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Original article

Czech socio-economic deprivation index and its correlation with mortality data

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Abstract

Objectives: The aim of the study was to create an index of socio-economic deprivation (SESDI) and to analyse correlation between SESDI and mortality data.

Methods: The SESDI components were selected from the census data (2001) at enumeration district and district level. Two methods were used for creating the SESDI: 1/ a sum of Z-scores of specific components (INDEX1); and 2/ standardized score – average values of specific components were divided by a maximum value of the specific component at the corresponding geographical level (INDEX2). Pearson's correlation coefficient was used for assessing the relationship between indices, and between indices and mortality data (SMR).

Results: The final indices were applied to districts in the Czech Republic (N = 77). The correlation of INDEX1 and INDEX2 was high (r = 0.99). Analysis of relationships between degree of deprivation and total and selected specific SMR in the Czech Republic confirmed that mortality was associated with degree of deprivation.

Conclusion: The use of socio-economic deprivation indices in analysis of routinely collected mortality data in public health might help to explain health inequalities.

Keywords: Mortality – Poverty classification – Small-area analysis – Socioeconomic factors.

Introduction

The results of epidemiological studies have more or less confirmed that mortality within social classes and occupational groups is higher, the worse the position of these groups in the social structure,[1-11] the lower level of education attained and the lower income of these groups. Evidence of association between socio-economic position and life-style risk factors was also found. [9, 12]

The susceptibility of people to develop ill health can be influenced by characteristics of the geographic area where they live.[13, 14] Populations in socio-economically deprived areas are considered more susceptible to poor health compared to those in affluent areas.[15]

In recent decades indices of socio-economic deprivation have been created in various countries to indicate the level of deprivation in different geographical areas, and have been used to analyse health data by area-level deprivation. In the Czech Republic no socio-economic deprivation index (SESDI) has yet been constructed for use in ecological studies. The aim of this study, financed by the Grant Agency of the Czech Ministry of Health, was to create such an SESDI and to use it for correlation with mortality data.

When creating the SES deprivation index, it is very important to take into account a distinction between two concepts of poverty – absolute and relative. Deprivation indices are based on the concept of relative poverty, and the deprivation it measures is related to the average living standard of that society.[16] This is the main reason for construction of deprivation indices separately for specific population/country. Firstly it is necessary to indicate the norm/average standard of living. In general deprivation indices are related to the geographical rather than the individual level. The score of a specific area is standardized by the average of all areas.[17] Deprivation indices are most commonly used in the United Kingdom; some of them are based on census data (Jarman Underprivileged Area Score, MATDEP, Townsend, Carstairs, DoE etc.), the others on combination of census data and data from the state administration (i. e. Area deprivation index, ILC index, DETR, Area deprivation in Scotland).[18]

Methods

The index was constructed at two levels using 2001 census data (Czech Statistical Office). The Czech Republic is administratively split into 14 regions (NUTS3 – Nomenclature Unit of Territorial Statistics 3), 77 districts (NUTS4) and 52 941 census enumeration districts (ED – area with at maximum 140 flats or 400 inhabitants). Mortality and demographic data are routinely collected at the district level.[21]

Correlation analysis, analysis of variance (ANOVA) and χ^2-test on 5 % significance level were used for statistical analysis and selection of the SESDI components. The set of index components was selected at the district level, then the SESDI was created and verified at the ED level in the Moravian Region and finally the SESDI was constructed at the district level and used for analysis of mortality differences.

Two methods were applied for creating the SESDI. For the first one, based on the Townsend index,[17, 19] the sum of Z-scores of specific components was calculated (INDEX1). The other index (INDEX2) was created according to the methodology of MATDEP and SOCDEP index[17] that used standardized score – average values of specific components were divided by a maximum value of the specific component at the corresponding geographical level, i. e. in enumeration districts of the Moravian Region and in the Czech districts. INDEX2 was constructed separately for material deprivation (INDEX2mat) and for social deprivation (INDEX2soc).

