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Spatial convergence of mortality in Poland

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Abstract. Aim. The aim is to observe whether there is a territorial similarity of changes in mortality due to selected causes in Poland in the years 2002–2017. Convergence models were used to verify the hypothesis that, since Poland's accession to the EU, the country has seen a spatial convergence of mortality due to major causes of death.
Results and conclusion. The country's provinces have been homogenising in terms of death intensity levels evening out for the majority of examined groups of causes. This is indicated by the confirmed absolute beta-convergence for most variables, including the two major causes of death: I00–I99 and C00–D48. However, a confirmation of beta-convergence does not always apply to both a broader and a narrower group of causes. In turn, sigma-divergence of mortality due to most of the examined causes in Poland's provinces indicates increasing variation in the years 2002–2017, which means that the provinces were not becoming similar. Such findings indicate that the formulated hypothesis has not been confirmed.

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1. Introduction

Analysis of changes in population processes in various communities shows that, frequently, their trajectory becomes increasingly similar over time (Wilson, 2011). The changes generalise the demographic transition theories that characterise both the first and second demographic transitions. The first demographic transition describes dropping death and fertility rates, initially accompanied by a growing natural increase rate, then followed by a drop. Over time, the direction and pace of changes in birth and death rates began to converge in a growing number of countries (Chesnais, 1986). In most countries in which the first demographic transition had ended, the expected stabilisation of mortality and fertility was disturbed in the 1960s. The new transformations, referred to as the "second demographic transition", consisted in, for instance, falling birth rates and a further decrease in mortality, leading to longer life spans. This character and direction of population process transformations suggested that countries with a high death intensity would follow those in which mortality is lower and, consequently, the length of life in various communities would be evening out. Thus, convergence would be taking place.

The concept of convergence was at the core of demographic transition theory. Palloni (1981) formulated a thesis that changes in mortality are irreversible and have the same directions in various populations, which results in any differences between them being blurred. The point of reference in studying convergence of mortality was epidemiological transition theory (Omran, 1971), which explains long-term changes in morbidity and mortality patterns. Despite criticism, Vallin and Meslé integrated the theory (2004) as the first stage of the global health transformation process. Although in the first half of the 20th century no formal attempts were made to verify the concept of convergence (Wilson, 2001), in the 21st century, studies on countries in Europe, North America and Latin America have been conducted using, for instance, convergence models. The following variables have been used in the studies: life expectancy at birth, infant mortality, and standardised death rates by sex and age. The results of research into convergence of mortality have differed. Spinakis et al. (2011) found divergence of mortality of elderly persons in 27 European Union countries in the years 1997–2008. Alvarez, Aburto and Canudas-Romo (2020) proved the existence of regional differences in infant life expectancy in 20 Latin American countries in the years 2000–2014.

Vallin and Meslé (2004) showed that the appearance of new health threats (e.g. AIDS) and the introduction of new, expensive medical technologies caused changes in death intensity in developing countries not to follow the path of highly developed countries. The similarity of previously observed changes in length of life was stopped. McMichael et al. (2004) argued, showing diversified changes in the length of life in countries on various continents, that future health benefits are not guaranteed by the determinism of the convergence process, and that increased heterogeneity of changes in the mortality process in different populations should be expected. Mackenbach et al. (2017) showed that the disproportions in mortality in 17 European countries in the years 1970–2010 resulted from a diversified impact of behavioural risk factors (tobacco smoking, excessive alcohol consumption) and social factors (poverty, national economic, political and cultural conditions).

The observable discrepancies in mortality changes in different countries drew attention to studies into regional convergence, especially NUTS2 and NUTS3. Gächter and Theurl (2011) analysed the similarity of changes in the state of health in the federated states of Austria, which is a relatively homogenous country. The state of health was expressed by means of standardised death rates. After analysing changes in total death intensity and death intensity by sex, the authors confirmed the occurrence of beta-convergence of mortality rates between examined populations. One of the possible reasons for the changes they identified was the federal government's efforts aimed at the country's harmonious development.

For much of the 20th century, Poland's changes in mortality were highly unsatisfactory, and there were periods in which death intensity was in fact growing. The process was also significantly territorially differentiated (Pułaska-Turyna, 1990; Wojtyniak & Goryński, 2018). Since Poland's accession to the EU, the central government and local self-governments

have had funds at their disposal for evening out differences in the regions' socio-economic situation. The goal of the study presented here was to find out whether the steps taken in recent years, which have been partly financed by EU funds, have contributed, as intended, to eliminating the differences. In connection with the above, the following hypothesis was formulated: in Poland, since its accession to the EU, there has occurred a spatial convergence in mortality due to major causes of death.

