Is Area-level Socioeconomic Deprivation Associated With Mortality Due to Circulatory System Diseases in Poland?

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Abstract

Background. Socioeconomic status (SES) influences cardiovascular health, but studies on the relation between deprivation and circulatory system diseases (CSD) in Eastern Europe are scarce. This study aimed to assess the relationship between SES and mortality from CSD at the population level in 66 sub-regions of Poland.

Methods. Area-based index based on education, structure in employment, salary, unemployment and poverty was constructed to assess SES. Data on mortality and the components of SES were obtained from the Central Statistical Office. Associations were tested using multivariate Poisson regression models.

Results. In men, compared to 2010, percent of Deaths Prevented or Postponed (DPP) in 2014 was 31.1% for CSD, 23.4% for ischemic heart disease (IHD) and 21.4% for cerebrovascular diseases (CD). In women proportion, of DPP was 12.8%, 25.6% and 21.6 respectively. CSD mortality was negatively related to SES with the exception to CD mortality in women. However, low-SES regions experienced a greater decrease in CSD mortality than high-SES regions.

Conclusions. Decrease of CSD mortality was more pronounced in women than in men, particularly in more deprived sub-regions compared with affluent regions. After adjustment for covariates SES was related with CSD and IHD mortality in men, and with CD mortality women.

Background

Circulatory system diseases (CSD) developing from atherosclerotic disease, including ischemic heart disease (IHD) and cerebrovascular diseases (CD), are the most common causes of death. In non-fatal cases, long-term treatment is required, which restricts the capacity to work and consequently generates high cost in terms of both treatment and loss of professional productivity, particularly in people above the age of 50 years [1, 2]. Burden of CSD is unequal across Europe, with higher mortality in the countries in the central and eastern regions [3, 4]. The inequalities occurred as a consequence of diverse trends over the last several decades with turning points in a temporal relationship with dynamic transformations of the political and economic system in the Central-East European countries [5].

Poland is the fifth most populated member of the European Union (EU; without Great Britain). Despite of the dynamic decreasing trend of mortality since the beginning of the 1990s, mortality due to CSD is higher in Poland than the average in the EU, with approximately 170,000 deaths recorded annually [4, 5]. Within Poland, a territorial diversity in CSD mortality and significant differences between urban and rural residents and between people with different education levels is observed [6, 7]. Education which may increase awareness of beneficial health behaviors, through medical and prophylactic care and recommendations for disease treatment [8], but it is also one of the important factors determining the socioeconomic status (SES). Low SES contributes to stress-related biological risk factors for the development of cardiovascular diseases (hypertension, proinflammatory cytokines, diabetes, obesity) [9]. Furthermore, it may be related to poorer health due to more common risky health behaviors, such as tobacco smoking, unhealthy diet, and lower physical activity [10, 11].

Most of the evidence on the relationship between socioeconomic inequalities and CSD mortality is based on the studies conducted in Western Europe and the United States [12–15], whereas much less is available from the Central and Eastern European countries [16]. The recent study in Poland, Russia and Czechia, confirmed the strong relationship between a risk of death from CSD and psycho-socioeconomic factors [17, 18]. However, there is a need to obtain a more detailed overview on the factors determining inequalities in the health of people in the Central European countries, including Poland, where the political transformation in 1989 had a significant effect on changes in social structures [19, 20]. Despite the considerable increase of SES, certain professional groups adapted at a slower rate to the new market economy, and thus, the social and health inequalities increased. Further, economic changes decreased employment in the heavy industry and national farm holdings [21, 22], which has led to economic and social inequalities associated with the area of residence, i.e., impoverishment and social exclusion, and consequently excessive alcohol consumption due to the increase in perceived threat [20]. Up to now, most analyses focused on changes in mortality from CSD as a result of changes in the exposure to traditional risk factors (cholesterol, blood pressure), changes in the lifestyle, and improvement of health care services [23, 24]. No research addressed the problem of socioeconomic factors at the population level. It is likely that the territorial variation in CSD mortality in Poland may be explained by SES differences and their changes in time.

The present study aimed to assess the relationship between SES and mortality due to CSD at a population level in 66 sub-regions of Poland.

Methods

An ecological study was done, in which the informations on SES, lifestyle, and mortality due to CSD collected from 66 administrative sub-regions of Poland was analyzed. Sub-regions were defined according to the Nomenclature of Territorial Units for Statistics NUTS-3 in 2006 [25]. Information for analysis in the period 2010–2014 was obtained from the Central Statistical Office and the Social Diagnosis survey conducted every 2 years since 2000 on the same sample of households [26].