Relationships between the SESDI and mortality data were analysed using standardized total and specific mortality rates for the year 2001. The age-standardized mortality rate (SMR) was calculated by direct standardization – a weighted average of the age-specific mortality rates per 100 000 population, where the weights are the proportions of population in the corresponding age groups of the WHO standard European population.

Correlation and regression analysis were used for analysis of relationships between indices and their sub-indices, and between indices and SMR.

Statistical analyses was conducted using STATA v.9, and geographical outcomes were visualized by the software ArcView v. 9.2.

Results

The SESDI components were retrieved from the census data (2001) that are routinely analysed at the district level in the Czech Republic. Index components were selected from 5 domains of material and social deprivation (housing quality, material standard, access to phone/PC/internet, family status and education).

For the first selection components were derived from 10 census components on material deprivation (proportion of detached houses, ownership of housing, ownership of cottage houses, housing water supply, flats without amenities, density of housing, phone, PC, internet and car ownership) and 8 census components on social deprivation (basic/university education, unemployment, proportion of singles, complete/incomplete families with and without children). Some of these components were omitted due to low frequency (proportion of flats without amenities was distributed between 0.4–1.6 %) or due to the similar distribution in all districts (water supply varied from 97.7–99.1 %). Inter-correlation and overlapping were found between some components. E.g. for proportion of detached houses and ownership of housing, r was 0.84, therefore the proportion of detached houses was selected. Similar overlapping was found between complete and incomplete families with and without children; and between basic and university education, so that the components incomplete families with children and proportion of people with basic education were taken into the final set of the SESDI components. Percentage of incomplete families with children was also included due to recent information from the Czech Statistical Office that one third of these families were threatened by poverty.[20] Finally components on equipment of housing with PC and internet were omitted; these census components were found to be correlated more with education than with other material components.

The proportion of detached houses ownership was higher in rural areas, while in urban districts ownership of cottage houses outside cities was higher in addition to rental housing. Therefore both components were included into the final set of 9 components comprising ownership of accommodation (detached houses, cottage houses), car, phone and density of housing, proportion of people with basic education, unemployed, singles and incomplete families with children. This set of 9 components constituted a basis for construction of the socio-economic deprivation index.

In the first step of the SESDI construction census data were gathered at the ED level for 6 districts (in total 5 114 EDs) in the Moravian region (Moravskoslezsky Region). The goal of the ED study was verification of the selected set of components. The differences between the six districts were tested at the level of their EDs for specific components. The results of the analysis confirmed statistically significant differences between districts for all selected material and social components ($p < 0.001$) at the ED level. As the data on incomplete families with children were not available at the ED level, instead of this variable single men and women were entered into the SESDI separately.

Int J Public Health 54 (2009) 267–273

Table 1. Descriptive characteristics of selected components and indices.

Component/Index (MC – material component, SC – social component)	Number of ED	Mean ($\bar{x}$)	Standard deviation (s)	Min.	Max.
MC_1 – other than detached houses (%)	4 840	65.78	36.27	0	100
MC_2 – density of housing (m^2/person)	4 839	17.88	3.72	4	49
MC_3 – no car (%)	4 840	49.67	12.40	0	100
MC_4 – no phone (%)	4 840	24.91	11.48	0	100
MC_5 – no cottage houses (%)	4 840	82.95	14.25	0.84	100
SC_1 – unemployment (%)	4 901	15.93	9.34	0	100
SC_{2F} – single women (%)	4 899	54.28	8.60	0	100
SC_{2M} – single men (%)	4 889	52.16	8.16	0	100
SC_3 – basic education (%)	4 903	26.50	9.67	0	98.1
INDEX1	4 838	–0.025	5.44	–20.89	29.46
INDEX2	4 838	4.35	0.70	2.17	7.49
INDEX2mat	4 839	2.87	0.53	1.31	4.47
INDEX2soc	4 885	1.49	0.27	0.50	3.70

The computation of indices was based on descriptive characteristics of selected material (MC) and social (SC) components (Table 1).