2. Research materials and methods

Similarities in changes in mortality in Poland were analysed based on standardised death rates in individual provinces (voivodeships). Death intensity was measured using rates characterising deaths due to selected causes. In Poland, as in many countries, the most common causes of death include (relevant International Statistical Classifications of Diseases and Related Health Problems (ICD-10) are given in parentheses): neoplasms (C00–D48), diseases of the circulatory system (I00–I99), diseases of the respiratory system (J00–J99), diseases of the digestive system (K00–K93) and external causes of death (V01–Y89). In 2018, those caused 82.7% of all deaths. Within those broad groups of causes, the impact of individual diseases differs. To evaluate mortality convergence or divergence, the diseases causing most deaths in each group were selected. The circulatory system diseases included: ischaemic heart diseases (I20–I25), cerebrovascular diseases (I60–I69); and neoplasms included: malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal (C18–C21), malignant neoplasm of stomach (C16), malignant neoplasm of trachea, bronchus and lung (C33, C34). The most common causes of death were: among the respiratory system diseases – chronic lower respiratory diseases (J40–J47) and pneumonia (J12–J18); and among the digestive system diseases – chronic liver disease (K70, K73, K74). As regards external causes of death and poisonings, mortality due to the following causes was analysed: transport accidents (V01–V99, Y85) and intentional self-harm (X60–X84, Y870).

For the listed 15 causes of death (broad and narrow groups of causes), data about standardised death rates were collected for Poland's 16 provinces in the years 2002–2017. In the case of mortality caused by C33–C34, the data covered the years 2007–2017. The data came from the Eurostat database (2020a; 2020b), in which Europe's population structure was used for standardisation. The rate values for the years 2002–2010 were smoothed using a moving average, whereas the values for the period 2011–2017 were not. Despite the different ways of presenting the death rates, it was decided to use both sets of data, recognising that the smoothing of values only eliminates the impact of accidental fluctuations on regularities observed over time. The missing death rates for the examined causes for six provinces for the years 2011 and 2012 were supplemented by linear interpolation.

Figures 1 and 2 show standardised death rates due to five groups of death causes in the years 2002 and 2017, respectively. The provinces were divided into quartile groups in the two years. An examination of the maps indicates that there were significant changes in the intensity of deaths due to the selected groups of causes between 2017 and 2002 in a few cases. Only in the case of diseases of the circulatory system did Podkarpackie province move from the fourth quartile group in 2002 to the first in 2017, which reflects a significant improvement in the situation in the area. A similar improvement is visible in the case of Lubuskie and Świętokrzyskie provinces as regards mortality due to diseases of the respiratory system. In the other cases, 2017 as compared with 2002 saw smaller changes in death intensity, or there was no change in the relative position of a given province (belongingness to a specific quartile group) in the studied community.

A comparison of the values of the measures of death intensity in the extreme years of the period in question indicates that their inter-province variation decreased most for the causes responsible for the biggest number of deaths. The range, i.e. the difference between the units with the highest and smallest mortality, decreased by nearly a half for respiratory diseases and by a third for neoplasms (Table 1). The falling variation was accompanied by a drop in death intensity due to the diseases. The opposite is true for diseases of the respiratory system. The variation in standardised death rates fell, while values in 2017 as compared with 2002 rose. For diseases of the digestive system and external causes, the variation in death intensity in

