1002/hec.1475.

KHANG, Y. H., YANG, S., CHO, H. J., JUNG-CHOI, K., YUN, S. C. 2010: Decomposition of socioeconomic differences in life expectancy at birth by age and cause of death among 4 million South Korean public servants and their dependents. *International Journal of Epidemiology*, 39, 1656-1666. DOI: https://doi.org/10.1093/ije/dyq117.

KHREIS, H., WARSOW, K. M., VERLINGHIERI, E., GUZMAN, A., PELLECUER, L., FERREIRA, A. J. et al. 2016: The health impacts of traffic-related exposures in urban areas: Understanding real effects, underlying driving forces and co-producing future directions. *Journal of Transport & Health*, 3, 249-267. DOI: https://doi.org/10.1016/-j.jth.2016.07.002.

KIESEWETTER, G., SCHOEPP, W., HEYES, CH., AMANN, M. 2015: Modelling PM2,5 impact indicators in Europe: Health effects and legal compliance. *Environmental Modelling and Software*, 74: 201-211. DOI: https://doi.org/10.1016/j.envsoft.2015.02.022.

KINO, S., BERNABÉ, E., SABBAH, W. 2017: Socioeconomic inequality in clusters of health-related behaviours in Europe: latent class analysis of a cross-sectional European survey. *BMC Public Health*, 17(1), 1-8. DOI: https://doi.org/10.1186/s12889-017-4440-3.

KRATINA J., LUKA, V., MERTL, J., PERNICOVÁ, H., POKORNÝ, J., PONOCNÁ, T. et al. 2015: *Zpráva o životním prostředí v Jihomoravském kraji 2015*. CENIA, česká informační agentura životního prostředí, Ministerstvo životního prostředí ČR. [cit. 10.08.2017]. Retrieved from: https://www.mzp.cz/C1257458002F0DC7/cz/zpravy_zivotni_prostredi_kraje_2015/$FILE/SOPSZP-Jihomoravsky_kraj-20170301.pdf>.

KŘUPKA, J.¸ PROVAZNÍKOVÁ, R., LANGER J., KAŠPAROVÁ M. 2013: Standards of living indices modelling in European Monetary Union Members Countries. In *Proceedings of the 2013 International Conference on Economics and Business Administration* (129-136).

LAKES, T., BRÜCKNER, M., KRÄMER, A. 2014: Development of an environmental justice index to determine socio- economic disparities of noise pollution and green space in residential areas in Berlin. *Journal of Environmental Planning and Management*, 57(4), 538-556. DOI: https://doi.org/10.1080/09640568.2012.755461.

LEVY, J. I., HAMMITT, J. K., SPENGLER, J. D. 2000: Estimating the mortality impacts of particulate matter: What can be learned from between-study variability? *Environmental Health Perspectives*, 108(2), 109-117.

MARMOT, M. G., SMITH, G. D., STANSFELD, S., PATEL, C., NORTH, F., HEAD, J. et al. 1991: Health inequalities among British civil servants: the Whitehall II study. *Lancet*, 337(8754), 1387-1393. DOI: https://doi.org/10.1016/0140-6736(91)93068-K.

MARMOT, M. 2017: Social justice, epidemiology and health inequalities. *European Journal of Epidemiology*, 32(7), 537-546. DOI: https://doi.org/10.1007/s10654-017-0286-3.

MARMOT, M., BELL, R. 2012: Fair society, healthy lives. *Public Health*, 126(1), 4-10. DOI: https://doi.org/10.1016/j.puhe.2012.05.014.

MARMOT, M., FRIEL, S., BELL, R., HOUWELING, T. A. J. 2008: Closing the gap in a generation: health equity through. *Lancet*, 372(9650), 1661-1669. DOI: https://doi.org/-10.1016/S0140-6736(08)61690-6.

MATTHEWS, R. J., SMITH, L. K., HANCOCK, R. M., JAGGER, C., SPIERS, N. A. 2005: Socio-economic factors associated with the onset of disability in older age: a longitudinal study of people aged 75 years and over. *Social Science & Medicine*, 61(7), 1567-1575. DOI: https://doi.org/10.1016/j.socscimed.2005.02.007.

