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Economic Development and the Spread of Diseases of Affluence in EU Regions

Abstract: *Diseases of affluence* (*diseases of the twenty-first century*, *Western diseases*) by definition should have higher prevalence and/or mortality rates in richer and more developed countries than in poorer, underdeveloped states. Therefore, it has been indicated that it is the civilizational progress (directly or indirectly via changes in lifestyle, diet, physical activity, stress, etc.) that stimulates epidemic outbreaks of some illnesses (cancer, diseases of respiratory and cardiovascular systems, diabetes, mental disorders). On the other hand substantial financial resources, highly qualified medical personnel, and cutting-edge technology of richer states, should allow for effective prevention, diagnostics, and treatment of these diseases. The European Union as a whole, as well as all its member states and their regions, may be considered "highly developed" in terms of economy. Does it, however, mean that EU can be perceived as homogeneous as far as the *diseases of affluence* epidemiology is concerned? Are the relatively small differences in economic regional development (compered to worldwide inequalities) a significant factor in the spatial distribution of the *diseases of affluence*? To evaluate the possible dispersion in the epidemiology of some of the so called *Western diseases* and their relation to regional development, tools of spatial statistics have been incorporated. The research covers 261 EU NUTS 2 regions for the years 2003–2010. This research may provide some insight into the existence of hypothetical *diseases of affluence* as well as help recognize spatial patterns of prevalence and mortality rates for these illnesses.

Keywords: diseases of affluence, health, socioeconomic development, spatial analysis

JEL: C46, C38, I14, I15, O18, O57

1. Introduction

In the modern world new and unexpected medical dangers constantly arise. It may mean new diseases, naturally mutated or bioengineered, but more and more often also changes in epidemiological patterns of existing disorders. The diseases of affluence, also known as the diseases of the twenty-first century or Western diseases have become an alarming phenomena in the last decades. Well known illnesses, like cardiovascular diseases, respiratory system diseases, cancer, diabetes, or mental disorders (including addictions) have re-appeared as modern diseases and constitute a severe problem addressed in many WHO reports (*WHO Report: ATLAS...*, 2010: 7–22; *WHO Report: Global Report...*, 2016: 90–91; *WHO Report: Global status...*, 2011: 1–160). Circulatory illnesses as well as respiratory system diseases and cancer are a viable threat to the public health. Therefore since early twentieth century they have been addressed in healthcare policies in most developed countries, which has already resulted in the longer expected lifespan of the population (Schneider, Lilienfeld, 2011: XIII–XV, 475–525; *WHO report: A global...*, 2013: 8–35; Winkleby, Jatulis, Frank, Fortmann, 1992: 816–819). Statistics shows that almost half of deaths in most developed countries are caused by the cardiovascular problems, which are considered to be the flagship example among the diseases of affluence. However, there is no unified definition or established list of the infamous twenty-first century diseases. Nevertheless, it is generally believed that regions with higher economic indicators are more at risk, than the poorer ones. "One of the strongest and most consistent predictors of a person's morbidity and mortality experience is that person's socioeconomic status (SES)" (Winkleby, Jatulis, Frank, Fortmann, 1992: 816). Although, there is no irrefutable evidence or methodology to state that any disease is influenced by regional socio-economic development, these illnesses are considered to be, direct or indirect, cost and by-product of social, cultural, technological, and economic progress in highly developed societies (Kotarski, 2013: 117–125; Link, 2007: 75–76; Aue, 2009: 175). Proving or disproving some of the common notions may turn out to be very beneficial for the assessment and the development of regional, international, and global policies regarding the so called diseases of the twenty-first century. For the purpose of this analysis the hypothesis of diseases of affluence can be stated as: *the more affluent (wealthy, developed etc.) the object (country, region, social group, household, person etc.), the more intense the prevalence (frequency of cases, severity of symptoms, mortality rate etc.) of the disease.*

The European Union as a whole, as well as all its member states and their regions, may be considered as "highly developed" regions in terms of economy. Does it, however, mean that EU can be perceived as homogeneous as far as the diseases of affluence epidemiology[1] is concerned? Does the economic diversity in EU (rel-

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[1] Epidemiology is a science concerning transmission of diseases and factors (mainly health-related but also other e.g. socio-economic) stimulating and inhibiting them. The field includes analysis of: correlation between prevalence and other factors, spatio-temporal patterns of diseases, prevent-

atively small compared to worldwide inequalities) constitute a significant factor for the spatial distribution of the diseases of affluence? To evaluate possible dispersion in the epidemiology of some of the potential Western Diseases and their correlation with regional development, some tools of spatial statistics have been incorporated. Namely, uni- and bivariate local and global Moran's *I* statistics.

There are 3 specific aims of this paper: (1) to verify the clustering of similar regions with high or low prevalence of each disease, (2) to assess the regional relation between economic development and the prevalence of each disease, (3) to verify if this regional relation is constant both over time and space. This research may provide some answers to the questions concerning the existence of the *diseases of affluence* as well as allow for the recognition of the spatial patterns of prevalence and mortality rates for these illnesses.

