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The Analysis of the Life Expectancy and the Selected Causes of Deaths in Poland with the Use of Spatial Statistics Methods

Abstract

The goal of the presented research was to test the spatial autocorrelation of the life expectancy and the age-standardized mortality rates for selected causes of death in Poland according to gender in 2010. It was assumed that in the above mentioned cases the positive spatial autocorrelation in populations of men and women appears, and the spatial diversity of mortality depends on the standard of living of the population in question and on the level of industrialization of the region and its consequences. It has been stated that most of the considered coefficients show positive spatial autocorrelation, but differences between populations of men and women were observed. Agricultural capacity of the voivodeship shows positive effect on life expectancy and the level of some of the mortality rates of both genders.

1. Introduction

With the development of the methods of spatial statistics, as well as of the geographic information system (GIS), it became possible to conduct the deepened research on spatial variation of mortality characteristics. The aim of the presented study was to verify the supposition – using the basic spatial statistics methods - whether life expectancy (e_0) and mortality rates from selected causes of deaths in Poland show spatial autocorrelation. The especially

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interesting question was, whether the pattern of spatial autocorrelation was the same for men and women (living in the same country, at the same time). Finally, an attempt was made to find factors possibly influencing the observed spatial differences and spatial autocorrelation patterns of the coefficients taken into account.

2. The applied method

The research was conducted with the use of the basic spatial statistics methods, i.e.:

1. Moran's global statistic *I*, defined as follows (Kopczewska 2006, p.72):

$$I = \frac{n}{\sum_i \sum_j w_{ij}} \cdot \frac{\sum_i \sum_j w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2} \tag{1}$$

where: n – denotes the number of spatial units indexed by i and j (here voivodeships or in the case of life expectancy, also subregions of Poland), y – the considered coefficient, w_{ij} – element of the matrix of spatial weights W, constructed according to numbers of the first order neighbours, row-standardized. Expected value of statistic I is:

$$E(I) = \mu = \frac{-1}{n-1} \tag{2}$$

Assuming that the sample comes from the independent random variables normally distributed, test statistic I_s :

$$I_S = \frac{I - E(I)}{D(I)} \tag{3}$$

is asymptotic normal distributed[1] $N \approx (0,1)$. On this basis the hypothesis $H_o : I = 0$ against the hypothesis $H_1 : I \neq 0$ is tested.

[1] See for instance (Ekonometria przestrzenna 2010, p.109).

Local Moran statistic I_i is defined as:

$$I_i = \frac{(y_i - \bar{y})\sum_i w_{ij}\left(y_j - \bar{y}\right)}{\sum_i (y_i - \bar{y})^2 / n} \qquad (4)$$

with the expected value (Anselin 1995) given by:

$$E(I_i) = \frac{-1}{n-1}\sum_{j=1}^{n} w_{ij}\ . \qquad (5)$$

The local Moran test, based on the conditional randomisation or permutation (see: Anselin 1995), detects the local spatial autocorrelation. There can be two interpretations of the local Moran statistics: as indicators of the local spatial clusters (regions where adjacent areas have similar values) and as a diagnosis for the outliers in global spatial patterns (areas distinct from their neighbours). The Local Moran statistic I_i decomposes Moran's I into contributions for each location:

$$I = \sum_i \frac{I_i}{n} \qquad (6)$$

Additionally the Moran scatterplots and maps were applied. Moran scatterplot allows (Anselin 2005) to explore the global patterns of autocorrelation in space. The graph depicts the standardized variable (here life expectancy or age-standardized mortality rates) in the *x*-axis versus the spatial lag of that standardized variable, where the spatial lag shows the effects of the neighboring spatial units. Moran scatterplot presents the relation of the variable in the location *i* with respect to the values of that variable in the neighboring locations. By construction, the slope of the line in the scatter plot is equivalent to the Moran's *I* statistic. If that slope is positive it means that there is the positive spatial autocorrelation: high values of the variable in location *i* tend to be clustered with high values of the same variable in locations that are neighbors of *i*, and vice versa. If the slope in the scatter plot is negative it means that high values in a variable in location *i* tend to be co-located with lower values in the neighboring locations.