McGUINNESS, D., McGLYNN, L. M., JOHNSON, P. C. D., MACINTYRE, A., BATTY, G. D., BURNS, H. et al. 2012: Socio-economic status is associated with epigenetic differences in the pSoBid cohort. *International Journal of Epidemiology*, 41(1), 151-160. DOI: https://doi.org/10.1093/ije/dyr215.

McLAUGHLIN, S. J., CONNELL, C. M., HEERINGA, S. G., LI, L. W., ROBERTS, J. S. 2010: Successful aging in the United States: prevalence estimates from a national sample of older adults. *Journal of Gerontology: Social Sciences*, 65B, 216-226. DOI: https://doi.org/10.1093/geronb/gbp101.

McNAMARA, C. L., BALAJ, M., THOMSON, K. H., EIKEMO, T. A., SOLHEIM, E. F., BAMBRA, C. 2017: The socioeconomic distribution of non-communicable diseases in Europe: Findings from the European Social Survey (2014) special module on the social determinants of health. *European Journal of Public Health*, 27(1), 22-26. DOI: https://doi.org/10.1093/eurpub/ckw222.

MEARA, E. R., RICHARDS, S., CUTIER, D. M. 2008: The gap gets bigger: changes on mortality and life expectancy, by education, 1981–2000. *Health Affairs*, 27(2), 350-360. DOI: https://doi.org/10.1377/hlthaff.27.2.350.

MINICUCI, N., NAIDOO, N., CHATTERJI, S., KOWAL, P. 2016: Data Resource Profile: Cross-national and cross-study sociodemographic and health-related harmonized domains from SAGE plus ELSA, HRS and SHARE (SAGE+, Wave 1). *International Journal of Epidemiology*, 45(5), 1403-1403j. DOI: https://doi.org/10.1093/ije/dyw181.

NIPH 2015: *Environmental Health Monitoring System in the Czech Republic - Summary Report 2012*. Praha (NIPH).

NORSKER, F. N., ESPENHAIN, L., A ROGVI, S., MORGEN, C. S., ANDERSEN, P. K., NYBO ANDERSEN, A. M. 2012: Socioeconomic position and the risk of spontaneous abortion: a study within the Danish National Birth Cohort. *BMJ Open*, 2(3), 1-7. DOI: https://doi.org/10.1136/bmjopen-2012-001077.

OUŘEDNÍČEK, M., TEMELOVÁ, J., POSPÍŠILOVÁ, L. (eds.) 2011: *Atlas of Socio-spatial Differentiation of the Czech Republic*. Praha (Nakladatelství Karolinum).

PEARCE, J. R., RICHARDSON, E. A., MITCHELL, R. J., SHORTT, N. K. 2011: Environmental Justice and Health: A Study of Multiple Environmental Deprivation and Geographical Inequalities in Health in New Zealand. *Social Science & Medicine*, 73(3), 410-420. DOI: https://doi.org/10.1016/j.socscimed.2011.05.039.

PETERS, A., VON KLOT, S., HEIER, M. et al. 2004: Exposure to Traffic and the Onset of Myocardial Infarction. *The New England Journal of Medicine*, 351(17), 1721-1730. DOI: https://doi.org/10.1056/NEJMoa040203.

PIENTA, A., HAYWARD, M., D., JENKINS, K., R. 2000: Patterns of Health and Marriage in Later Life. *Journal of Family Issues*, 21, 559-586.

POPE III, C. A. 2007: Mortality Effects of Longer Term Exposures to Fine Particulate Air Pollution: Review of Recent Epidemiological Evidence. *Inhalation Toxicology*, 19(1), 33-38. DOI: https://doi.org/10.1080/08958370701492961.

POPE III, C. A., BURNETT, R. T., THUN, M. G., CALLE, E. E., KREWSKI, D., ITO, K. et al. 2002: Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *The Journal of the American Medical Association*, 287(9), 1132-1141. DOI: https://doi.org/10.1001/jama.287.9.1132.