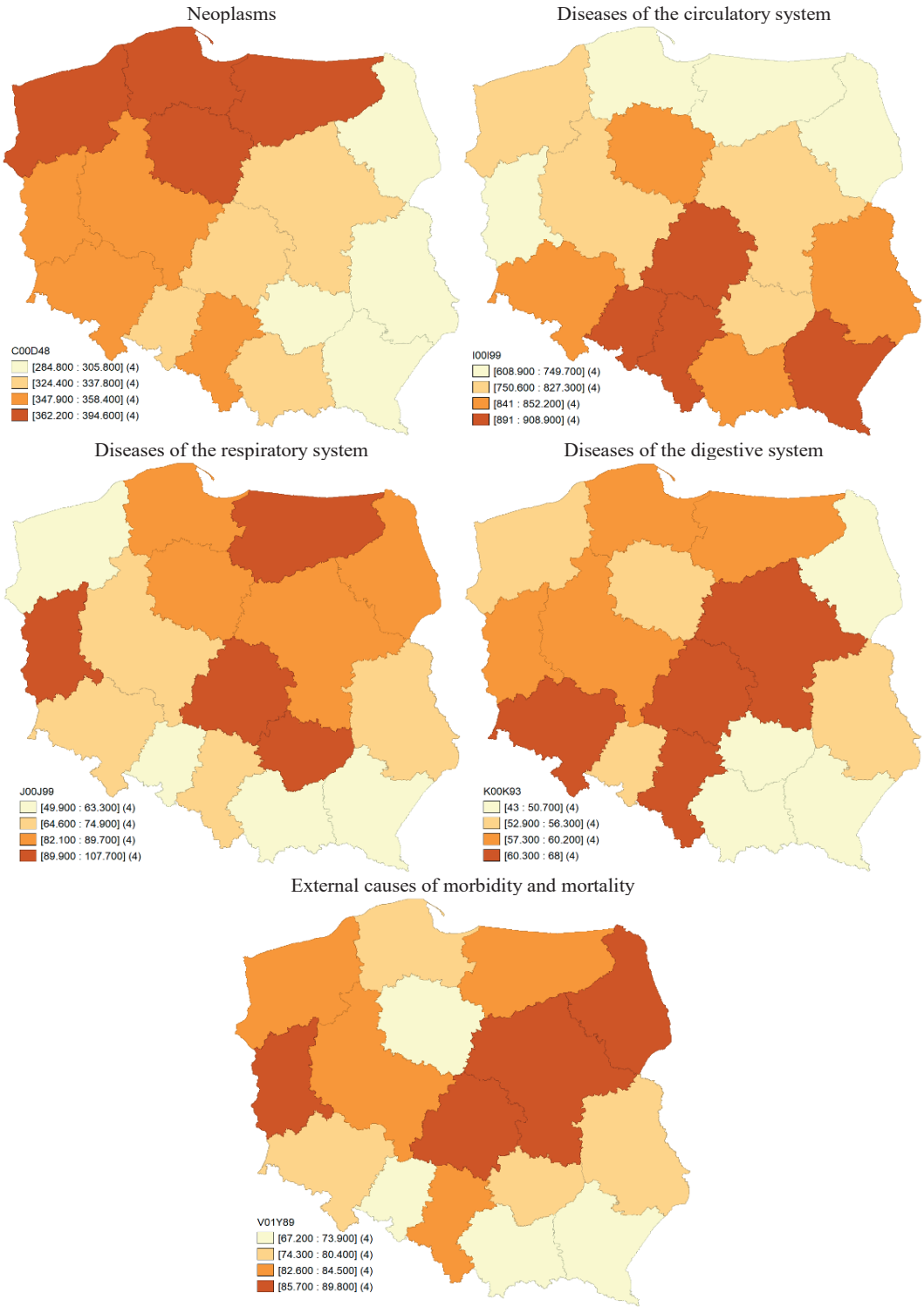

Fig. 1. Standardised death rates by selected causes in Poland's provinces in 2002
Source: own work based on acquired data (Eurostat 2020a)