Creation of INDEX1 was based on Z-scores of individual observations (X), arithmetic mean of all observations ($\bar{X}$) and standard deviation (s) of ED-level (or district-level) values. Calculation of the Z-score is based on the formula [1]

$$Z = \frac{X - \bar{X}}{s} \qquad [1]$$

The calculation of INDEX1 (formula [2]) is based on formula [1] and on the basic characteristics of components summarized in Table 1.

$$INDEX1 = \frac{MC_1 - 65.78}{36.27} + \frac{17.88 - MC_2}{3.72} + \frac{MC_3 - 49.67}{12.40} + \frac{MC_4 - 24.91}{11.48} + \frac{MC_5 - 82.95}{14.25} + \frac{SC_1 - 15.93}{9.34} + \frac{SC_{2F} - 54.28}{8.60} + \frac{SC_{2M} - 52.16}{8.16} + \frac{SC_3 - 26.50}{9.67} \qquad [2]$$

A positive/negative value of the Z-score indicates that the observation is higher/lower than the average value. In the component "density of housing" (m^2 per person) the respective value was deducted from the average value to get deprivation. The resulting INDEX1 was a sum of all components' Z-scores, resulting in both positive and negative index values. Thus INDEX1 measures both relative affluence and deprivation.

INDEX2 was constructed by another method. The values of specific components for each enumeration district (or district) were divided by the maximum ED-level (or district-level) values of that component. INDEX2 was constructed separately for material deprivation (INDEX2mat) and for social deprivation (INDEX2soc).

$$INDEX2mat = \frac{MC_1}{100} + (1 - \frac{MC_2}{49}) + \frac{MC_3}{100} + \frac{MC_4}{100} + \frac{MC_5}{100} \qquad [3]$$

$$INDEX2soc = \frac{SC_1}{100} + \frac{SC_{2F}}{100} + \frac{SC_{2M}}{100} + \frac{SC_3}{98.1} \qquad [4]$$

$$INDEX2 = INDEX2mat + INDEX2soc \qquad [5]$$

These sub-indices were based on corresponding material [3] and social components [4]. Their sum constitutes the final INDEX2 [5]. The values of the final index ranged from 0 to 9. Table 1 includes descriptive characteristics of the indices. Correlations between indices were high, especially between INDEX1 and INDEX2 (r = 0.95). The lowest correlation was found between the sub-indices of INDEX2 for material and social deprivation (r = 0.53).

The districts were divided into two groups according to the average value of indices. In the first group (Bruntal, Karvina and Ostrava) the value of indices indicated higher deprivation and varied for INDEX1 from 0.53 to 1.80 and for INDEX2 from 4.50 to 4.52. The other 3 districts (Novy Jicin, Frydek-Mistek and Opava) were more affluent (INDEX1: from -0.50 to –1.79; INDEX2: from 4.08 to 4.24). The splitting of districts corresponded with published information from the Czech Statistical Office.[20]

Component/Index (MC – material component, SC – social component)	Number of districts	Mean ($\bar{x}$)	Standard deviation (s)	Min.	Max.
MC_1 – other than detached houses (%)	77	49.5	16.0	20.7	87.8
MC_2 – density of housing (m^2/person)	77	18.9	1.0	16.5	22.5
MC_3 – no car (%)	77	46.8	6.8	37.1	62.0
MC_4 – no phone (%)	77	45.5	1.9	41.9	49.5
MC_5 – no cottage houses (%)	77	93.6	5.1	79.0	100.0
SC_1 – unemployment (%)	77	9.1	3.7	3.9	19.7
SC_2 – single people (%)	77	31.9	3.1	26.3	38.3
SC_3 – basic education (%)	77	24.4	2.8	14.5	30.8
SC_4 – incomplete families with children (%)	77	8.6	1.3	6.0	11.8
INDEX1	77	0.00	6.18	-10.11	16.84
INDEX2	77	6.15	0.65	5.17	8.02
INDEX2mat	77	3.34	0.35	2.75	4.16
INDEX2soc	77	2.82	0.34	2.25	3.87

Table 2. Descriptive characteristics of selected components and indices – district level.