2. Data

Data used in this statistical analysis represent death rates for each of the diseases. Using the mortality rate according to the cause of death, as a measure of epidemiology, is debatable, however in a way it does represent the prevalence. The death rates are in this case a result of the combined effects of: the real prevalence or epidemiology (the number of ill people), the efficiency of diagnostics (the number of diagnosed cases of the illness), and the health care efficiency (people living with the disease and possibly dying from other causes). It is difficult, if not impossible, to state which factor is decisive, and whether it is constant in time and space. However, there is very little data available on prevalence, or even diagnosed prevalence. It should be mentioned, that in case of spatial statistics the dataset needs to be complete for all regions, to implement the spatial weight matrix. Therefore, the death rates analysis should be treated as a compromise between theory concerning prevalence or epidemiology, and the availability of data. In this analysis 5 potential diseases of affluence are considered: diabetes, diseases of the respiratory system, neoplasms (cancer), diseases of the circulatory system (cardiovascular diseases), and finally mental and behavioural disorders.

All the data used in the statistical analysis are taken from the Eurostat Database. They all cover the period of 2003–2010 and 261 EU NUTS 2 regions. For each disease a three-year average of standardized death rates (per 100 000 inhabitants) is used. The age standardized death rates (SDRs) are calculated by Eurostat as weighted, (the weights are defined by the age distribution of that population) average, age-specific death rates of European Standard Population based on the

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ing and controlling health problems. Consequently, epidemiology is equally focused on contagious diseases (often referred to as the diseases of poverty) and the diseases of affluence (Porta, 2008: 79; Beaglehole, Bonita, Kjellstrom, 1992: 3–7).
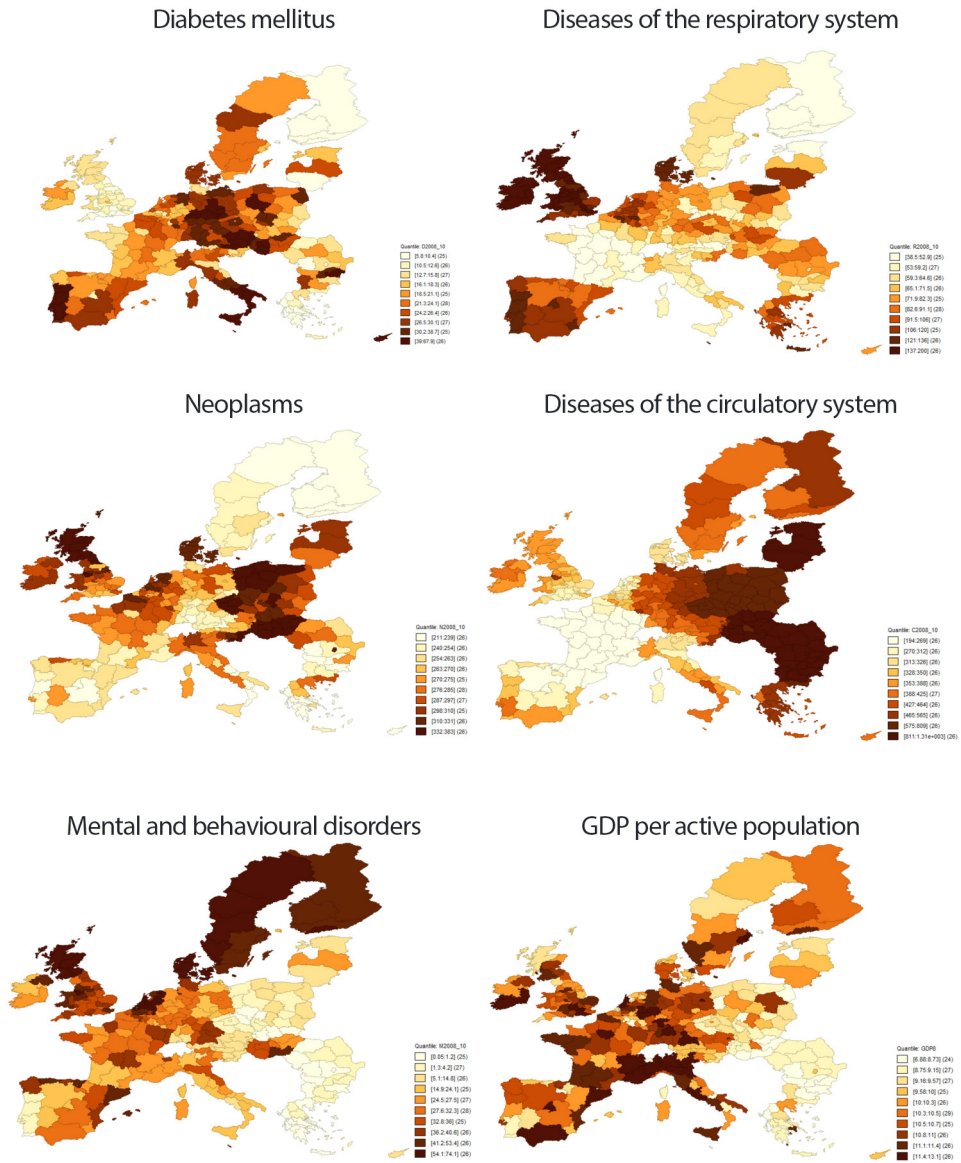
EU27 and EFTA averages over the projected period 2011–2030 (Eurostat Glossary…; *Eurostat: Products manuals and guidelines*; *Report of Eurostat's task force…*, 2013: 11–14). The regional affluence, or socio-economic development, is represented by Gross Domestic Product (GDP), expressed in Purchasing Power Standard per active population.[2] In all comparisons between GDP and the prevalence, GDP is taken into account for the first year of each three-year average corresponding to the three-year average of causes of deaths. This GDP lag reflects two factors: (1) the time lag of economic effects on health and (2) the causality, where economic development influences the prevalence of each disease.