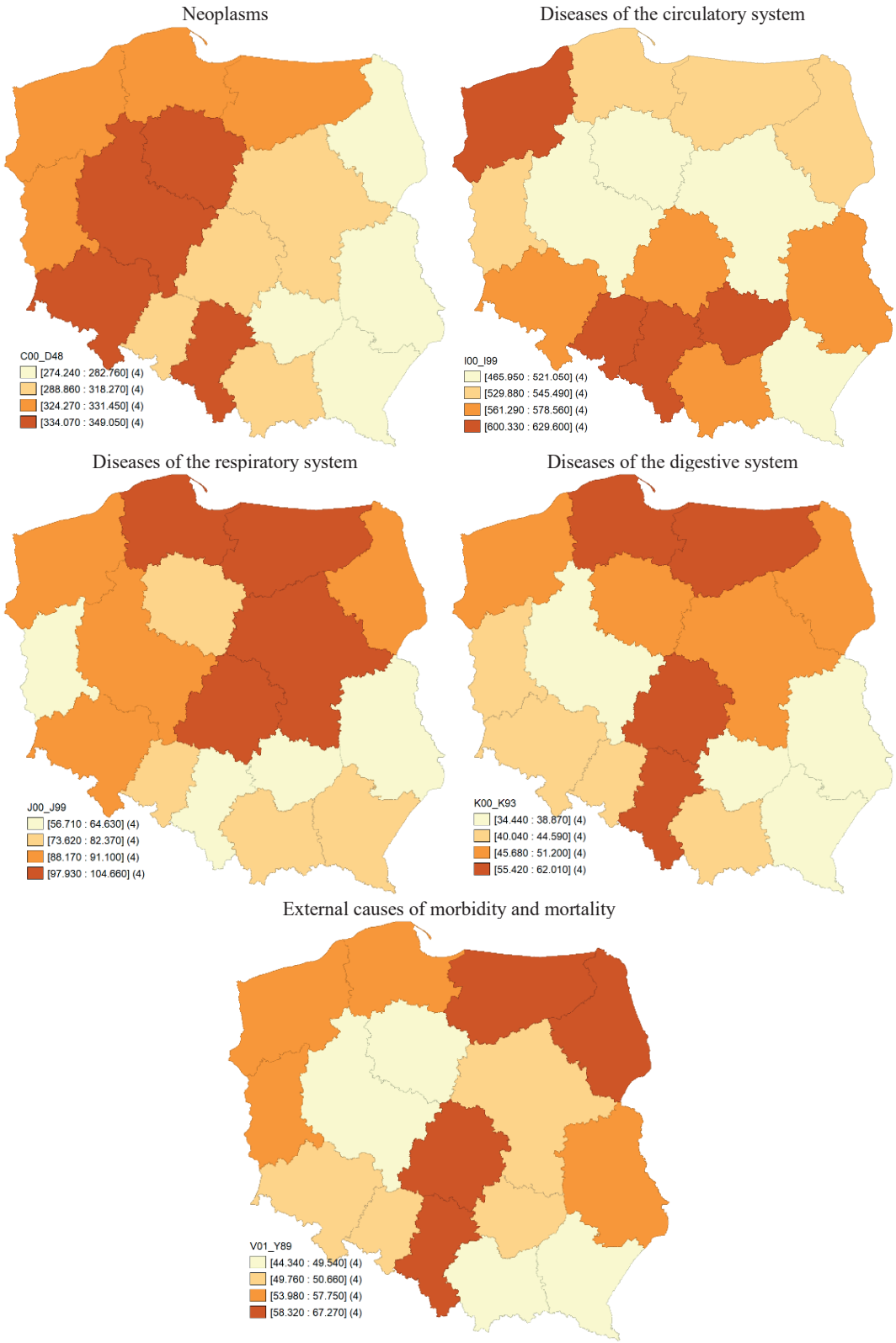

Fig. 2. Standardised death rates by selected causes in Poland's provinces in 2017
Source: own work based on acquired data (Eurostat 2020b)

the provinces increased in 2017 in comparison with 2002.

Changes in the ranges of rates of death due to a given group of causes do not mean that the variation in mortality due to individual causes was changing in the same way. Indices of range dynamics for the major individual causes of death show that, in the selected groups of causes, the variation measured by the range changed in various directions, e.g. in the I00–I99 group of causes the variation of mortality due to cerebrovascular diseases I60–I69 dropped significantly, while it grew for ischaemic heart diseases I20–I25.

To examine similarities of spatial mortality changes, the absolute beta- and sigma-convergence models were used (Barro, Sala-i-Martin, 1992; Boyle, McCarthy, 1997; Sala-i-Martin, 1996). This analysis method has been and is primarily used to investigate the similarity of changes in economic phenomena, but it is also applied in investigating demographic processes (Krupowicz & Kuropka, 2019). Where beta-convergence was found to occur, the character of the observed changes was identified. In was then indicated which provinces had been catching up or falling behind, and which had been distancing themselves or marginalising, approaching the value of the analysed variable.

Absolute beta-convergence was verified by means of a cross-sectional regression model in the form:

$$\ln\left(\frac{y_{iT}}{y_{i0}}\right) = a + b \cdot \ln\left(y_{i0}\right), \qquad (1)$$

where:

$\ln\left(\frac{y_{iT}}{y_{i0}}\right)$ – tempo of changes in the examined variable between final and initial study periods; y_{iT} – value of studied variable in final period of analysis; y_{i0}– value of studied variable in initial period of analysis; a, b – model parameters; i – object of study, i = 1, …, N.

The model parameters (1) were estimated by least squares method (LSM). The significance of the parameter b was examined by Student's t-test. A statistically significant negative value of the parameter b means the existence of beta-convergence. In turn, a statistically significant positive value of the parameter indicates the existence of beta-divergence.

Table 1. Range of standardised death rates by selected groups of causes in Poland's provinces, 2002 and 2017

Causes of death	2002	2017	Dynamics 2002 = 100
Neoplasms C00–D48	109.8	74.8	**68.1%**
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	14.5	12.8	88.3%
Malignant neoplasm of stomach C16	9.2	7.3	79.3%
Malignant neoplasm of trachea, bronchus and lung C33, C34	29.1	34.9	119.9%
Diseases of the circulatory system I00–I99	300.0	163.7	**54.6%**
Ischaemic heart diseases I20–I25	171.1	240.1	140.3%
Cerebrovascular diseases I60–I69	91.6	33.0	36.0%
Diseases of the respiratory system J00–J99	57.8	48.0	**83.0%**
Chronic lower respiratory diseases J40–J47	24.8	20.4	82.3%
Pneumonia J12–J18	40.2	40.2	100.0%
Diseases of the digestive system K00–K93	25.0	27.6	**110.4%**
Chronic liver disease K70, K73, K74	13.3	13.0	97.7%
External causes of morbidity and mortality V01–Y89	22.6	22.9	**101.3%**
Transport accidents V01–V99, Y85	10.2	5.4	52.9%
Intentional self-harm X60–X84, Y870	8.2	11.4	139.0%

Source: own calculations based on acquired data (Eurostat 2020a; 2020b)

Based on the parameter b from the model (1), the rate of convergence β was determined as follows:

$$\beta = \frac{-\ln(1+b)}{T} \quad (2)$$

where: T – interval between final and initial periods of analysis.