Mortality

For the analysis, data on deaths during the period 2010–2014 were used. The causes for these deaths have been encoded according to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10) as CSD (codes: I00–I99), including IHD (I20–I25) and CD (I60–I69).

In statistical analyses, the age standardized number of deaths was used. A direct standardization method considering demographic structure in 5-year age groups separately for each of the 66 sub-regions of Poland was used. As standard population, we assumed populations of males and females in Poland in 2010, for which standardized mortality coefficients were determined [27]. The coefficients were calculated for the population aged over 14. In addition to the standardized mortality coefficients, 95% confidence intervals were presented.

When describing the dynamics of changes in mortality rates in the period 2010–2014, the deaths prevented or postponed (DPP) index was used [28]. The index value is the percentage obtained as the difference between the expected number of deaths in 2014, with the assumption that the mortality rate was the same as in 2010, and the actual number of deaths in 2014 relative to the expected number of deaths in 2014:

$$DPP = \frac{deaths\ expected_{2014} - deaths\ observed_{2014}}{deaths\ expected_{2014}} \cdot 100\%$$

Area-level SES index

The SES index was constructed using the following sub-region characteristics: percentage of people with university education (%), percentage of people employed in finance and real estate (%),average monthly salary (PLN), unemployment rate (%) and percentage of people on social support due to poverty (%) [29]. To calculate the SES index, its component variables were standardized via linear transformation such that their expected value was equal to 0 and the standard deviation was equal to 1. In addition, in the case of destimulants (variables: unemployment, social support users), their sign was reversed. Finally, the SES value was assumed as the arithmetic mean of the transformed components. The index was calculated based on the averaged values of component variables in the period 2010–2014. In addition, the 66 sub-regions were divided into three tercile groups based on the SES value: group with the lowest values of the index and thus the highest deprivation level (deprived), group with the highest index values (affluent), and middle group.

Other explanatory variables

Tobacco consumption and body mass index (BMI) in the 66 sub-regions were calculated based on the Social Diagnosis survey from 2011. This survey included 26,453 people aged 16 and above, who were residents of 12,386 households. The households were selected based on the two-stage stratified sampling method, first at the voivodeship level, followed by the class of residential location (large cities, small cities, and villages) [26].

Statistical analysis

To determine the relationship between mortality and SES, the Poisson regression model for count data was used. As this model aimed to represent the coefficient of mortality per 100,000 residents, and not the number of deaths, the age-standardized number of deaths in individual sub-regions was taken as a dependent variable, including the number of people in sub-regions as the offset. Calculations were realized using generalized linear models with Poisson distribution as probability distribution and logarithm as a link function.

Due to repeated measurements in the same statistical units (mortality in sub-regions in subsequent years in the period 2010–2014), we used generalized estimating equations (GEE) for obtaining generalized linear models for correlated data [30]. In GEE models, an exchangeable structure was assumed for the working correlation matrix.

The Poisson models were presented using the regression coefficients exponentially transformed, so they can be interpreted as the expected relative change of dependent variable (here: number of deaths standardized for the age) calculated for the increase of independent variable by 1 unit, i.e., relative risk. The presented coefficients can also be interpreted as a relative change of mortality coefficients and not only death number. Furthermore, 95% confidence intervals were presented for the coefficients of the regression model and their *p*-values of corresponding Wald's tests.

The created regression models included three causes (CSD, IHD, CD) of death in men and women. As independent variables, the models included calendar year (for assessment of time effect on the dependent variable) and the aforementioned index—the level of socioeconomic development in the sub-regions. In addition, lifestyle characteristics were included: BMI and frequency of smoking tobacco in the sub-region (respectively in female and male population) and population density in the sub-region with logistic transformation at base 2 applied.

Statistical calculations were performed using the IBM® SPSS® Statistics for Windows, version 20.0 statistical package (IBM Corporation, Armonk, NY, USA). The level of statistical significance was assumed at α=0.05.

Results

In the period 2010–2014, 868,418 deaths due to CSD were recorded in Poland, including 405,235 deaths among men (46.7%). The main causes of deaths among CSD were IHD (32.0%) and CD (24.6%).