3. Empirical results

The presented research was conducted[2] on the basis of 16 voivodeships of Poland (spatial units NUTS2); in the case of the life expectancy for men and women smaller units (66 subregions, NUTS3) could be taken into account. The data for the year 2010 come from the Chief Statistical Office in Warsaw. All the considered mortality rates were standardized with regard to age. The following variables were subjects of the study for men (m) and women (k): life expectancy in voivodeships (Y_{om},Y_{ok}) and subregions (X_{om},X_{ok}), general mortality rates (Y_{1m},Y_{1k}), cancer mortality rates (Y_{2m},Y_{2k}), circulatory system diseases mortality rates (Y_{3m},Y_{3k}) and respiratory system diseases mortality rates (Y_{4m},Y_{4k}). While circulatory system diseases and cancer were the most frequent causes of death in 2010 in Poland (tab.1), respiratory system diseases were chosen with regard to their specific spatial differences pattern.

Table 2 presents the results of the testing of the hypothesis about the absence of the spatial autocorrelation on the basis of Moran global statistic *I* (as described above). It can be observed that not all of the considered variables show significant spatial autocorrelation.

Table 1. Percent of deaths for chosen causes in Poland, 2010

DISEASE	PERCENT OF DEATHS
Circulatory system	46.0
Cancer	25.4
Respiratory system	5.1

Source: author's own.

As can be observed (fig.1, tab.2) the life expectancy for men in voivodeships does not show spatial autocorrelation – different values of life expectancy are randomly distributed across the country. The shortest life expectancy for men in Poland in the year 2010 was observed in the voivodeship Lodzkie; on the contrary, the longest life expectancy for men was in the voivodeships Malopolskie and Podkarpackie, in the southern part of the country.

[2] For calculation there were used computer programs R and EXCEL, for visualisation – programs EXCEL and Statistica.

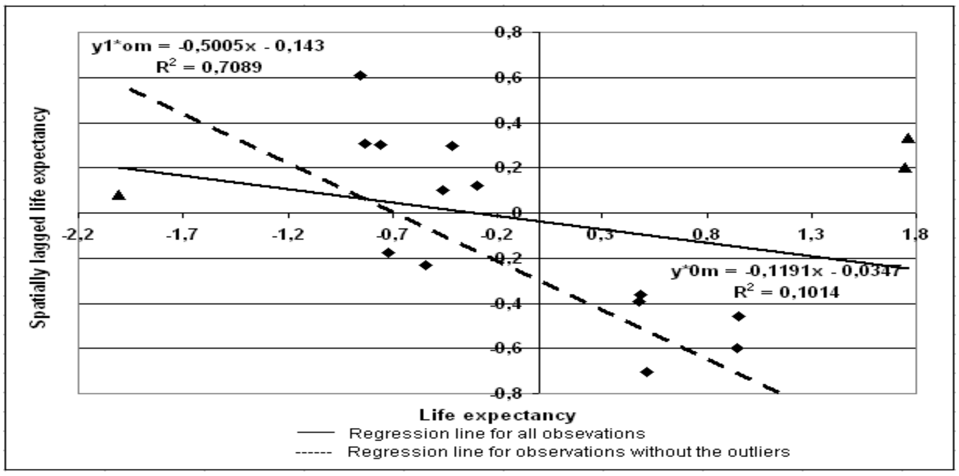
Table 2. Results of testing hypothesis of absence of spatial autocorrelation

COEFFICIENT	MORAN *I* STATISTIC		TEST STATISTIC I_S	
	MEN	WOMEN	MEN	WOMEN
Life expectancy	-0.1191	**0.2771**	-0.6163	**4.0433**
Life expectancy, subregions	**0.4002**	**0.6095**	**4.5198**	**6.7966**
General mortality rates	-0.1311	**0.1908**	-0.7577	**3.0285**
Cancer mortality rates	**0.4194**	**0.4602**	**5.7161**	**6.1962**
Circulatory system diseases mortality rates	-0.0790	**0.1044**	-0.1453	**2.0123**
Respiratory system diseases mortality rates	**0.1901**	**0.2502**	**3.0201**	**3.7268**

Remark: cases of rejected null hypothesis ($\alpha = 0.05$) are marked in bold.