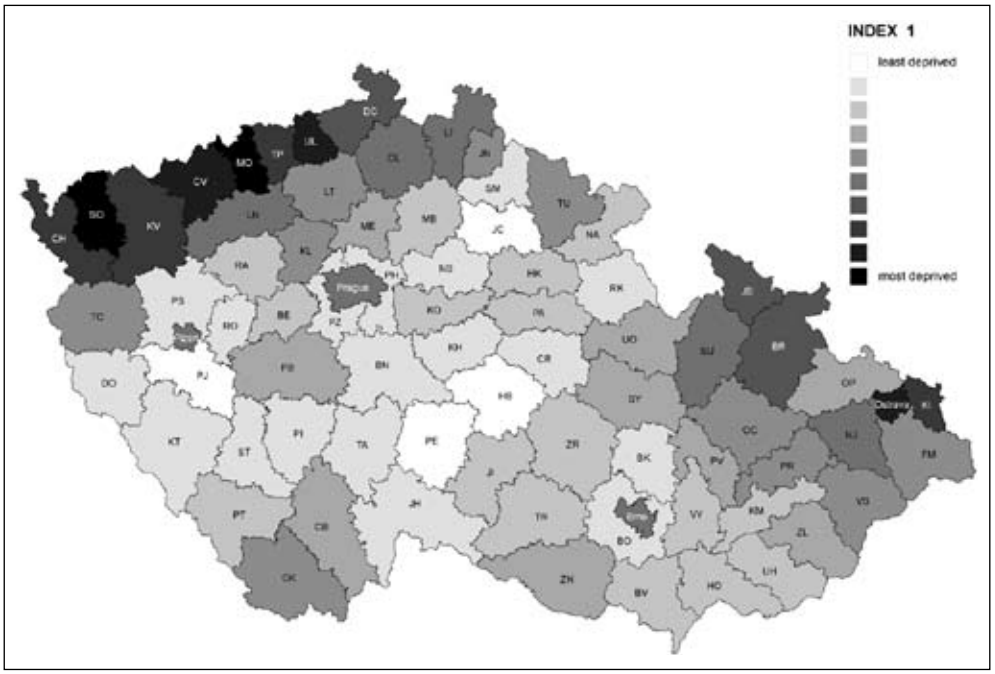

Figure 1. Distribution of INDEX1 in districts of the Czech Republic.

Construction of the SESDI at district level (77 districts in the Czech Republic) used the same methods as for ED level. The final values of INDEX2 ranged between 0 and 9. Table 2 includes descriptive characteristics of components and indices at the district level.

Correlations between indices were high (r = 0.77 to 0.99). The lowest correlation was found again between INDEX2mat and INDEX2soc (r = 0.77).

The districts are presented by the level of deprivation using INDEX1 (Fig. 1) and INDEX2 on 10-degrees scale from the least to the most deprived.

The newly constructed indices were used for the correlation analysis between district deprivation level and level of total and specific SMR. The causes of death were selected based on the outcomes of our pilot study on relationships between specific SES factors from national census data at district level and mortality.[22] In published results,[4, 23] deprivation was reported to be correlated with mortality data, especially SMR for CVD.[18]

Results of correlation analyses (Pearson's correlation coefficient) between SMR (total and specific) and indices and subindices (INDEX1, INDEX2, INDEX2mat and INDEX2soc) are summarized in Table 3.

Table 3. Correlation between indices and sub-indices and SMR.