Descriptive statistics for socioeconomic variables and lifestyle variables were presented in Table 1, by three subgroups of Polish sub-regions based on the SES index value. Mean values of the index variables in subgroups reflect the role of these variables as stimulants or destimulants—in the sub-regions with the highest SES index values (affluent), high values are attained by stimulants and low values by destimulants. Therefore, this group had the highest average level of salary (3,835 PLN), percentage of people with university education (21.2%), and percentage of people employed in finance and real estate (4.8%), and at the same time, the lowest unemployment rate (9.0%) and percentage of people on social support due to poverty (5.3%). Opposite characteristics occurred in the sub-regions with the lowest SES values (deprived), where the lowest mean values were obtained by salary (3,071 PLN), percentage of people with university education (12.5%), and percentage of people employed in finance and real estate (2.0%). On the other hand, the highest unemployment levels (17.8%) and people on social support due to poverty (11.7%) were observed in these sub-regions.

Table 1
Descriptive statistics for socio-economic status, lifestyle characteristics, and urbanization in 66 sub-regions of Poland during the period 2010–2014 by categories of SES index

Index of socio-economic status (tercile)	Deprived	Middle	Affluent
	SES index -1.23 to -0.44	SES index -0.42 to -0.03	SES index 0.01 to 3.23
SES INDEX and its components			
SES index	0.72 ± 0.23 (0.90/0.66/0.54)	0.24 ± 0.13 (0.37/0.28/0.09)	0.97 ± 0.79 (0.39/0.69/1.50)
Average salary [PLN]	3,071 ± 125 (2,971/3,057/3,164)	3,209 ± 200 (3,104/3,180/3,313)	3,835 ± 465 (3,445/3,776/4,130)
University education [%]	12.47 ± 1.16 (11.84/12.36/13.38)	14.11 ± 1.81 (12.74/13.77/14.83)	21.20 ± 6.72 (15.88/19.03/26.42)
Employed in finance and real estate [%]	2.02 ± 0.69 (1.46/1.88/2.47)	2.33 ± 0.68 (1.78/2.35/2.86)	4.78 ± 2.86 (2.80/3.50/6.70)
Unemployment rate [%]	17.80 ± 3.56 (15.00/17.04/20.46)	14.50 ± 2.68 (13.06/14.33/17.09)	9.02 ± 3.11 (6.26/9.49/11.22)
People on social support due to poverty [%]	11.70 ± 1.77 (10.43/11.87/13.15)	8.63 ± 1.68 (7.30/8.82/9.87)	5.27 ± 1.49 (4.19/5.32/6.29)
LIFESTYLE indicators			
Smoking (men) [%]	34.2 ± 5.9 (29.2/33.9/38.2)	32.4 ± 5.7 (28.6/30.8/35.4)	33.0 ± 4.0 (29.8/33.6/35.6)
Smoking (women) [%]	17.6 ± 4.8 (13.9/16.7/20.6)	19.3 ± 4.8 (15.2/18.8/22.4)	22.8 ± 4.0 (20.6/23.3/26.0)
BMI (men) [kg/m²]	26.5 ± 0.4 (26.2/26.5/26.8)	26.5 ± 0.4 (26.3/26.4/26.6)	26.4 ± 0.5 (26.1/26.4/26.8)
BMI (women) [kg/m²]	25.4 ± 0.3 (25.2/25.5/25.6)	25.3 ± 0.4 (25.0/25.3/25.5)	25.1 ± 0.4 (24.7/25.1/25.4)
Population density			
Population density [n/km²]	80.0 ± 26.6 (59.4/76.6/94.2)	124.9 ± 60.6 (80.8/103.6/173.3)	956.2 ± 1,015 (166.0/403.2/2,020.1)
Values are presented as mean ± standard deviation (first quartile/median/third quartile)			
Abbreviation: SES – socio-economic status; BMI—body mass index			

Substantial difference in population density was noted, which in the poorest sub-regions was on average 80 people/km² and in the wealthiest sub-regions was over 10-fold higher—956 people/km², indicating that high values of SES index are mainly linked to highly urbanized areas. The percentage of smoking men was similar in all three groups of sub-regions, ranging from 32.4–34.2%. A considerably more variation was found for smoking women. In the sub-regions with the lowest SES index, smoking women constituted the smallest percentage of the population (17.6%), and in the sub-regions with the highest scores, they were considerably higher (22.8%). No significant differences were found for characteristics of nutrition. Mean BMI ranged between 26.4 and 26.5 kg/m² and between 25.1 and 25.4 kg/m² in men and women respectively.

The territorial distribution of sub-regions by SES is presented in Fig. 1. Sub-regions with the highest SES index were primarily the areas of large urban agglomerations.