Source: author's own.

Figure 1. Moran plot for life expectancy (e_0), men

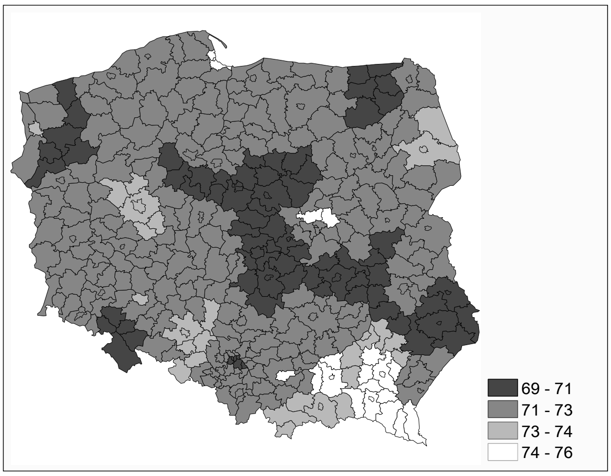


Source: author's own.

However, the theoretical elimination of the three outliers (voivodeships: Lodzkie, Malopolskie, Podkarpackie, marked on fig.1 with black triangles) indicates, that apart from the three voivodeships, the life expectancy for men is characterized by negative spatial autocorrelation (y1*om, dashed line), which means, that in the case of the remaining voivodeships it is revealed that the neighboring values are more dissimilar than expected by chance.

A considerably different pattern emerges from the men life expectancy considerations based on the subregions of Poland (tab.2, fig.2) – here the spatial autocorrelation is more positive than expected at random, which indicates the clustering of similar values across smaller items in geographic space. The longest life expectancy is observed (tab.3) in the big cities: Warsaw, Cracow, subregion trojmiejski containing the cities of Gdansk, Sopot and Gdynia and in the south-eastern corner of Poland (subregions: rzeszowski and tarnowski). The lowest values of men life expectancy can be seen (as in fig.2) in the subregions of the voivodeship Lodzkie, and subregion stargardzki in the northern part of Poland.

Figure 2. Spatial differences in men life expectancy (in years), subregions



Source: author's own.

For women both spatial patterns of life expectancy (the one based on the voivodeships as well as the one based on the subregions), are different than those for men (fig.3 and 4). Apparently the Polish women living, generally speaking, in the eastern part of the country enjoy longer life than the ones living in the westren part. In this case both spatial differences patterns are similar, however the more detailed analysis (subregions) uncovered some significant exceptions: Warsaw, Wroclaw and subregion trojmiejski, but, as indicated in table 3, the longest women life expectancy is observed in the eastern subregions of Poland (and not in the big cities as in the case of men). The shortest women life expectancy was observed in the subregions belonging to the voivodeships: Lodzkie and Slaskie.

A strong positive spatial autocorrelation can be observed for the men and women mortality of cancer (tab.3, fig.5 and 6). Apparently the inhabitants of the north-western part of Poland are more at risk from cancer, and, in the case of women, especially those living in the voivodeship kujawsko-pomorskie. The lowest values, for both genders, can be observed in the eastern part of Poland – with generally much higher level of age-standardized cancer mortality rates in the population of men. For the age-standardized mortality rates for the diseases of the respiratory system the spatial differences pattern as well as the level of positive spatial correlation (tab.3) are similar for both genders, but the voivodeship Warminsko-mazurskie takes the strongly exceptional position (fig.7) – the mortality rates are very high (especially for men). The theoretical elimination of that outlier could change the slope of the regression line in the Moran scatter plot for men from a_1 = 0.1901 to a_2 = 0.6484 (fig.8, y1*4m, dashed line), and for women from a_1 = 0.2502 to a_2 = 0.6762.