A positive value of the rate β indicates convergence and specifies its medium-period tempo of change (expressed as a percentage).

Based on the regression model of variation measure over time, sigma-convergence was verified as follows (Friedman, 1992):

$$v_t = a + b \cdot t \quad (3)$$

where: v_t– coefficient of variation of the logarithms of the examined variable in period t; a, b – model parameters; t – study period, $t = 1, \ldots, n$.

The parameters of the model (3) were also estimated using LSM. The significance of the parameter b was examined by Student's t-test. A negative, statistically significant value of the parameter attests to sigma-convergence. On the other hand, a positive and statistically significant value indicates sigma-divergence.

Sigma-convergence (or divergence) was subject to confirmation by the variance change test. Where sigma-convergence was suspected, the significance of the variance drop in the initial and final periods was tested. On the other hand, a supposed occurrence of sigma-divergence was tested by checking the significance of variance growth in the compared periods.

A test of the significance of the parameter b in the model (3) of sigma-convergence provides information about changes in the variation of the variable values in the examined period or time, while the test of variance changes only checks the significance of such changes in the extreme (initial and final) periods. Conclusions as to the occurrence of convergence (divergence) may be ambiguous where tests are contradictory.

3. Results

3.1 Absolute beta-convergence

Using data regarding standardised death rates by selected groups of causes in Poland's provinces, models were constructed (1). The results of estimation of the model parameters and their verification with Student's t-test are presented in Table 2. The obtained values of the parameter b in the absolute beta-convergence models were negative, except for the model for mortality due to diseases of the digestive system (Table 2). At the significance level of 0.05 (or 0.1), it may be claimed that the parameters significantly differed from zero, which indicates the existence of this type of convergence of death rates in 10 of the 15 considered groups of causes. This means that in the year 2017, as compared with 2002, the intensities of deaths due to such causes in the provinces evened out, resulting in the units becoming more similar to one another in terms of mortality (especially the two major causes of death: diseases of the circulatory system and neoplasms). Confirmation of beta-convergence for a broad group of causes does not always amount to the occurrence of convergence for individual causes of death, and vice versa. In the case of I00–I99, the convergence regarded the entire group and the major causes of death from this group, i.e. I20–I25 and I60–I69. By contrast, convergence was confirmed for the entire groups C00–D48 and J00–J99 but this only applied to one of the major causes in the groups (C18–C21 and J12–J18, respectively). Absolute beta-convergence for mortality due to external causes of morbidity and mortality or due to J40–J47, C16, C33–C34 was not confirmed. There is also no confirmation of beta-divergence of mortality due to diseases of the digestive system; the positive parameter b was statistically insignificant.

The tempo of convergence of mortality by cause, as defined by the coefficient of convergence β in the study period in Poland's provinces, varied (Table 2). The intensity of deaths that was evening out fastest was that due to diseases of the respiratory system (16.2%). There was a high tempo of convergence for mortality due to cerebrovascular diseases (16.0%).

However, in most provinces (10), the mortality due to J00–J99 rose, so the high value of the coefficient β means that the situation deteriorated. The tempo of convergence of mortality due to neoplasms was one of the lowest (1.6%). An analysis of the obtained model parameters means that Poland's provinces were becoming alike in terms of the mortality rate from the perspective of most of the examined groups of causes, although if death rates grow in most of the provinces this convergence is not a desirable change.

3.2 Identification of the nature of convergence

To identify the nature of the convergence between provinces' changes in mortality by cause, the examined units were divided into groups. The groupings were determined according to the value of the variable (cause-specific death rates) in a given province in the year 2002 and the dynamics of the changes in the examined variable in the period 2002–2017 relative to mean values. The mean values were calculated as the coefficients of the centre of gravity of the model (1). Convergence may consist in catching up or falling behind, while divergence can consist in marginalising or distancing. The results of the grouping for the ten variables with a confirmed beta-convergence are presented in Table 3.