CSD mortality was the highest in the sub-regions with the lowest SES index and the lowest in the sub-regions with the highest socioeconomic development level. Simultaneously, the dynamics of mortality decreased in the period 2010–2014, as expressed by a significant decrease in the percentage of DPP with an increase in the SES index ($p < 0.001$). In men, IHD mortality was the lowest in the sub-regions with the lowest SES. In addition, a decrease in the percent of DPP was observed ($p < 0.001$).

The relationship between the male deaths due to CD and the SES index was unambiguous. The highest mortality was observed in the sub-regions with an average level of socioeconomic development and in the affluent sub-regions. However, a statistically significant linear decrease in the DPP percentage was observed ($p < 0.01$) (Table 2).

Table 2
Age-standardized mortality rates from circulatory system diseases (CSD) and proportion of deaths prevented or postponed (DPP) in men in the years 2010 and 2014 by SES

Index of socio-economic status	**Deprived**		**Middle**		**Affluent**		**Total**	
Calendar year	2010	2014	2010	2014	2010	2014	2010	2014
Population number	N = 4,620,670	N = 4,626,798	N = 4,941,680	N = 4,954,502	N = 6,087,462	N = 6,080,211	N = 15,649,812	N = 15,661,511
Circulatory system diseases								
SMR (95% CI)	554.21 (547.43–560.98)	475.30 (469.24–481.36)	536.50 (530.06–542.94)	461.97 (456.23–467.72)	485.90 (480.58–491.21)	430.09 (425.29–434.89)	520.43 (516.93–523.94)	452.11 (448.97–455.26)
Observed number of deaths	24,672	23,301	25,598	24,521	31,177	30,981	81,447	78,803
Expected number of deaths*		27,167		28,419		34,948		90,649
Number (percentage) of DPP relative to expected deaths		3,866 (14.2%)		3,898 (13.7%)		3,967 (11.4%)		11,846 (13.1%)
Linear trend for DPP	p **< 0.001**							
Ischemic heart disease								
SMR (95% CI)	151.56 (147.95–155.16)	112.86 (109.84–115.87)	163.38 (159.77–166.98)	119.35 (116.38–122.32)	161.02 (157.92–164.11)	130.47 (127.78–133.16)	158.93 (156.97–160.90)	122.12 (120.45–123.78)
Observed number of deaths	6,741	5,467	7,822	6,299	10,310	9,277	24,873	21,043
Expected number of deaths*		7,390		8,632		11,436		27,468
Number (percentage) of DPP relative to expected deaths		1,923 (26.0%)		2,333 (27.0%)		2,159 (18.9%)		6,425 (23.4%)

Significant results are shown in bold
Abbreviations: SES—socioeconomic status; SMR—standardized mortality rate per 100,000 population; CI—confidence interval; DPP—deaths prevented or postponed
*Assuming that death rates by age groups from 2010 persist in 2014

Index of socio-economic status	**Deprived**		**Middle**		**Affluent**		**Total**	
Linear trend for DPP	p **< 0.001**							
Cerebrovascular diseases								
SMR (95% CI)	100.27 (97.34–103.21)	78.67 (76.16–81.19)	107.94 (105.00–110.88)	83.13 (80.65–85.61)	89.00 (86.70–91.30)	71.85 (69.86–73.84)	97.94 (96.40–99.49)	77.08 (75.76–78.40)
Observed number of deaths	4,457	3,834	5,149	4,383	5,722	5,143	15,328	13,360
Expected number of deaths*		4,896		5,697		6,389		16,991
Number (percentage) of DPP relative to expected deaths		1,062 (21.7%)		1,314 (23.1%)		1,246 (19.5%)		3,631 (21.4%)
Linear trend for DPP	p **< 0.01**							
Significant results are shown in bold								
Abbreviations: SES—socioeconomic status; SMR—standardized mortality rate per 100,000 population; CI—confidence interval; DPP—deaths prevented or postponed								
*Assuming that death rates by age groups from 2010 persist in 2014								

In women, the relationship between mortality and SES index was similar to that in men. CSD mortality standardized for age was the lowest in the sub-regions with the highest socioeconomic level and the highest in deprived sub-regions. The percentage of prevented deaths decreased significantly with the increase of the SES index ($p < 0.001$). IHD mortality, was the lowest in the sub-regions with the highest socioeconomic development and the lowest (from the 2014 perspective) in the sub-regions with the highest SES values. Percent of DPP decreased significantly ($p < 0.001$) with an increase of SES index. Similar to men, CD mortality was the highest in middle sub-regions and the lowest in affluent sub-regions. No significant differences were observed in the percentage of prevented deaths ($p = 0.286$), and it was at the same level in all three sub-region groups (Table 3).