RIEDEL, N., KÖCKLER, H., SCHEINER, J., BERGER, K. 2015: Objective Exposure to Road Traffic Noise, Noise Annoyance and Self-Rated Poor Health-Framing the Relationship between Noise and Health as a Matter of Multiple Stressors and Resources in Urban Neighbourhoods. *Journal of Environmental Planning and Management*, 58(1–2), 336-356. DOI: https://doi.org/10.1080/09640568. 2013.859129.

SEEDHOUSE, D. 1995: *Health: The Foundations of Achievement*. New York (John Wiley and Sons).

SHARE. 2018: *SHARE - Survey of Health, Ageing and Retirement in Europe*. Munich: SHARE. [cit. 22.02.2018]. Retrieved from: http://www.share-project.org/.

SHKOLNIKOV, V. M., ANDREEV, E. M., JASILIONIS, D., LEINSALU, M., ANTONOVA, O. I., McKEE, M. 2006: The changing relation between education and life expectancy in central and eastern Europe in the 1990s. *Journal Epidemiol Community Health*, 60, 875-881. DOI: https://doi.org/10.1136/jech.2005.044719.

SHKOLNIKOV, V. M., ANDREEV, E. M., LEON, D. A., McKEE, M., MESLÉ, F., VALLIN, J. 2004: Mortality Reversal in Russia The story so far. *Hygiea Internationalis an Interdisciplinary Journal for the History of Public Health*, 4(1), 29-80. DOI: https://doi.org/10.3384/hygiea.1403-8668.044129.

SHUMAKER, S. A., OCKENE, J. K., RIEKERT, K. A. eds. 2009: *The Hand-book of health behavior change*. New York (Springer Publishing).

SUBRAMANIAN, S. V., KAWACHI, I. 2004: Income inequality and health: what have we learned so far? *Epidemiologic Reviews*, 26, 78-91. DOI: https://doi.org/10.1093/epirev/mxh003.

SWIFT, R. 2011: The relationship between health and GDP in OECD countries in the very long run. *Health Economics*, 20, 306-322. DOI: https://doi.org/10.1002/hec.1590.

ŠLACHTOVÁ, H., JIŘÍK, V., TOMÁŠEK, I., TOMÁŠKOVÁ, H. 2016: Environmental and Socioeconomic Health Inequalities: a Review and an Example of the Industrial Ostrava Region. *Central European Journal of Public Health*, 24, 26-32. DOI: https://doi.org/-10.21101/cejph.a4535.

ŠRÁM, R. J., BENES, I., BINKOVÁ, B., DEJMEK, J., HORSTMAN, D., KOTĚSOVEC, F. et al. 1996: Teplice Program: The Impact of Air Pollution on Human Health. Environmental Health Perspectives VO - 104. *Environmental Health Perspective*, 104(4), 699-714.

ŠRÁM, R. J., BINKOVA, B., DOSTAL, M., MERKEROVA-DOSTALOVA, M., LIBALOVA, H., MILCOVA, A. et al. 2013: Health impact of air pollution to children. *International Journal of Hygiene and Environmental Health*, 216, 533-540. DOI: https://doi.org/10.1016/j.ijheh.2012.12.001.

ŠVECOVÁ, V. 2009: Urinary 8-oxodeoxyguanosine levels in children exposed to air pollutants. *Mutation Research - Fundamental and Molecular Mechanisms of Mutagenesis*, 662(1-2), 37-43. DOI: https://doi.org/10.1016/j.mrfmmm.2008.12.003.

TOBIASZ-ADAMCZYK, B., BRZYSKI, P., GALAS, A., BRZYSKA, M., FLOREK, M. 2011: Relationship between characteristics of social network, health-related quality of life and mortality patterns in older age. Krakow study. *Journal of Epidemiology and Community Health*, 65, A215. DOI: http://dx.doi.org/10.1136/jech.2011.142976h.23.