Cause of Death (ICD-10 code+)	INDEX1		INDEX2		INDEX2mat		INDEX2soc	
	men	women	men	women	men	women	men	women
All (A00 – Y98)	0.60*	0.53*	0.60*	0.52*	0.41*	0.36*	0.72*	0.63*
Cancer (C00–C97)	0.47*	0.44*	0.48*	0.44*	0.31*	0.38*	0.60*	0.46*
Lung cancer (C33-34)	0.55*	–	0.54*	–	0.40*	–	0.61*	–
Breast cancer (C50)	–	0.02	–	0.03	–	0.04	–	0.02
Cardiovascular diseases (I00-I99)	0.32*	0.37*	0.30*	0.36*	0.19	0.20	0.38*	0.48*
Gastrointestinal diseases (K00-K93)	0.53*	0.41*	0.52*	0.40*	0.40*	0.33*	0.58*	0.42*
Respiratory diseases (J00-J99)	0.31*	0.14	0.31*	0.14	0.23*	0.10	0.36*	0.17

+ ICD-10 - International Classification of Diseases (WHO)
* 5 % significance level

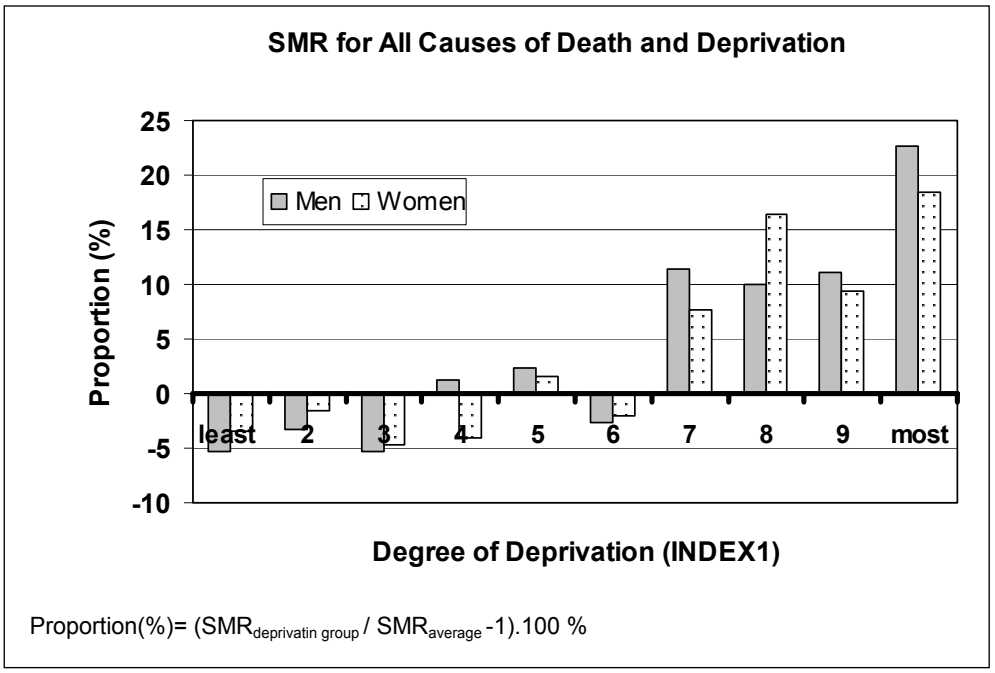

Figure 2. Relationship between degree of deprivation and total SMR in 77 Czech districts.

Positive associations were seen, both in men and women, between deprivation and total mortality, cancer mortality, and mortality for gastrointestinal diseases, and between deprivation and mortality for lung cancer in men. These associations were stronger in men than in women. A weak positive association was seen between deprivation and mortality for respiratory diseases and cardiovascular diseases (in both sexes).

Further analyses using INDEX2soc and INDEX2mat also showed that the total and specific SMRs in men and women were more strongly correlated with components of social deprivation than material deprivation (Table 3).

Relationships between deprivation (INDEX1) and total and selected specific SMRs in the Czech Republic are presented in Fig. 2 (0 = average SMR of all 77 districts in CR).