Table 3
Age-standardized mortality rates from circulatory system diseases (CSD) and proportion of deaths prevented or postponed (DPP) in women in the years 2010 and 2014 by SES

Index of socio-economic status	**Deprived**		**Middle**		**Affluent**		**Total**	
Calendar year	2010	2014	2010	2014	2010	2014	2010	2014
Population number	N = 4,866,545	N = 4,870,994	N = 5,295,490	N = 5,312,335	N = 6,862,253	N = 6,869,611	N = 17,024,288	N = 17,052,940
Circulatory system diseases								
SMR (95% CI)	572.65 (566.10–579.20)	484.34 (478.58–490.10)	571.24 (564.92–577.56)	479.61 (474.09–485.12)	502.13 (497.01–507.25)	455.46 (450.84–460.07)	543.21 (539.81–546.62)	470.92 (467.91–473.94)
Observed number of deaths	27,710	26,345	29,603	28,168	35,165	36,393	92,478	90,906
Expected number of deaths*		30,998		33,396		39,876		104,307
Number (percentage) of DPP relative to expected deaths		4,653 (15.0%)		5,228 (15.7%)		3,483 (8.7%)		13,401 (12.8%)
Linear trend for DPP	p **< 0.001**							
Ischemic heart disease								
SMR (95% CI)	116.90 (113.87–119.93)	78.54 (76.15–80.93)	126.26 (123.21–129.30)	89.97 (87.52–92.43)	125.06 (122.46–127.67)	101.50 (99.28–103.73)	123.11 (121.45–124.77)	91.51 (90.15–92.87)
Observed number of deaths	5,648	4,215	6,545	5,216	8,766	8,063	20,959	17,494
Expected number of deaths*		6,288		7,349		9,887		23,523
Number (percentage) of DPP relative to expected deaths		2,073 (33.0%)		2,133 (29.0%)		1,824 (18.4%)		6,029 (25.6%)

Significant results are shown in bold
Abbreviations: SES—socioeconomic status; SMR, standardized mortality rate per 100,000 population; CI—confidence interval; DPP—deaths prevented or postponed
*Assuming that death rates by age groups from 2010 persist in 2014

Index of socio-economic status	Deprived		Middle		Affluent		Total	
Linear trend for DPP	**$p < 0.001$**							
Cerebrovascular diseases								
SMR (95% CI)	120.19 (117.11–123.27)	94.90 (92.27–97.52)	128.20 (125.13–131.27)	99.08 (96.50–101.66)	111.01 (108.55–113.46)	86.79 (84.72–88.86)	118.84 (117.21–120.47)	92.82 (91.44–94.19)
Observed number of deaths	5,804	5,077	6,652	5,723	7,775	6,843	20,231	17,643
Expected number of deaths*		6,385		7,406		8,705		22,500
Number (percentage) of DPP relative to expected deaths		1,308 (20.5%)		1,683 (22.7%)		1,862 (21.4%)		4,857 (21.6%)
Linear trend for DPP	$p = 0.286$							
Significant results are shown in bold								
Abbreviations: SES—socioeconomic status; SMR, standardized mortality rate per 100,000 population; CI—confidence interval; DPP—deaths prevented or postponed								
*Assuming that death rates by age groups from 2010 persist in 2014								

The relation between CSD mortality and time, SES, lifestyle, and population density is presented in Table 4. For both women and men, there was a statistically significant decrease of mortality from CSD (2.9% annually for men and 2.8% annually for women), from IHD (6.6% annually for men and 7.7% annually for women), and from CD (6.1% annually for men and 6.6% annually for women). A relationship between SES and decreasing mortality was found for CSD and IHD deaths in men and for CD deaths in women. Higher mean BMI was related to higher mortality due to CSD in women, but there was no significant relationship between BMI and mortality from IHD and CD. A relation between smoking and the increase of mortality was found for CSD mortality in men. High SES index (by and large related to urban agglomerations) was related to lower mortality. High population density was related to greater mortality from CSD in women and men and to CD mortality only in women.