The conducted classification indicates that, in the years 2002–2017, in most of Poland's provinces, mortality by the selected causes was subject to slowing-down or catching-up convergence. The convergence of mortality due to diseases of the circulatory system was of the slowing-down nature in seven provinces (Dolnośląskie, Kujawsko-pomorskie, Łódzkie, Małopolskie, Podkarpackie, Śląskie and Wielkopolskie). In those provinces with above-average mortality, the tempo of change in intensity of deaths was below average. In four

Table 2. Parameters of models of absolute beta-convergence of mortality by selected causes in Poland's provinces, 2002–2017

Causes of death	Model parameters			β coefficient
	b	*a*	R^2	
Neoplasms C00–D48	-0.2111 **	1.1489	0.2013	1.6%
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	-0.3720 **	1.3633	0.3263	3.1%
Malignant neoplasm of stomach C16	-0.2196	0.1815	0.0314	1.7%
Malignant neoplasm of trachea, bronchus and lung C33, C34	-0.0834	0.3263	0.0146	0.9%
Diseases of the circulatory system I00–I99	-0.7308 **	4.5076	0.4715	8.7%
Ischaemic heart diseases I20–I25	-0.8508 **	4.0945	0.2580	12.7%
Cerebrovascular diseases I60–I69	-0.9096 **	4.0962	0.5705	16.0%
Diseases of the respiratory system J00–J99	-0.9121 **	4.0201	0.5310	16.2%
Chronic lower respiratory diseases J40–J47	-0.1208	0.0432	0.0071	0.9%
Pneumonia J12–J18	-0.6958 **	2.8055	0.5659	7.9%
Diseases of the digestive system K00–K93	0.0836	-0.5278	0.0055	-0.5%
Chronic liver disease K70, K73, K74	-0.5006 **	1.4946	0.3508	4.6%
External causes of morbidity and mortality V01–Y89	-0.2548	0.7199	0.0716	2.0%
Transport accidents V01–V99, Y85	-0.5261 **	0.8408	0.1936	5.0%
Intentional self-harm X60–X84, Y870	-0.8194 *	1.9579	0.1457	11.4%

Explanation: ** – statistically significant at α = 0.05; * – statistically significant at α = 0.1
Source: own calculations based on acquired data (Eurostat 2020a; 2020b)

provinces (Lubuskie, Podlaskie, Pomorskie and Warmińsko-mazurskie), the mortality due to I00–I99 had the catching-up nature. In those administrative units with below-average death intensity, the tempo of change in mortality was above average.

It was only in the case of mortality due to neoplasms that distancing or marginalising divergence occurred. This individual divergence does not match the convergence confirmed with model (1). The parameter *b* (although negative and statistically significant) is relatively close to zero. Thus, the convergence tempo was very low, and so a detailed analysis of the deviations from the centre of gravity provided different results here. Seven provinces (Dolnośląskie, Kujawsko-pomorskie, Lubuskie, Łódzkie, Śląskie and Wielkopolskie) experienced distancing, i.e. mortality due to acause had a death rate above the average for the 16 units and, at the same time, the growth dynamics of the rate were above average. Four provinces (Małopolskie, Mazowieckie, Opolskie and Podlaskie) saw marginalisation of the mortality due to neoplasms, i.e. with death rates below average in the examined units, the tempo of change in the mortality was below average.

In the case of mortality due to C18–C21, the effects making up the convergence or divergence processes were distributed nearly evenly across all provinces. Slowing down and catching up occurred in four provinces each, while five provinces experienced a distancing and three a marginalising.

Table 3. Character of convergence of mortality by selected causes in Poland's provinces, 2002–2017

Specification	**Neoplasms C00–D48**	Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	**Diseases of the circulatory system I00–I99**	Ischaemic heart diseases I20–I25	Cerebrovascular diseases I60–I69	**Diseases of the respiratory system J00–J99**	Pneumonia J12–J18	Chronic liver disease K70, K73, K74	Transport accidents V01–V99, Y85	Intentional self-harm X60–X84, Y870
Dolnośląskie	D	D	S	M	C	C	C	S	C	S
Kujawsko-pomorskie	D	S	S	S	C	S	S	M	S	M
Lubelskie	C	C	D	C	S	M	C	S	C	C
Lubuskie	D	D	C	C	D	S	M	C	C	D
Łódzkie	D	S	S	M	S	S	S	S	S	D
Małopolskie	M	C	S	C	M	C	C	C	M	S
Mazowieckie	M	M	M	S	S	D	S	S	S	C
Opolskie	M	D	D	S	S	C	C	M	M	M
Podkarpackie	C	C	S	S	C	C	C	C	M	S
Podlaskie	M	M	C	C	C	D	S	C	D	S
Pomorskie	S	S	C	D	C	D	D	C	S	C
Śląskie	D	D	S	S	S	M	S	S	M	M
Świętokrzyskie	C	M	D	S	S	S	S	C	D	C
Warmińsko-mazurskie	S	C	C	C	S	S	S	D	S	D
Wielkopolskie	D	S	S	S	D	C	C	S	D	S
Zachodniopomorskie	S	D	D	S	C	C	C	D	S	S

Explanation: S – slowing down, C – catching up, M – marginalising, D – distancing
Source: own calculations based on acquired data (Eurostat 2020a; 2020b)

3.3. Sigma-convergence

To check if there was sigma-convergence of mortality by the selected causes, the coefficient of variation of logarithms of death rates in the provinces in the years 2002–2017 was calculated. The estimated parameters of the models (3) are presented in Table 4.