Table 3. Subregions of highest and lowest life expectancy (in years) according to gender

HIGHEST LIFE EXPECTANCY, MEN		HIGHEST LIFE EXPECTANCY, WOMEN	
75.3	Warsaw	82.1	bialostocki
75.1	Cracow	82.0	tarnobrzeski
74.6	trojmiejski	81.8	łomzynski
74.4	rzeszowski	81.7	rzeszowski
74.2	tarnowski	81.7	suwalski
LOWEST LIFE EXPECTANCY, MEN		LOWEST LIFE EXPECTANCY, WOMEN	
70.0	lodzki	79.1	grudziadzki
70.0	Lodz	79.1	sosnowiecki
70.0	skierniewicki	79.0	Lodz
70.0	stargardzki	78.8	lodzki
69.9	piotrkowski	78.5	katowicki

Source: author’s own.

Figure 3. Spatial differences in women life expectancy (in years), voivodships

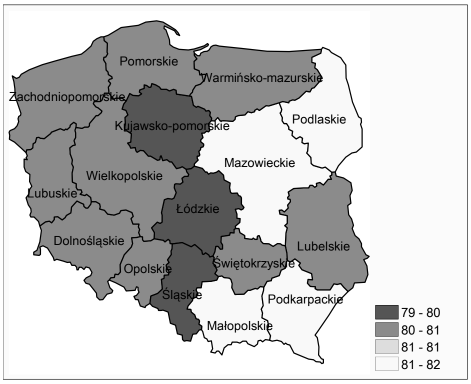
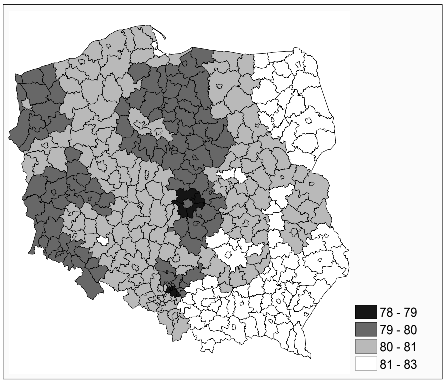


Figure 4. Spatial differences in women life expectancy (in years), subregions



Source: author’s own.

Figure 5. Spatial differences in cancer mortality rates*, men, voivodships

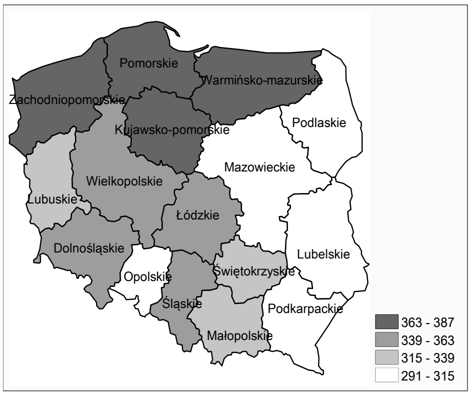
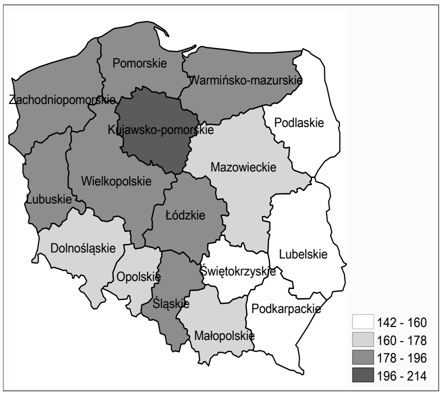


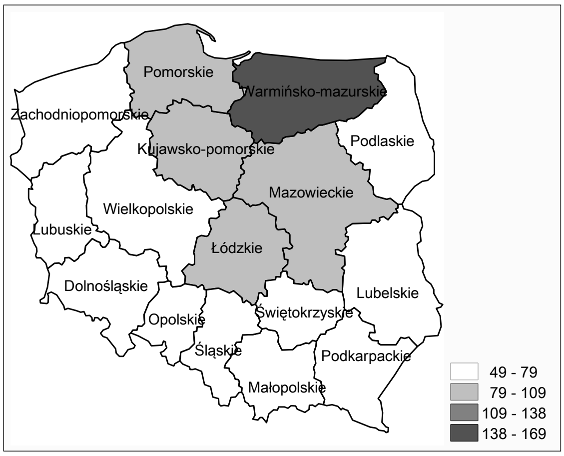
Figure 6. Spatial differences in cancer mortality rates*, women, voivodships



Note: * – per 100 000 population

Source: author's own.