Table 4

Relation between mortality from circulatory system diseases (CSD) and socioeconomic status (SES), lifestyle, and population density in 66 sub-regions of Poland, 2010–2014

Group diseases	Variables in the model	Men		Women	
		exp(β) with 95% CI	*p*	exp(β) with 95% CI	*p*
Circulatory system diseases (ICD-10: I00–I99)	Time [1-year increase]	**0.971 (0.967, 0.976)**	**0.000**	**0.972 (0.966, 0.978)**	**0.000**
	SES index [1-unit increase]	**0.947 (0.908, 0.987)**	**0.011**	0.952 (0.905, 1.002)	0.058
	BMI [1-kg/m² increase]	1.031 (0.967, 1.099)	0.357	**1.079 (1.013, 1.150)**	**0.018**
	Smoking [1% increase]	**1.005 (1.002, 1.009)**	**0.004**	0.997 (0.992, 1.002)	0.309
	Population density [twofold increase]	1.002 (0.976, 1.029)	0.871	1.008 (0.981, 1.037)	0.555
Ischemic heart disease (ICD-10: I20–I25)	Time [1-year increase]	**0.934 (0.914, 0.955)**	**0.000**	**0.923 (0.892, 0.956)**	**0.000**
	SES index [1-unit increase]	**0.824 (0.695, 0.978)**	**0.027**	0.791 (0.624, 1.002)	0.052
	BMI [1-kg/m² increase]	1.125 (0.946, 1.337)	0.183	1.025 (0.785, 1.339)	0.856
	Smoking [1% increase]	1.002 (0.990, 1.015)	0.713	1.002 (0.984, 1.020)	0.853
	Population density [twofold increase]	**1.126 (1.010, 1.254)**	**0.032**	**1.152 (1.010, 1.313)**	**0.035**
Cerebrovascular diseases (ICD-10: I60–I69)	Time [1-year increase]	**0.939 (0.930, 0.949)**	**0.000**	**0.934 (0.914, 0.955)**	**0.000**
	SES index [1-unit increase]	0.994 (0.910, 1.087)	0.901	**0.823 (0.690, 0.981)**	**0.029**
	BMI [1-kg/m² increase]	1.092 (0.980, 1.216)	0.111	1.003 (0.826, 1.218)	0.978
	Smoking [1% increase]	1.006 (0.999, 1.014)	0.107	0.999 (0.984, 1.014)	0.867
	Population density [twofold increase]	0.967 (0.908, 1.030)	0.295	**1.118 (1.011, 1.236)**	**0.030**

Separate models for each disease group by gender including the effects of time trend, SES index, BMI, prevalence of smoking, and population density

Significant results are shown in bold

Abbreviations: exp(β)—exponentiated coefficient of Poisson regression model; CI—confidence interval; ICD-10—International Statistical Classification of Diseases and Related Health Problems, Tenth Revision; BMI—body mass index

Discussion

Main findings

In the 66 sub-regions of Poland, there was a large geographic variation in the CSD mortality and in SES. Both in men and in women, the largest mortality was found in the low-SES sub-regions, and the lowest was found in the high-SES sub-regions. However, low-SES sub-regions benefited more from the decrease in CSD mortality in men. In general, the higher was SES, the smaller was a decrease in CSD mortality and the smaller was the number of DPP. In women, the differences in the number of DPP between the SES groups were similar to men except for CD where the trend was nonsignificant. The relation between SES and CSD mortality was significant in men after adjustment for population density, mean BMI, and mean smoking rate. In women, there was a significant relation with mean BMI but the relation between CSD mortality and SES was not significant after adjustment of covariates, despite β coefficients were similar to men.

Interpretation of results

Our study indicate that variation of CSD mortality in sub-regions of Poland can be explained partially at least by the differences in SES. Our results comply with the research in which synthetic SES indexes were used to assess the relationship between deprivation and mortality due to CSD and IHD [12–14]. Some studies suggest that deprivation has a stronger impact on CSD mortality in men than in women [12, 31]. The gender differences in mortality are possibly associated with the performed profession via elevated exposure to risk factors, particularly among male manual workers [32]. We confirmed the relation between SES and mortality from CD in women which also described in the other study [33–35].

In our study, CSD mortality was associated with tobacco smoking only in men. which could reflect the higher smoking rates in the affluent sub-region group as compared with deprived sub-region. In MORGAM study, which showed that in Poland, smoking is less prevalent among women with low and secondary education as compared with women with higher education particularly in less urbanized areas [36]. It has been suggested that economic development and social and cultural processes in the Eastern European countries associated with gender empowerment affect the differences in smoking between educated and uneducated women [37].