The spatial distribution of socio-economic status, measured by GDP per active population, clearly shows a division between Western-Northern regions and Eastern-Central Europe, with Balkans and Baltic states, which separates rich and affluent provinces from poorer and less developed ones.

Analysing the spatial distribution of the five potential diseases of affluence in EU regions it appears that there is no clear pattern, common for all the illnesses. The most deaths caused by diabetes are scattered across Germany, Slovakia, Czech Republic, Austria, Hungary, and parts of Balkans. The lowest values are noted in England (UK) and Finland. Diseases of the respiratory system seem to have the highest mortality rate in the whole of the British Isles, Denmark, and Iberian Peninsula, and the lowest ones in France and Italy. Cancer is most common in Central Europe, including Poland, Denmark, and Scotland (UK). The lowest death rates can be found in Scandinavia and Iberian Peninsula. On the other hand, cardiovascular diseases clearly divide Europe. The Eastern and Central Europe, with Balkans and Baltic states, constitute highest death rates, whereas the Western parts, especially Western Germany, have very low mortality indicators. Such distribution may preliminarily point to a disease of poverty rather than affluence. Finally, mental and behavioural disorders cause most deaths in Northern Europe (Scandinavia, Denmark, Scotland) and then in Western Europe. The lowest death rates are noted in Central and Eastern Europe (with Balkans and Baltic states). This may indicate that mental disorders are diseases of affluence (see Table 1). There is no clear or uniform patterning of these five diseases. Concluding, decile mapping alone does not give an answer about the possible clustering of high and low prevalence regions and if there is any dependence between prevalence and socio-economic development. Therefore, a further and more detailed analysis needs to be carried out.

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[2] Gross Domestic Product (GDP) is a simplified measure of the multidimensional socio-economic development. However, despite its flaws, it is the single most often used variable representing regional development. Using GDP per active population instead of per capita (or per inhabitant) should provide higher accuracy of measurement.

Table 1. Standardized death rates of diseases of affluence, 2008–2010 average and GDP per active population for 2008, by region of residence, by deciles

Diabetes mellitus

Diseases of the respiratory system

Neoplasms

Diseases of the circulatory system

Mental and behavioural disorders

GDP per active population

Source: own compilation

3. Methodology

In the analysis of epidemiology of Western diseases and regional development, two sets of spatial statistics measurements are used. Firstly, the (univariate) local and global Moran's *I* statistics allow for confirming any actual (statistically significant) grouping of similar regions, that are neighbouring NUTS 2 provinces with low-low, high-high, or mixed standardized mortality rates. Secondly, to verify grouping of regions with high or low mortality rates with high or low economic development (GDP per active population) bivariate local and global Moran's *I* statistics are introduced. The bivariate statistics measure the clustering of regions with high-low values of one variable (mortality rate of any disease) with high-low values of another variable (GDP) in bordering regions. These statistics do not reflect the affluence hypothesis *sensu stricto*, therefore three assumptions need to be made.

1. Direct and indirect, socioeconomic and medical consequences of regional development are not limited by regional borders.
2. Prevalence of potential diseases of affluence is not limited by regional borders.
3. Regional correlation of:
    a) high GDP per capita with high mortality regions
    b) low GDP per capita with low mortality regions
    will confirm the affluence hypothesis, while mixed clusters (low-high) will prove otherwise.

Assumptions 1 and 2 reflect the common notion that regional borders do not limit any nonphysical phenomena, especially in the EU with common market and no-border policy. Assumption 3 allows for identification of diseases of affluence, and by association – diseases of poverty.

The classic or univariate Moran's *I* statistic (Moran, 1950; Cliff, Ord, 1981; Suchecki, 2010) is the most popular test of spatial association. The local Moran's I_i shows whether the *i*-location is surrounded by locations with similar or opposite values. The local Moran's I_i statistic or Local Indicators of Spatial Association (LISA) takes the following form:

$$I_i = \frac{(x_i - \overline{x})}{\frac{1}{N}\sum_{j=1}^{N}(x_j - \overline{x})^2} \sum_{j=1}^{N} w_{ij}(x_j - \overline{x}).$$ (1)

The global Moran's *I* is a mean of local Moran's I_i statistics and measures general regional similarity for all regions:

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2},$$ (2)

where $\bar{x}$ is a mean of a given process and w_{ij} are the elements of **W** matrix, which in this paper is based on queen contiguity spatial weight matrix, 1st order (Anselin, 1988). We assume positive spatial autocorrelation if: $I > -\frac{1}{N-1}$ and negative spatial autocorrelation otherwise.