In most situations, the coefficients of variation tended to grow, which was attested to by the positive values of the parameters *b* in the sigma-convergence models. The parameters were statistically significant at 0.05 or 0.1 (Table 4). This means sigma-divergence, i.e. the variation in death rates for most of the selected death causes grew over time. The model parameter for mortality due to neoplasms was positive, although statistically insignificant. In turn, negative values of the parameter b were obtained for four models, i.e. mortality due to diseases of the circulatory system, pneumonia, chronic liver disease and malignant neoplasm of colon. The parameter turned out to be statistically insignificant in the model of mortality due to diseases of the circulatory system.

The statistical significance test performed on the coefficient of variation of cause-specific death rates was supplemented with a test of significance of the variance growth (or fall) in the beginning (2002) and end (2017) of the study period. The verification results have been collected in Table 5.

Although for most examined causes of death the dispersion of mortality between provinces increased (Table 4), only in eight cases was the variance higher in the final period than in the initial one (Table 5). The variance increase was statistically significant in five situations, i.e. mortality due to: diseases of the digestive system, chronic lower respiratory diseases, intentional self-harm, ischaemic heart diseases and malignant neoplasm of the stomach. For seven causes of death, the variance in the death rates

Table 4. Parameters of models of sigma-convergence of mortality by the selected causes in Poland's provinces, 2002–2017

Causes of death	Model parameters		
	b	*a*	R^2
Neoplasms C00–D48	0.0000	0.0143	0.0037
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	-0.0005 **	0.0340	0.3133
Malignant neoplasm of stomach C16	0.0009 **	0.0352	0.3712
Malignant neoplasm of trachea, bronchus and lung C33, C34	0.0008 **	0.0283	0.7541
Diseases of the circulatory system I00–I99	-0.0001	0.0149	0.1130
Ischaemic heart diseases I20–I25	0.0025 **	0.0398	0.6584
Cerebrovascular diseases I60–I69	0.0005 *	0.0293	0.1516
Diseases of the respiratory system J00–J99	0.0008 **	0.0467	0.2514
Chronic lower respiratory diseases J40–J47	0.0038 **	0.0280	0.6617
Pneumonia J12–J18	-0.0015 **	0.1111	0.3022
Diseases of the digestive system K00–K93	0.0025 **	0.0196	0.5547
Chronic liver disease K70, K73, K74	-0.0006 **	0.0815	0.2173
External causes of morbidity and mortality V01–Y89	0.0010 **	0.0203	0.4516
Transport accidents V01–V99, Y85	0.0031 **	0.0495	0.8093
Intentional self-harm X60–X84, Y870	0.0046 **	0.0294	0.7487

Explanation: ** – statistically significant at α = 0.05; * – statistically significant at α = 0.1
Source: own calculations based on acquired data (Eurostat 2020a; 2020b)

decreased, but only for mortality due to pneumonia was the drop statistically significant.

4. Discussion

A review of the literature has shown that the adopted set of variables and geographical coverage of our study make our findings non-comparable against the results of any other study. However, our conclusions regarding convergence of mortality coincide with results confirming beta-convergence and not confirming sigma-convergence of infant life expectancy in the Netherlands in a longer time horizon, which meant that the regional differences in mortality did not change (Janssen et al., 2016). Also, the rates of deaths, including those due to neoplasms, for the EU regions for the years 1995–2011 did not indicate an average decrease in dispersion over time, but only the catching-up effect in the regions (Maynou & Saez, 2016). Cavallieri and Ferrante (2020) confirmed convergence of infant mortality and infant life expectancy in 20 regions of Italy in the years 1996–2016. Regional convergence of the state of health expressed as infant life expectancy in the EU countries has been confirmed in some studies (Jaworska, 2011; Maynou et al., 2015; Stańczyk, 2016).

5. Conclusion

The hypothesis that since Poland's accession to the EU the country has experienced spatial convergence of mortality due to major causes of death has not been confirmed. The research findings show that the provinces have been becoming alike in terms of death intensity levels evening out for most

Table 5. Sigma-convergence – variance test, statistics – mortality by selected causes in Poland's provinces, 2002–2017