Increased total and selected specific SMRs were associated with the highest degrees of deprivation (7–10th degree). The highest increase was found for gastrointestinal disease mortality in women (up to 53.6 %), lung cancer mortality in men (up to 44.0 %) and gastrointestinal disease mortality in men (up to 37.6 %) in comparison with the average SMR. The highest degree of deprivation (7–10) was found in 15.6 % of districts with a combined population of 1 681 thousands inhabitants, out of the total 10 million inhabitants of the Czech Republic.

Discussion

Positive associations between deprivation and total mortality, cancer mortality, mortality for gastrointestinal diseases and, in

men mortality for lung cancer, have been the principal findings of the study. Detailed results confirmed that total and specific SMRs in men and women were more strongly correlated with factors of social deprivation than material deprivation.

In spite of continuing discussion over recent decades about using combined indices of deprivation, creating the SESDI allows the measurement of deprivation – a measure that provides an important basis for explanation of health differences.[24] Since the 80s, when the well known report of Sir Douglas Black[25] presented evidence that, apart from age and sex, the main determinant of ill health was poverty, it has also been important to monitor trends of deprivation, and it has been confirmed that the health inequalities gap has deepened in Great Britain during the last 20 years.[26]

In the presented study mortality data were analysed at the district level – the level at which existed the highest available spatial resolution of routinely collected data. Availability is a common problem with this type of data, but the choice of spatial scale is very important – the larger the unit of analysis, the more likely it is that problems of ecological fallacy will apply.[18] By analysing indicators in larger areas, outlier values of indicators in smaller areas are smoothed.

The SESDI was based on census data and was created by using two methods. The first method originated from the Townsend index,[17, 19] described as the best indicator of material deprivation currently available.[17] The other method was based on the methodology of MATDEP and SOCDEP index.[17] Correlation of both the newly constructed indices INDEX1 and INDEX2 was high in both enumeration district and district level. Similarly in favour of census based indices predicated also results of comparative analysis of index Area deprivation in Scotland using χ^2 and indices Jarman, MATDEP, Oxford, Townsend and Carstairs using Z-scores. The correlation between indices was high (0.63–0.84) in spite of the fact that the indices used different combinations of components and different statistical methods.[18]

There exists, however, some criticism of census based indices, e.g. Gordon[16] warned of their low validity. He used the regression analysis for comparison of census data and Breadline Britain Survey data, and only 82 % of cases were correctly classified.[16] On the other hand Carstairs and Morris[4] found that standardization for social class had only a little effect on mortality data, but mortality was radically adjusted when using the indices.

The main advantage of census based indices (which are, besides, the easiest and cheapest way of gathering data on deprivation) is their absolute coverage, reliability and representativness. Disadvantages include the fact that the census questionnaire is not created with a specific aim of measuring deprivation, and that no information is available for development of indicators in the 10-year period between two censuses.[18] In spite of some doubts regarding the accuracy of census based indices in between periods, Townsend, Jarman and Carstairs indices are commonly used in public health in Great Britain.[27] Deprivation indices are routinely used for analysis of health data and also for allocation of resources and primary care.

The presented analysis found that more than 1.5 million of the Czech population is threatened by the highest degrees of deprivation. Due to confirmed associations with increased total and selected specific SMRs public health policy should apply policy measures and health promotion strategy to decrease this health inequalities gap.

In conclusion, socio-economic deprivation indices are very good tools for identifying deprived areas. The indices described in this paper used different sources of data and were combined in different ways, but analyses confirmed that use of census data for their construction is applicable.

Using these data is the least labour-consuming and the least expensive, but the resulting index has its limitations. It has to be updated after each new census, and its validity decreases with time from the last census.

Analyses of relationships between deprivation and total and selected specific SMRs in the Czech Republic confirmed that increased mortality was associated with the highest degrees of deprivation.

Results from analyses of relationships between socio-economic deprivation indices and mortality data at area level might be a source of hypotheses for future research.

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