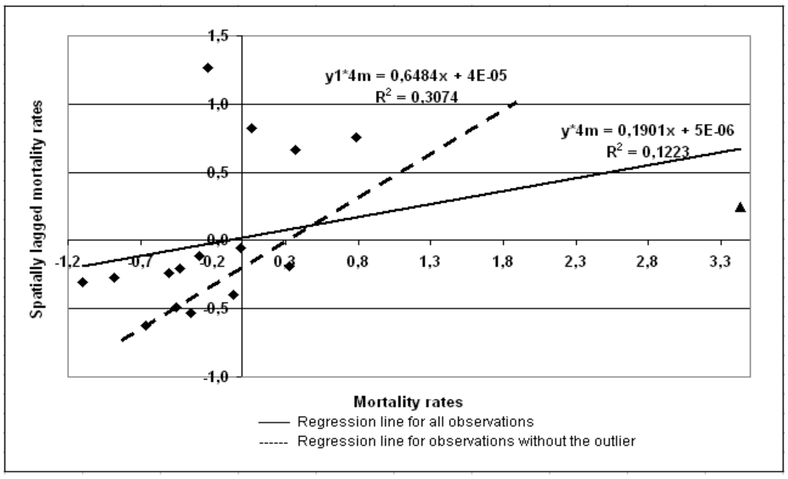
Figure 7. Spatial differences in respiratory diseases mortality rates*, men



* – per 100 000 population

Source: author's own.

Figure 8. Moran plot for respiratory diseases mortality rates, men



Source: author's own.

For women, the positive spatial autocorrelation was observed also for the general mortality rates – the pattern is similar to the one for the life expectancy and for the circulatory system diseases mortality rates, where the women living in the north-eastern part of Poland are in the most favourable position; the highest level of circulatory system diseases mortality rates can be observed in voivodeships: Lodzki, Swietokrzyski, Lubelski – in the central part of the country. In the case of men both adequate global Moran statistics *I* were not significant ($\alpha = 0.05$) though in the case of general mortality rates, similarily, as in the case of life expectancy, this situation is due to the same three outliers.

Table 4 presents the results of the testing of the significance of Local Moran Statistic I_i. Significant ($\beta = 0.9$) negative local statistic occurred only in one case – for men general mortality rates in voivodeship Kujawsko-pomorskie, which is surrounded by voivodeships with lower level of the mortality rates. Most of all the significant positive Local Moran Statistics I_i can be observed in the case of cancer mortality rates for men (Y_{2m}) and women (Y_{2k}) which supports the previous conclusion that in case of cancer clusters of items of similar values of mortality rates are distinctly visible.

The question arises what factors influence the values of the considered coefficients and cause the specific spatial autocorrelation patterns? To look for a possible explanation the set of 16 diagnostic variables was applied. The variables are indicators of factors often associated with the mortality level such as: the standard of living, the health care level, the industrialization and the connected phenomena including air pollution and population density, some stressful social occurrences (unemployment). They were: population per 1 km^2. (Z_1), share of urban population (Z_2), voivodeship revenues per 1 inhabitant (Z_3), voivodeship expenditures for health care per 1 inhabitant (Z_4), district revenues per 1 inhabitant (Z_5), district expenditures per 1 inhabitant (Z_6), district expenditures for education per 1 inhabitant (Z_7), district expenditures for culture per 1 inhabitant (Z_8), district expenditures for health care per 1 inhabitant (Z_9), share of forest land in land area (Z_{10}), sold production of industry per 1 inhabitant (Z_{11}), average monthly wages and salaries (Z_{12}), unemployment rate (Z_{13}), emission of air pollutant particulates per 1 km^2 (Z_{14}), emission of air pollutant sulphur dioxide per 1 km^2 (Z_{15}) and emission of air pollutant nitrogen oxides per 1 km^2 (Z_{16}).