Bivariate Moran's I measures are constructed in analogical manner. They measure local or global spatial correlation between x (death rate) and another variable y (GDP per active population) in nearby areas. Bivariate LISA is defined as:

$$I_i^{bv} = \frac{(x_i - \bar{x})}{\frac{1}{N}\sum_{j=1}^{N}(x_j - \bar{x})^2}\sum_{j=1}^{N} w_{ij}(y_j - \bar{y}), \tag{3}$$

where $\bar{y}$ is a mean of the 2nd variable. The global equivalent Moran's I is:

$$I^{bv} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(x_i - \bar{x})(y_j - \bar{y})}{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}. \tag{4}$$

All spatial analyses are based on queen contiguity spatial weight matrix, 1st order (Anselin, 1988).

4. Results and discussion

Analysing epidemic spatial clustering in the NUTS 2 regions and time indicates unique patterning for each disease. Only statistically significant clustering is taken into consideration (see Table 2).

Diabetes shows the smallest clusters among the 5 illnesses and little change over the period of 2003–2005 to 2008–2010. Low standardized death rates cluster together in Finland, UK, and Greece. The highest mortality characterizes South-West Iberian Peninsula, South Italy, parts of Germany, Austria, Slovakia, and Czech Republic. There are almost no mixed clusters. The overall spatial autocorrelation for diabetes measured with global Moran's I was very high, 0.62 for 2003–2005 and 0.61 for 2008–2010.

In the case of diseases of the respiratory system high mortality clusters form in the British Isles, Iberian Peninsula, and Benelux (Netherland, Belgium, Luxemburg), while the low ones form in Central and Western regions, especially France, Italy, and Germany. The main time difference is the disappearance of low values clusters for Scandinavia between 2003–2005 and 2008–2010. Mixed groupings are rare, if any. In general, the spatial autocorrelation for 2003–2005 $I = 0.74$ and for 2008–2010 $I = 0.79$ was even higher than for diabetes.

Neoplasms (cancer) have high mortality clusters in Northern UK and in Central Europe, including Poland, Slovakia, and Czech Republic, while low mortality clusters in: Scandinavia, Iberian Peninsula, and Balkans. Very few high-low or low-high clusters are observed. The grouping is very similar for the years 2003–2005 and 2009–2010. The global Moran's *I* for 2003–2005 equalled 0.66 and for 2008–2010 equalled 0.63.

Diseases of the circulatory system or cardiovascular diseases constituted the largest group of the five illnesses and created clusters stable over time. A low death rate cluster units concentrated in Western regions (France, Iberian Peninsula, Benelux, parts of UK, and Italy) while high mortality clusters formed in Central and Eastern Europe, including Poland, Balkans, and Baltic states. Overall Moran's statistic was extremely high with *I* = 0.92 for both 2003–2005 and 2008–2010.

Table 2. Univariate LISA for diseases of affluence standardised death rates, averages for 2003–2005 and 2008–2010, by NUTS 2 EU regions