The lowest mortality due to CSD was observed in the affluent sub-regions group, which predominantly include large urban agglomerations, small cities, and urban sub-regions. The low mortality in these sub-regions may be associated with access to different resources, including educational infrastructure, services, and job positions [35]. Furthermore, they offer a more favorable environment, such as access to gyms and shops selling healthy foods, as well as health care services, which may contribute to better health results [38–40]. Sub-regions with high deprivation levels are located in the eastern and northwest parts of the country and are characterized by a low population density; they seem less attractive to investors, which results in their lower possibilities for economic development. This confirms, among others, the fact that the location of many sub-regions with high deprivation level overlaps with areas where national farm holdings had been liquidated and which had experienced more harmful effects of the economic transformation. These areas lacked support programs targeting social groups who had been deprived of earlier forms of employment, which was consequently linked with a permanent deterioration of health [20, 22]. However, the IHD mortality pattern was reversed, i.e., mortality was the highest in the affluent sub-region group. In the case of CD, the highest mortality was found in the group of middle sub-regions, which may suggest the occurrence of other specific factors not included in the study (e.g., differences in access to medical care on stroke units) [41]. It should also be emphasized that the rapid decrease of mortality from CSD occurred in sub-regions with low SES values. In deprived and middle SES sub-regions, it was possible to prevent or delay over twice more deaths as compared with affluent sub-regions.

While the CSD and CD mortality was the lowest in the affluent group, the reduction of mortality between 2010 and 2014 was smaller compared to the sub-regions with low SES index. This could be explained by the fact that in the best-developed—highly urbanized—sub-regions, the reduction of mortality (due to better availability of suitable cardiologic care and procedures of invasive cardiology) had occurred in earlier years and the room for improvement of cardiovascular health was narrower [42]. Simultaneously in the group of deprived and middle sub-regions, the modern prevention and therapeutic methods are becoming more accessible. For example, the availability of life-saving procedures in invasive cardiology has been gradually increasing after 2000 not only in academic centers but also in district hospitals, which might resulted in reduced mortality also in smaller centers with lower SES index .This explanation is supported by the results of other analyses [42], according to which the reduction of mortality due to CSD in the group of people with higher education was particularly pronounced between 1991–1993 and 2001–2003, whereas between 2001–2003 and 2010–2012, it was considerably lower, and there was a low rate of mortality in people with low education in comparison with people with higher education.

Strengths And Limitations

To our knowledge, this is the first study using the SES index to assess the relationship with mortality due to CSD at the population level in Poland. The analysis was done on the basis of the whole country. In the sub-regions there was a large variation in CSD mortality and in SES. Further, sub-regions represented the whole variety of characteristics which are typical for Poland. The synthetic SES index enabled for approximate estimation of phenomena manifested by singular variables (education, structure in employment, salary, unemployment and poverty). A database concerning sub-regions defined based on NUTS-3 classification, which is used in the EU member states, was first time used for this purpose [25].

There are certain limitations in the interpretation of the results of our study. The ecological design does not allow to address the causality of the relations. In contrast to mortality and SES, information on covariates i.e. education, smoking and BMI was based on one point observation (Census 2011, Social Diagnosis 2011) which was the only available for studied sub-regions and which corresponded with a period of the study timing. It is unlikely that the these characteristics change much within the study observation time. The relation between SES and CSD mortality could be confounded by the sub-region differences in the exposure to the other uncontrolled factors so residual confounding should be taken into account.

Another problem is the quality of data on deaths associated with the differences in the reliability of coding of death causes by physicians who fill out the certificate of death. Our results show that the highest mortality due to IHD occurred in the most urbanized affluent tercile, which may be explained partially by the discrepancies in death certification encoding described earlier in Poland [43]. Such problem was identified also even in countries with highly advanced systems of health information [44]. However, territorial differences in coding causes of deaths causes could rather contribute to the greater impact of random variability on the results of our observations, and it is less likely that the occurrence of a systematic error would explain the observed relationships. The latter is supported by the overall accordance of relationships found for IHD, CD, and CSD.

Conclusions

The decrease in mortality from CSD was more pronounced in women than in men, particularly in the deprived and middle sub-regions as compared with high SES sub-regions. After adjustment for population density and lifestyle characteristics, the relationship between SES and mortality from CSD and IHD was more pronounced in men, while the relationship between SES and mortality from CD was found only in women.

Abbreviations

BMI: body mass index; CD: cerebrovascular diseases; CSD: circulatory system diseases; DPP: deaths prevented or postponed; GEE: generalized estimating equations; ICD: International Statistical Classification of Diseases and Related Health Problems; IHD: ischemic heart disease; NUTS: Nomenclature of Territorial Units for Statistics; SES: socioeconomic status

Declarations

Ethics approval and consent to participate:

not required.