On the basis of the diagnostic variables Z_1-Z_{16} the following synthetic variables were constructed[1]: $V_1 = (Z_1, Z_2)$ – characterizing the demographic features of the voivodeship, $V_2 = (Z_4, Z_9)$ – describing its level of health care, $V_3 = (Z_5, Z_6, Z_7, Z_8)$; the purpose of introducing the variable was to determine the factors influencing the social standard of living, $V_4 = (Z_{14}, Z_{15}, Z_{16})$ – characterizes the level of pollution in the voivodeships.

The coefficients of the correlation between the life expectancy, the above considered mortality rates and the synthetic or the diagnostic variables are presented in table 5.

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[1] In the form of unweighted averages, the values of diagnostic variables Z_j standardized according to formulae: $v_i = \frac{z_i - \bar{z}}{s(z)}$.

Table 4. Local Moran statistics (I_i), test statistics (I_l) and *p-values* for Y_{0m}-Y_{4m} and Y_{0k}-Y_{4k}

VOIVODSHIP	Y_{0m}			Y_{1m}			Y_{2m}			Y_{3m}			Y_{4m}		
	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*
DOLNOSLASKIE	-0.046	0.049	0.480	-0.001	0.154	0.439	-0.135	-0.157	0.562	-0.087	-0.048	0.519	0.227	0.843	0.200
KUJAWSKO-POMORSKIE	-0.364	-0.932	0.824	**-0.521**	**-1.423**	**0.923**	-0.144	-0.240	0.595	-0.249	-0.571	0.716	0.252	1.113	0.133
LODZKIE	-0.036	0.097	0.461	-0.035	0.100	0.460	**0.469**	**1.662**	**0.048**	0.225	0.910	0.181	0.037	0.362	0.359
LUBELSKIE	-0.123	-0.110	0.544	-0.091	-0.048	0.519	-0.020	0.090	0.464	-0.085	-0.037	0.515	0.410	1.189	0.117
LUBUSKIE	0.127	0.529	0.298	0.154	0.605	0.273	**0.929**	**2.689**	**0.004**	-0.238	-0.467	0.680	**0.603**	**2.144**	**0.016**
MALOPOLSKIE	-0.521	-1.066	0.857	-0.546	-1.129	0.870	**1.096**	**2.688**	**0.004**	-0.180	-0.266	0.605	0.000	0.192	0.424
MAZOWIECKIE	-0.157	-0.282	0.611	-0.236	-0.530	0.702	0.018	0.262	0.397	-0.010	0.177	0.430	-0.064	0.009	0.496
OPOLSKIE	0.583	1.269	0.102	**0.623**	**1.353**	**0.088**	0.539	1.165	0.122	-0.361	-0.573	0.717	0.251	0.792	0.214
PODKARPACKIE	-0.437	-0.867	0.807	-0.620	-1.301	0.903	**1.316**	**3.196**	**0.001**	0.148	0.503	0.307	0.059	0.361	0.359
PODLASKIE	0.125	0.374	0.354	0.198	0.520	0.301	-0.024	0.081	0.468	0.129	0.381	0.351	0.183	0.623	0.267
POMORSKIE	-0.176	-0.388	0.651	-0.015	0.182	0.428	**0.434**	**1.770**	**0.038**	-0.229	-0.576	0.718	0.085	0.571	0.284
SLASKIE	-0.565	-1.169	0.879	-0.628	-1.320	0.907	-0.426	-0.831	0.797	0.009	0.176	0.430	0.333	1.149	0.125
SWIETOKRZYSKIE	0.354	0.821	0.206	0.285	0.690	0.245	**1.408**	**2.835**	**0.002**	0.090	0.305	0.380	0.032	0.247	0.402
WARMINSKO-MAZURSKIE	-0.256	-0.443	0.671	-0.294	-0.535	0.704	0.312	0.875	0.191	**0.484**	**1.288**	**0.099**	**0.866**	**2.678**	**0.004**
WIELKOPOLSKIE	-0.185	-0.232	0.592	-0.167	-0.198	0.578	0.243	0.596	0.276	-0.160	-0.182	0.572	-0.296	-0.572	0.716
ZACHODNIOPOMORSKIE	-0.228	-0.315	0.624	-0.210	-0.282	0.611	**0.663**	**1.404**	**0.080**	-0.759	-1.350	0.911	0.117	0.458	0.323