| Years Disease	2003–2005	2008–2010
Neoplasms		
Diseases of the circulatory system		
Mental and behavioural disorders		
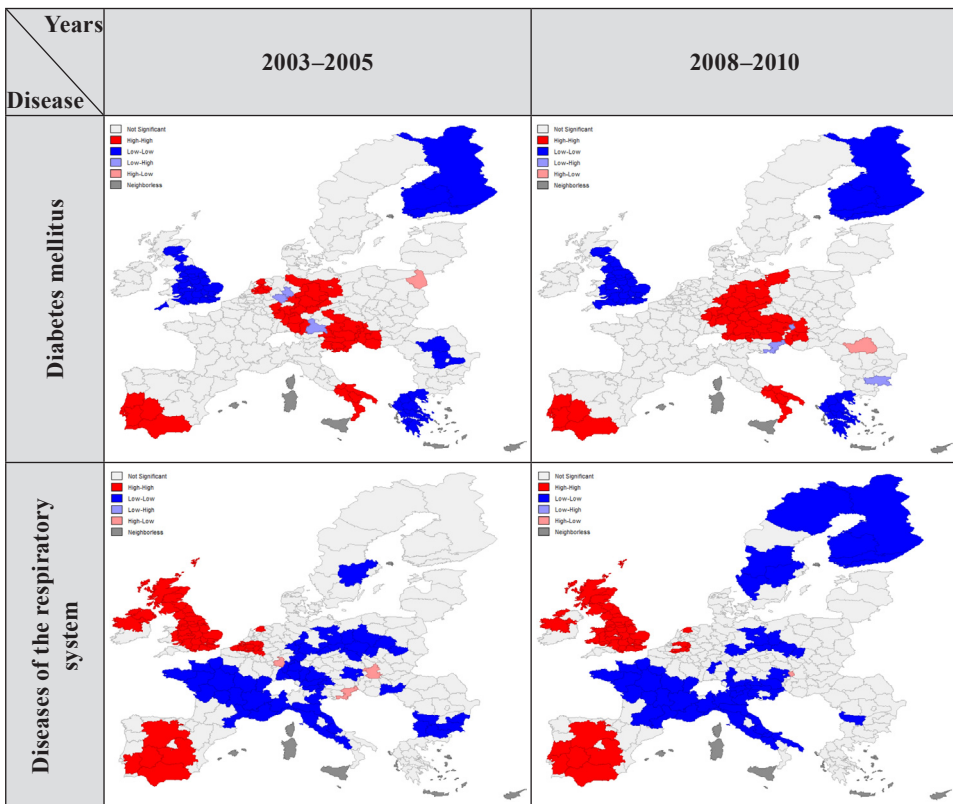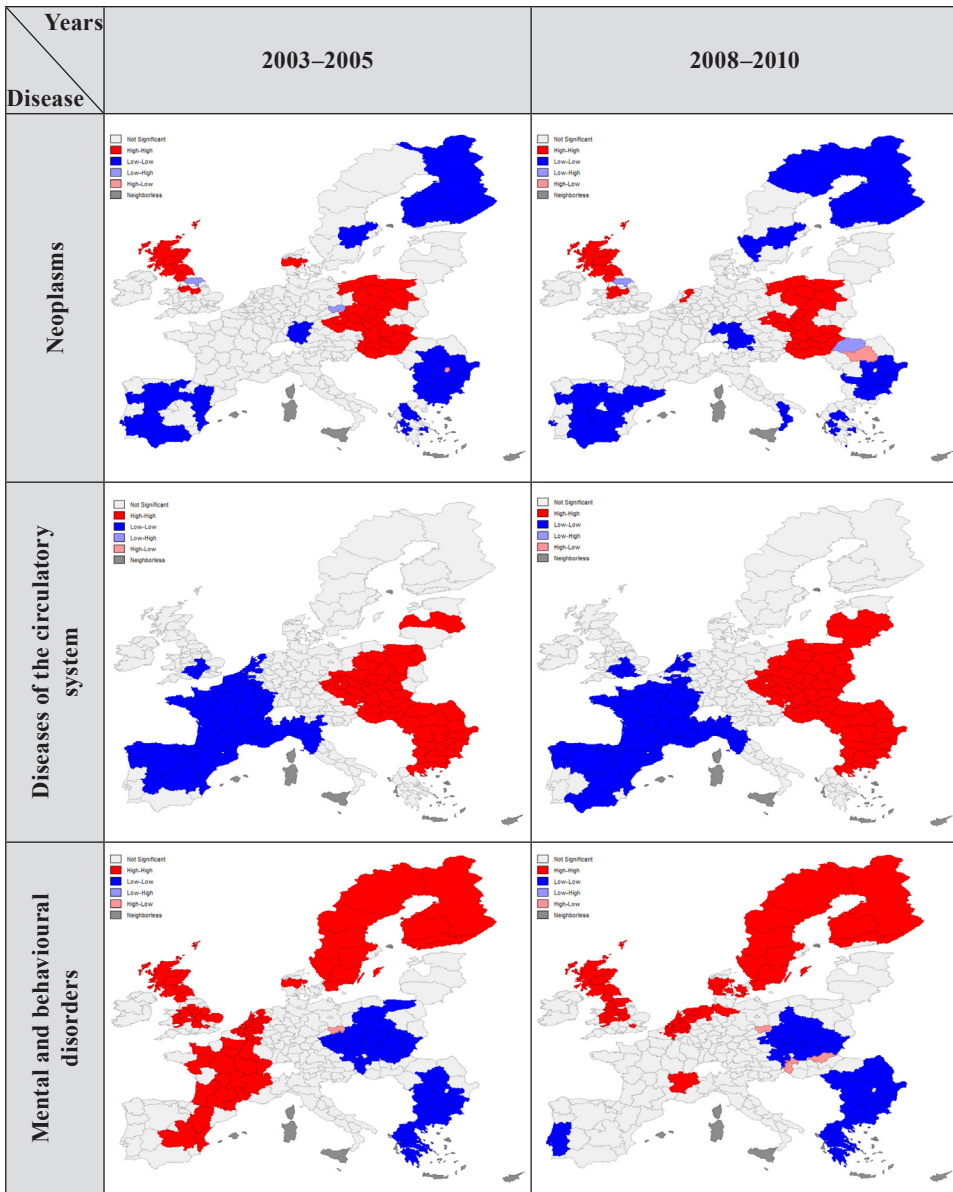
Source: own compilation.

For mental and behavioural disorders clustering process changed the most over time, compared to the other four illnesses. Low mortality clusters were noted in Central Europe, especially in Poland, and in Balkans, which decreased further in 2008–2010. Four high death rate groups for 2003–2005 formed in: Scandinavia, UK, France, Spain, Benelux, Northern Germany and Denmark. In 2008–2010 large parts of clusters in France,

Spain and Germany have disappeared. Global Moran's statistic for 2003–2005 equalled 0.7 and for 2008–2010 – 0.68, which is a very high autocorrelation.