TONNE, C., HALONEN, J. I., BEEVERS, S. D., DAJNAK, D., GULLIVER, J., KELLY, F. et al. 2016: Long-term traffic air and noise pollution in relation to mortality and hospital readmission among myocardial infarction survivors. *International Journal of Hygiene and Environmental Health*, 219, 72-78. DOI: https://doi.org/10.1016/j.ijheh.2015.09.003.

VARDOULAKIS, S., DEAR, K., WILKINSON, P. 2016: Challenges and Opportunities for Urban Environmental Health and Sustainability: the HEALTHY-POLIS initiative. *Environmental Health*, 15(1), 171-176. DOI: https://doi.org/10.1186/s12940-016-0096-1.

VEUGELERS, P. J. 2003: Socioeconomic disparities in health care use: Does universal coverage reduce inequalities in health? *Journal of Epidemiology & Community Health*, 57(6), 424-428. DOI: https://doi.org/10.1136/jech.57.6.424.

VEUGELERS, P. J., YIP, A. M., MO, D. 2001: The north-south gradient in health: analytic applications for public health. *Canadian Journal Public Health*, 92, 95-98. DOI: http://dx.doi.org/10.17269/cjph.92.60.

WARD, M. M. 2012: Sense of control and sociodemographic differences in self-reported health in older adults. *Quality of Life Research*, 21(9), 1509-1518. DOI https://doi.org/-10.1007/s11136-011-0068-4.

WEINMAYR, G., ROMEO E., SARIO, De M., WEILAND, S. K., FORASTIERE, F. 2010: Short-Term effects of PM_{10} and NO_2 on respiratory health among children with asthma or asthma-like symptoms: A systematic review and Meta-Analysis. *Environmental Health Perspectives*, 118(4), 449-457. DOI: https://doi.org/10.1289/ehp.0900844.

WHO. 2000: *The World Health Report, 2000*. Geneva (WHO).
WHO, 2016: International Statistical Classification of Diseases and Related Health Problems 10th Revision. Geneva. [cit. 26.02.2018]. Retrieved from: http://apps.who.int/classifi-cations/icd10/browse/2016/en.
WILKINS, R., BERTHELOT, J. M., NG, E. 2002: Trends in mortality by neighbour - hood income in urban Canada from 1971 to 1996. *Health Reports*, 13S, 1-28.
ZHU, L., GE, X., CHEN, Y., ZENG, X., PAN, W., ZHANG, X. et al. 2017: Short-term effects of ambient air pollution and childhood lower respiratory diseases. *Scientific Reports*, 7(1), 1-7. DOI: https://doi.org/10.1038/s41598-017-04310-7.
ŽMUK, B. 2015: Quality of life indicators in selected European countries: Hierarchical cluster analysis approach. *Croatian Review of Economic Business and Social Statistics*, 1(1-2), 42-54. DOI: https://doi.org/10.1515/crebss-2016-0004.

Acknowledgement: This articles is part of the project entitled "Territorial Dimension of Demographic Factors of Health and Health Condition of Czech Population", registration number 2017/008, generously supported by the Internal Grant Agency of the Faculty of Regional Development and International Studies, Mendel University in Brno.

Authors' affiliations

PhDr. Dana Hübelová, Ph.D.
Mendel University in Brno
Department of Applied Statistics and Demography
Faculty of Regional Development and International Studies
Třída Generála Píky 7, 613 00 Brno,
Czech Republic
dana.hubelova@mendelu.cz

Ing. Veronika Jadczaková, Ph.D.
Mendel University in Brno
Department of Applied Statistics and Demography
Faculty of Regional Development and International Studies
Třída Generála Píky 7, 613 00 Brno,
Czech Republic
veronika.jadczakova@mendlu.cz

Ing. Gabriela Rousová
Mendel University in Brno
Department of Applied Statistics and Demography
Faculty of Regional Development and International Studies
Třída Generála Píky 7, 613 00 Brno,
Czech Republic
xrousov1@node.mendelu.cz

Ing. Alice Kozumplíková, Ph.D.
Mendel University in Brno
Department of Environmentalists and Natural Resources
Faculty of Regional Development and International Studies
Třída Generála Píky 7, 613 00 Brno,
Czech Republic
alice.kozumplikova@mendlu.cz