VOIVODSHIP	Y_{0k}			Y_{1k}			Y_{2k}			Y_{3k}			Y_{4k}		
	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*	I_i	I_l	*p-value*
DOLNOSLASKIE	0.062	0.300	0.382	0.173	0.562	0.287	-0.319	-0.586	0.721	0.191	0.598	0.275	0.265	0.928	0.177
KUJAWSKO-POMORSKIE	-0.017	0.156	0.438	-0.116	-0.154	0.561	0.008	0.231	0.409	-0.311	-0.761	0.777	0.287	1.221	0.111
LODZKIE	0.091	0.491	0.312	0.008	0.235	0.407	**0.547**	**1.912**	**0.028**	**0.413**	**1.495**	**0.067**	0.132	0.686	0.246
LUBELSKIE	0.199	0.516	0.303	0.097	0.320	0.375	-0.013	0.103	0.459	-0.037	0.058	0.477	0.406	1.143	0.127
LUBUSKIE	0.264	0.898	0.185	0.265	0.906	0.182	**1.018**	**2.944**	**0.002**	-0.465	-1.082	0.860	**0.697**	**2.398**	**0.008**
MALOPOLSKIE	**0.642**	**1.654**	**0.049**	0.264	0.777	0.219	**1.560**	**3.784**	**0.000**	0.018	0.197	0.422	0.055	0.341	0.367
MAZOWIECKIE	**0.440**	**1.582**	**0.057**	**0.618**	**2.143**	**0.016**	0.073	0.436	0.331	0.252	0.994	0.160	-0.017	0.172	0.432
OPOLSKIE	0.361	0.831	0.203	0.201	0.523	0.300	0.289	0.689	0.245	-0.647	-1.125	0.870	0.373	1.064	0.144
PODKARPACKIE	-0.141	-0.174	0.569	-0.330	-0.619	0.732	**0.880**	**2.203**	**0.014**	**0.648**	**1.664**	**0.048**	**0.400**	**1.306**	**0.096**
PODLASKIE	0.365	0.838	0.201	0.302	0.722	0.235	0.306	0.721	0.235	-0.001	0.126	0.450	0.146	0.514	0.304
POMORSKIE	0.105	0.609	0.271	0.238	1.082	0.140	**0.341**	**1.445**	**0.074**	-0.141	-0.263	0.604	0.039	0.393	0.347
SLASKIE	0.177	0.569	0.285	-0.138	-0.167	0.566	-0.250	-0.425	0.665	0.127	0.451	0.326	0.298	1.023	0.153
SWIETOKRZYSKIE	**1.239**	**2.536**	**0.006**	**0.773**	**1.644**	**0.050**	**1.784**	**3.585**	**0.000**	0.323	0.754	0.225	0.038	0.254	0.400
WARMINSKO-MAZURSKIE	-0.113	-0.109	0.543	0.018	0.200	0.421	0.341	0.947	0.172	**1.034**	**2.560**	**0.005**	**1.280**	**3.771**	**0.000**
WIELKOPOLSKIE	**0.594**	**1.283**	**0.100**	0.609	**1.322**	**0.093**	0.242	0.598	0.275	0.352	0.810	0.209	-0.467	-0.968	0.833
ZACHODNIOPOMORSKIE	0.167	0.453	0.325	0.101	0.328	0.371	0.577	1.247	0.106	-0.063	0.007	0.497	0.016	0.200	0.421

Remark: Bold denotes significant values of statistic I_l ($\beta = 0.1$, $1\text{-}\beta = 0.9$).

Source: author's own.