Existence of large and positively correlated clusters, spreading beyond not only province but also state borders, supports the assumption concerning spilling over of Western diseases' prevalence and mortality. This may also be an indicator of dependence between regional economic development and epidemiology. However, this relationship needs further research.

Analysing statistically significant clustering process among regions with high/low prevalence (defined as standardized mortality rates) of possible Western diseases in each region and high/low economic development (expressed by GDP per active population, PPS), in contiguous provinces, gave some unexpected outcomes. The high-high or low-low grouping can be treated as an indicator of diseases of affluence, while mixed high-low and low-high clusters suggest the opposite, i.e. diseases of poverty (see Table 3).

Table 3. Bivariate LISA for diseases of affluence standardised death rates (averages for 2003–2005 and 2008–2010) and GDP per active population (PPS; for 2003 and 2008, respectively) by NUTS 2 EU regions
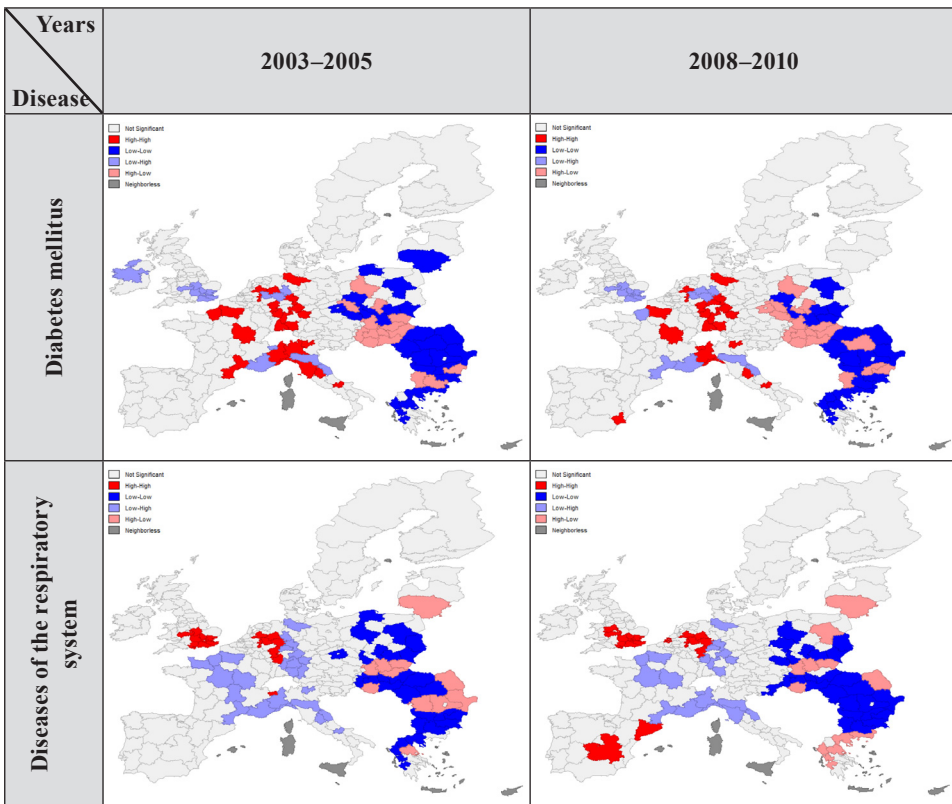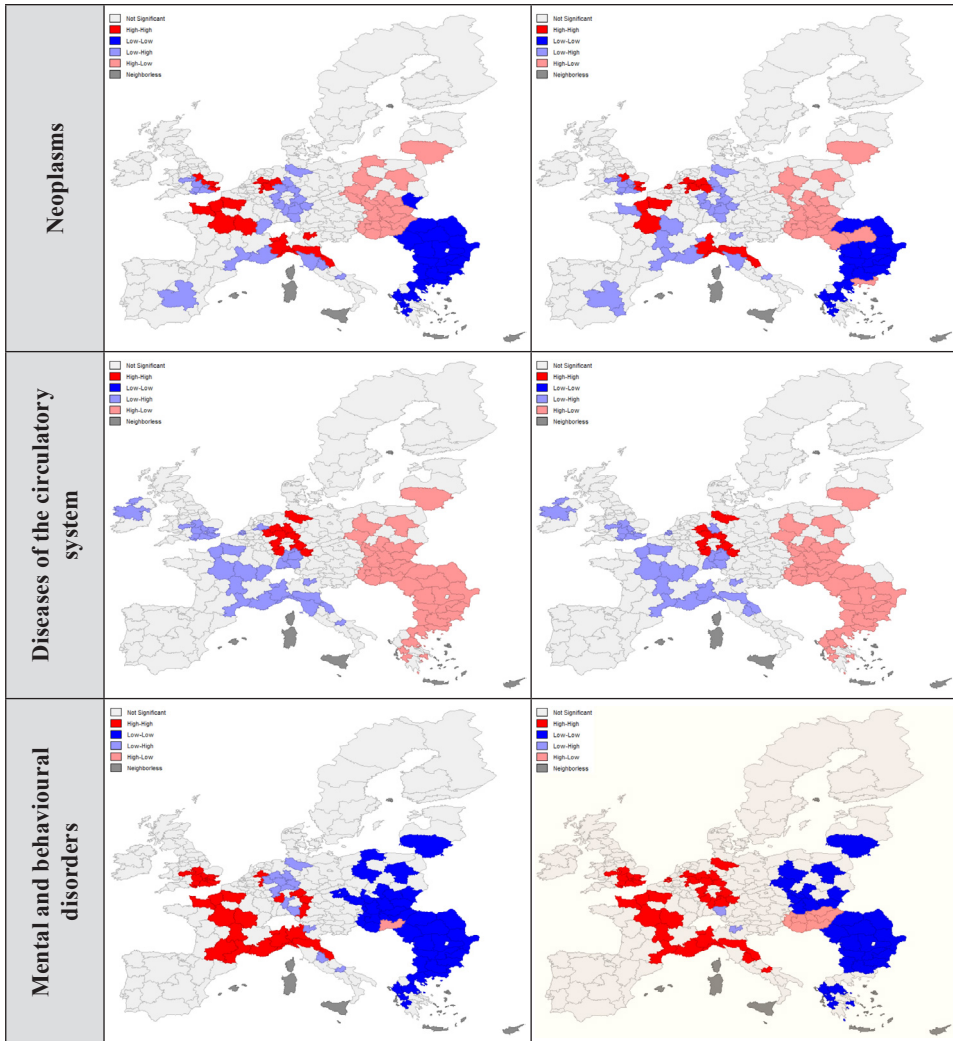
Source: own compilation.