The study did not have identifiable individual subjects and therefore it did not need ethics approval.

Consent for publication:

not applicable.

Availability of data and materials:

The datasets analyzed during the current studies are publicly available.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

Conceptualization: JJ, AG, AP; Data curation: AG; Formal Analysis: JJ; Funding Acquisition: AG; Investigation: AG, JJ; Methodology: JJ, AG; Project administration: AG; Software: JJ; Supervision: AG, AP; Validation: AG; Writing – original draft preparation: JJ, AG, AP; Writing – review and supervision: AP.

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Figures

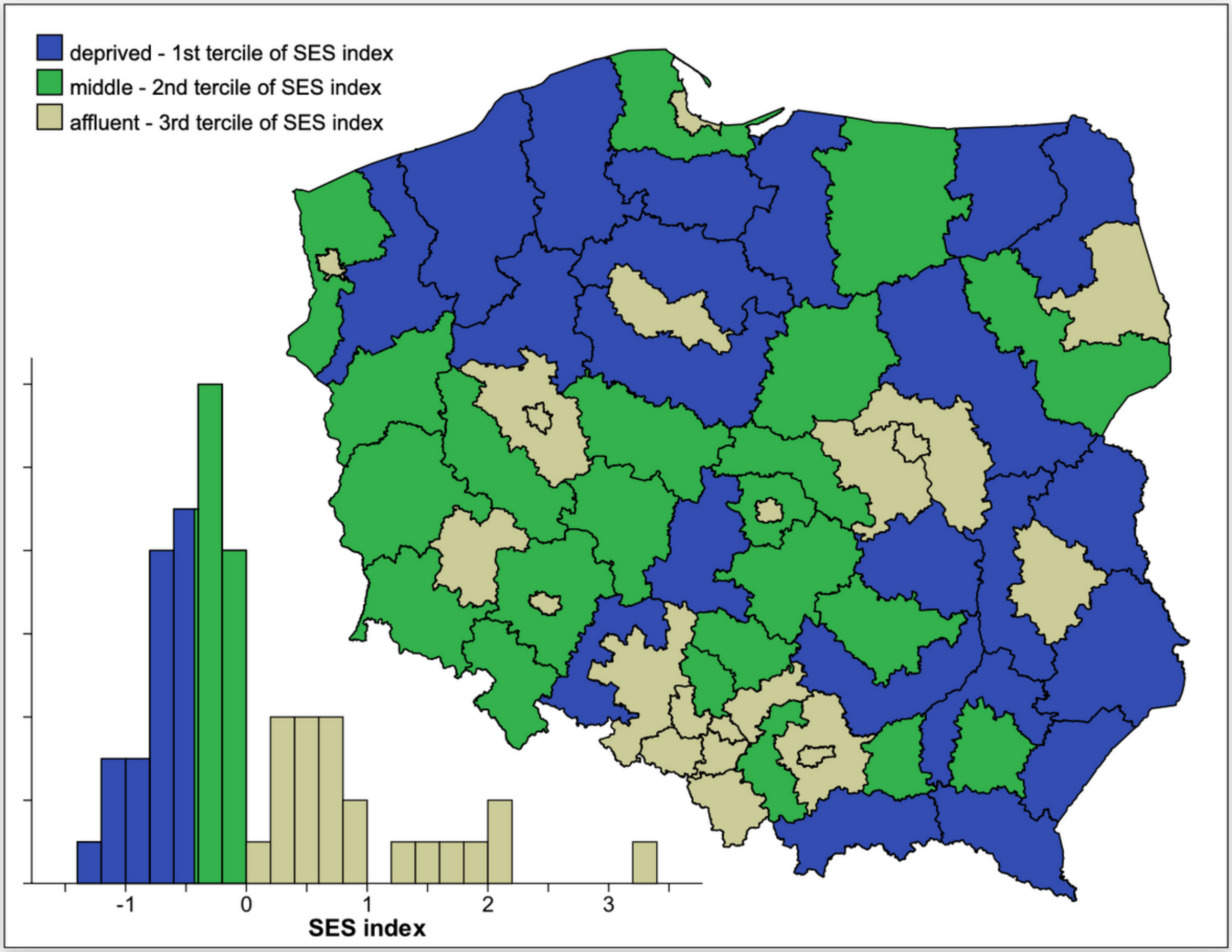

Figure 1

Geographic variation of mean socio-economic status index (66 sub-regions of Poland, years 2010–2014) Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.