Causes of death	Variance		Test for decrease	Test for increase	*p*-value
	2002	2017	Empirical statistics *F*		
Neoplasms C00–D48	0.0086	0.0069	1.2513	–	0.3348
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	0.0156	0.0106	1.4704	–	0.2321
Malignant neoplasm of stomach C16	0.0117	0.0246	–	2.0964	0.0816
Malignant neoplasm of trachea, bronchus and lung C33, C34	0.0158	0.0207	–	1.3082	0.3047
Diseases of the circulatory system I00–I99	0.0124	0.0083	1.4904	–	0.2243
Ischaemic heart diseases I20–I25	0.0683	0.1438	–	2.1036	0.0807
Cerebrovascular diseases I60–I69	0.0198	0.0125	1.5847	–	0.1913
Diseases of the respiratory system J00–J99	0.0501	0.0372	1.3467	–	0.2857
Chronic lower respiratory diseases J40–J47	0.0284	0.0797	–	2.8031	0.0273
Pneumonia J12–J18	0.1317	0.0611	2.1556	–	0.0741
Diseases of the digestive system K00–K93	0.0140	0.0340	–	2.4345	0.0476
Chronic liver disease K70, K73, K74	0.0458	0.0326	1.4022	–	0.2603
External causes of morbidity and mortality V01–Y89	0.0081	0.0113	–	1.3974	0.2625
Transport accidents V01–V99, Y85	0.0270	0.0372	–	1.3771	0.2716
Intentional self-harm X60–X84, Y870	0.0191	0.0758	–	3.9709	0.0056

Source: own calculations based on acquired data (Eurostat 2020a; 2020b)

examined groups of causes. This is indicated by the confirmed absolute beta-convergence for most variables, including two major groups of causes of death: I00–I99 and C00–D48 (Table 6). However, a confirmation of beta-convergence does not always apply to both a broader and a narrower group of causes. It was observed that the tempo of convergence varied. One of the lowest ones regarded mortality due to neoplasms, and the highest one was for mortality due to diseases of the respiratory system.

In the years 2002–2017, in Poland's provinces, the intensity of deaths due to the examined causes was generally growing increasingly diversified, and so the provinces were not becoming similar to one another. Only for three of the causes of mortality (pneumonia, chronic liver disease and malignant neoplasm of the colon) did variation decrease, indicating that the provinces were becoming alike. A test of the directional coefficient of regression and a test of variance indicated the same direction of changes in the variation of mortality by cause – for eight causes it was an increase, and for four it was a decrease (Table 6). For three causes of death (neoplasms, diseases of the respiratory system, cerebrovascular diseases) the direction was opposite. Both tests for variation over time confirmed sigma-divergence only for five mortality causes (malignant neoplasm of stomach, ischaemic heart diseases, chronic lower respiratory diseases, diseases of the digestive system and intentional self-harm), and sigma-convergence for intensity of deaths due to pneumonia. Furthermore, in two broad groups of death causes (diseases of the circulatory system and neoplasms), neither convergence (i.e. becoming alike) nor divergence of mortality in the provinces was confirmed (Table 6). This multi-directional nature of the findings does not allow conclusions to

Table 6. Confirmation of type of convergence of mortality due to selected causes in Poland's provinces, 2002–2017

Causes of death	Absolute beta-convergence	Sigma-convergence		
	Test 1	Test 1	Test 2	Direction of change in tests
Neoplasms C00–D48	Yes	–	–	Opposite
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal C18–C21	Yes	Yes	–	Decrease
Malignant neoplasm of stomach C16	–	(Yes)	(Yes*)	Increase
Malignant neoplasm of trachea, bronchus and lung C33, C34	–	(Yes)	–	Increase
Diseases of the circulatory system I00–I99	Yes	–	–	Decrease
Ischaemic heart diseases I20–I25	Yes	(Yes)	(Yes*)	Increase
Cerebrovascular diseases I60–I69	Yes	(Yes*)	–	Opposite
Diseases of the respiratory system J00–J99	Yes	(Yes)	–	Opposite
Chronic lower respiratory diseases J40–J47	–	(Yes)	(Yes)	Increase
Pneumonia J12–J18	Yes	Yes	Yes*	Decrease
Diseases of the digestive system K00–K93	–	(Yes)	(Yes)	Increase
Chronic liver disease K70, K73, K74	Yes	Yes	–	Decrease
External causes of morbidity and mortality V01–Y89	–	(Yes)	–	Increase
Transport accidents V01–V99, Y85	Yes	(Yes)	–	Increase
Intentional self-harm X60–X84, Y870	Yes*	(Yes)	(Yes)	Increase

Explanation: Test 1 – test significance of parameter b; Test 2 – test of variance; Yes – convergence confirmed; (Yes) – divergence confirmed; – lack of conformation; * – at $\alpha = 0.1$
Source: own work

be drawn as to convergence or divergence between provinces in terms of mortality by major causes that would not raise any doubt. This warrants the claim that the financial support provided so far under the cohesion programmes aimed at eliminating socio-economic differences between provinces has proven ineffective. One reason might be that the principal determinant of state of health is lifestyle, and its changes are impossible to see over a short period of time.

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