For diabetes Central and Eastern Europe (with Balkans) were a mix of low mortality – low GDP and high mortality – low GDP clusters. In 2008–2010 there were more clusters of high mortality and low GDP rates than in 2003–2005. In Western Europe (UK, Germany, France, and Italy) we can observe small and dispersed clusters of high mortality – high GDP and low mortality – high GDP. Again, over the period of 2003–2005 to 2008–2010 the overall number of clusters decreased, however the mixed groups slowly grew in numbers. Generally, spatial autocorrelation measured by the global Moran's statistic equalled 0.08 in 2003–2005 and –0.02 in 2008–2010, turned out to be very small and with a changing sign. There-

fore, it is difficult to state whether diabetes is a disease of affluence or poverty. However, in Central and Eastern Europe, especially Balkans, there were strong indicators that diabetes mortality rates' distribution had markings of Western diseases. Nevertheless, the pattern changed over the period of analysis, which means that mortality increased faster than economic development in these regions.

The clustering of diseases of the respiratory system was very similar to the diabetes one – in Central and Eastern Europe we observed largely low mortality – low GDP and high mortality – low GDP groups, while in Western Europe we recognised a few high mortality – high GDP and low mortality – high GDP clusters. However, over time, the number of high-high and low-low clusters increased, often replacing the mixed ones. It may mean that, over time, respiratory diseases were turning into a disease of affluence, but mostly in less affluent or poorer regions. Overall Moran's I was low and decreasing with time – for 2003–2005 it was $I = 0.13$ and for 2008–2010 – $I = 0.05$.

In case of neoplasm (cancer) there were two major clusters, fairly stable over the period of analysis: high mortality – low GDP in Central and Eastern Europe and low mortality – low GDP in the Balkan region. This is a unique case among the five illnesses, where Central and Eastern Europe and Balkans are divided and show opposite tendencies. In Western Europe, similarly as for diabetes and respiratory system diseases, some small mixed clusters of high mortality – high GDP and low mortality – low GDP could be spotted for both periods of time. The global spatial autocorrelation showed very weak and negative relation: $I = -0.01$ for 2003–2005 and $I = -0.07$ for 2008–2010, which had marginal effect.

Cardiovascular (or circulatory system) diseases were indicated by three separate and large clusters. Firstly, for Central and Eastern Europe (with Balkans) bivariate LISA indicated high mortality related to low GDP. Secondly, Western Europe (France, Italy, and British Isles) was characterised by low mortality with high GDP. In these two regions cardiovascular illnesses seemed to be diseases of poverty, not affluence. Thirdly, in Germany there were some high mortality – high GDP clusters, where circulatory problems may have been considered as a Western disease. The global Moran's I in 2003–2005 equalled –0.57 and in 2008–2010 –0.54, which was high and negative.

Mental and behavioural disorders showed strong indicators of being diseases of affluence. A large cluster of low mortality – low GDP has formed in Central and Eastern Europe, especially Balkans. It decreased from 2003–2005 to 2008–2010, mainly due to a large part of Hungry turning to high mortality – low GDP. On the other hand in Western Europe (France, UK, and Italy) a high mortality – high GDP clusters could be found. Moreover they increased over time due to low mortality – high GDP in Germany turning into high mortality – high GDP. This, together with a relatively high global Moran's I of 0.42 for 2003–2005 and 0.45 for 2008–2010 is the strongest indicator of diseases of affluence among the five illnesses in question.