The most important factors determining the life expectancy and the mortality pattern in the voivodeships of Poland seem to be the ones connected with the agricultural character of the voivodeship (Z_{10}, V_1) – less industry (Z_{11}) and its consequences (population density, share of urban population) respond to the more favourable values of the mortality characteristics of the voivodeships; on the contrary the factors contributing to the affluence of a voivodeship are positively correlated with some of the mortality rates and negatively with the life expectancy for men. The life expectancy for women and some kinds of their mortality rates are sensitive to pollution (V_4) – the more polluted the voivodeship the less favourable the women mortality characteristics. Some of the both genders mortality rates are positively correlated with the unemployment rate, which seems to be an important factor determining the mortality pattern, and the average wages and salaries are, at least in the profile of the voivodeships, not important. The above remarks can be indicators for the directions of the more detailed analysis of the mortality patterns in Poland and the factors influencing them.

Table 5. Correlation between coefficients Y_{0m}-Y_{4m}, Y_{0k}-Y_{4k}, synthetic variables V_1-V_4 and diagnostic variables Z_{10} –Z_{13}

VARIABLES	COEFFICIENTS OF CORRELATION r(Y,V), r(Y,Z):	
MEN	POSITIVE VALUES	NEGATIVE VALUES
Y_{0m}	Z_{10}(0.57)	V_3(-0.4)
Y_{1m}	V_3(0.41)	Z_{10}(-0.48)
Y_{2m}	V_1(0.32). Z_{13}(0.31). V_3(0.41)	Z_{10}(-0.38)
Y_{3m}	Z_{13}(0.33)	-
Y_{4m}	V_3(0.59). Z_{13}(0.54)	-
WOMEN	POSITIVE VALUES	NEGATIVE VALUES
Y_{0k}	Z_{10}(0.40)	V_1(-0.51). V_4(-0.42)
Y_{1k}	V_1(0.44). V_4(0.41)	Z_{10}(-0.39)
Y_{2k}	V_1(0.48). Z_{11}(0.44)	Z_{10}(-0.35)
Y_{3k}	-	-
Y_{4k}	V_3(0.61). Z_{13}(0.56)	-

Remark: For 16 observations coefficient of correlation is significant (according to *t*-Student's test) beginning from the value r^* : □ = 0.05, r^* = 0.50; □ = 0.1, r^* = 0.42; □ = 0.2, r^* = 0.33.

Source: author's own.

4. Conclusions

1. The selected causes of death as well as the life expectancy in most cases show the positive spatial autocorrelation, which may indicate that there are some common determinants of their level in bigger parts of the country.
2. In many cases the spatial autocorrelation pattern is different for men and women, which means that there are some special determinants of the level of the discussed coefficients, apart from coming out from the geographical position of the items.
3. In the author's opinion special attention should be paid to the outliers (identified with use of Moran's scatter plots as well as with Moran's local statistic *Ii*), because the differences (e.g. socio-economic) among the outliers and their surroundings may explain their causes. The occurrence of the outliers may also strongly influence the spatial correlation pattern of the considered variable.
4. The results of the study could be applied in the process of formulating the social policy within the scope of the population's health.

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Streszczenie

BADANIE DŁUGOŚCI ŻYCIA ORAZ WYBRANYCH PRZYCZYN ZGONÓW W POLSCE Z ZASTOSOWANIEM METOD STATYSTYKI PRZESTRZENNEJ

Celem prezentowanego badania było testowanie hipotezy o braku autokorelacji przestrzennej w odniesieniu do przeciętnego dalszego trwania życia oraz standaryzowanych ze względu na wiek współczynników zgonów dla wybranych przyczyn zgonów w Polsce według płci w 2010 r. Przypuszczano, że w wyżej wymienionych przypadkach występuje dodatnia autokorelacja przestrzenna w populacjach mężczyzn i kobiet oraz, że przestrzenne zróżnicowanie umieralności zależy od poziomu życia danej populacji i stopnia industrializacji regionu i jej konsekwencji. Okazało się, że większość z rozważanych współczynników wykazuje dodatnią autokorelację przestrzenną; zaobserwowano też różnice między populacjami mężczyzn i kobiet. Rolniczy charakter województwa wykazuje pozytywne oddziaływanie na przeciętne dalsze trwanie życia i wartości niektórych współczynników zgonów dla obu płci.