5. Conclusions

While analysing and interpreting the data and drawing the conclusions, some mixed and unexpected results arose for four out of the five diseases in questions (excluding mental disorders). This may be attributed partly to two, not strictly statistical, factors. Firstly, it needs to be remembered that the prevalence was measured by death rates, i.e. mortality in the total population. This could not be avoided due to the lack of data. However, in fact, we do not know if the prevalence *sensu stricto*, that is the number of ill people or their fraction in the population, is spatially correlated to the level of economic development. Moreover, we do not know if the mortality among ill people is constant (over time and space) or if it is spatially correlated to GDP levels as well. It may be reasoned that the more developed the region (due to better health care), the lower mortality (among the sick or within the whole population). If so, it can be observed by the mixed relations (high-low, low-high) and in fact could be perceived as a symptom of diseases of poverty, where more people die in poorer and underdeveloped (socioeconomically and also medically) regions. Interloping of small low-low/high-high clusters with mixed groups and the transformation of one into the other over time, proves that the "disease of affluence" is not a fixed distinction forming a constant list of illnesses with constant and fixed distributions over time and space. Secondly, the analysed region of EU is fairly homogeneous in the sense of mortality and economic development, compared to the dispersion in the rest of the world. Therefore, the potential relations may be weaker thus more difficult to find and confirm statistically.

Diabetes, respiratory system diseases, and cancer can be perceived as diseases of affluence in some regions, mainly in the poorer provinces of Central and Eastern Europe. There, lower mortality is the reflection of lower prevalence *sensu stricto*. However, in some neighbouring regions the relation is inversed – low economic development correlates with high mortality. In these regions high death rates might be a result of higher prevalence and/or worse health care. Either way, more attention should be paid to these regions in creating health care policies, as they are in danger of socioeconomic inequality in access to medical aid.

Cardiovascular diseases are perceived as a flagship example of diseases of affluence and yet the outcomes of this research indicate the exact opposite. In the sense of mortality caused by heart problems, it is a strong example of a disease of poverty. Clearly, more people die of heart problems in poorer regions than in more developed ones. Again, we still cannot conclude if (1) the prevalence (number or fraction of ill people within the population) is positively or negatively correlated to GDP, (2) health care in richer states offers a chance for a longer life with a disease, but the fact is, that people are more likely to die of cardiovascular diseases in Central and Eastern Europe than in the Western states.

Mental disorders measured by death rate are surprisingly, strongly and positively correlated to economic development. While these illnesses are themselves quite unique and their mortality (suicides, addiction related deaths, etc.) is not as straight forward as with cancer or cardiovascular diseases, the spatial statistical approach clearly shows that they are a good example of Western diseases. Moreover since the relation is fairly clear in a homogenous region of EU, it can be concluded that in fact this mortality is easily influenced by small changes in economic development.

Overall, it has been proven that high and low mortality of some diseases form statistically significant clusters as well as bivariate clusters with GDP per active population. This confirms the existence of spatial patterns in the epidemiology of the illnesses in question. However, using these patterns to draw definite conclusions about the existence of *diseases of affluence* requires further and more detailed analysis in cooperation with medical and public health experts.

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Rozwój regionalny i epidemiologia chorób cywilizacyjnych w regionach UE

Streszczenie: Choroby cywilizacyjne z definicji charakteryzują się większą zachorowalnością i/lub umieralnością w krajach wysoko rozwiniętych niż w tych mniej rozwiniętych. Dlatego można spotkać się z hipotezą, że to rozwój cywilizacji (bezpośrednio lub pośrednio, przez zmiany w diecie, stylu życia, aktywności fizycznej, stres itp.) stymuluje zachorowalność na pewne choroby (nowotwór, choroby układu krążenia i oddechowego, cukrzyca, choroby psychiczne). Z drugiej strony zasoby finansowe, wykwalifikowany personel medyczny, zastosowanie nowoczesnych rozwiązań technologicznych w krajach bogatszych powinny znaleźć odzwierciedlenie w efektywniejszej prewencji, diagnostyce i leczeniu tych chorób. Unia Europejska – jako całość, jak również poszczególne państwa członkowskie i regiony – uznawana jest za obszar wysoko rozwinięty gospodarczo i społecznie. Czy oznacza to zatem, że jest ona jednorodna pod względem epidemiologii chorób cywilizacyjnych? Czy stosunkowo małe różnice w poziomie ekonomicznego rozwoju regionalnego (w porównaniu z nierównościami światowymi) stanowią istotną determinantę przestrzennego rozkładu chorób cywilizacyjnych? W celu zbadania potencjalnych dyspersji w epidemiologii prawdopodobnych chorób cywilizacyjnych i ich związku z rozwojem regionalnym zastosowano narzędzia statystyki przestrzennej. Badanie obejmuje 261 regionów NUTS 2 UE w latach 2003–2010. Niniejsza analiza może dostarczyć odpowiedzi na pytanie, czy choroby cywilizacyjne istnieją i jaki jest rozkład ich zachorowalności.

Słowa kluczowe: choroby cywilizacyjne, zdrowie, rozwój ekonomiczno-społeczny, analiza przestrzenna

JEL: C46, C38, I14, I15, O18, O57