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ENVIRONMENTAL DETERMINANTS OF SELECTED FAMILY-ORIENTED HEALTH INDICATORS

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Abstract. Based on the levels of environmental contamination and degradation, synthetic measures of environmental hazards in urban and rural regions in Poland were developed. At the same time, negative family health indicators associated with environmental contamination were determined. These indicators included: low birth weight, fraction of deaths with low birth weight, excessive male and female mortality in the 30–64 age group. The study revealed a relationship between synthetic measures of environmental hazards and selected health indicators. This relationship, along with the spatial distribution of areas with the highest index values, should be taken into consideration while planning improvements and preventive activities.

For several years the activities of the Department of Environmental Health Hazards at the Nofer Institute of Occupational Medicine, Poland, have been focused on the development of methods for a quantitative assessment of environmental hazards which produce adverse effects on the population's health. These projects have resulted in a number of original developments following the principles of environmental toxicology. They concern the assessment of environmental health hazards over large country areas (1,2,3,4).

The present paper deals with the spatial relationships between the level of environmental contamination and selected negative family health indicators in urban and rural regions in Poland.

FAMILY HEALTH STATUS IN POLAND

The turn of the 1980s is marked by a substantially slow rate of population growth in Poland. The decreased female fertility is accompanied by low birth rate and high general mortality rate (over 10%) last noted at the beginning of

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the postwar period. The 1993 report of the State Demographic Commission (6) revealed a deterioration of the population's health status due to cardiovascular diseases, cancer, injury and poisoning. For example, an upward tendency in martality from cardiovascular diseases in Poland, results in a higher by 60% standardized mortality ratio (SMR) as compared to the values of West European countries, where a reverse trend has been observed.

An increased territorial differentiation between the general and specific mortality rates is worth noting. Poland is known to have a high rate of premature deaths, especially in the 45–65 age group.

Following Bejnarowicz (7) who quotes literature data on the subject, the health status of Polish families (88% of the whole Polish population) (8) depends primarily on lifestyles and dietary habits, including cigarette smoking, alcohol consumption, daily diet, physical activity – personal and population characteristics which are modifiable.

The lifestyle factors are also partly linked with the problem of disintegration of Polish families. The percentage of illegitimate births has increased (5) while the general birth rate has been declining, which poses a severe social problem of orphanhood.

Disadvantageous dietary habits and behaviours lead to the development of adverse health effects among the family members. They include elevated incidence of artherial sclerosis, ischaemic heart disease, myocardial infarction, cancer, liver cirrhosis, nervous system impairments, obesity, injuries and disability. Parental negative health behaviours also affect the quality of health of newborns resulting in: increased rate of low birth weight and risk of congenital malformations.

Analyses of mortality rates by sex and age reveal that their persistent high level, characteristic of the postwar period (over 10 deaths per 1.000 inhabitants), is mostly due to excessive deaths of males in the 45–64 age group (9,10). At this age people become more vulnerable to different health impairments and health risks, which may be associated with individual health behaviour on the one hand, and occupational status related with increasing responsibility and psychosocial stress, on the other. The psychosocial stress is aggravated by the employment situation, particularly by the fear of losing job as a result of close-downs, and little likelihood of reemployment in one's forties or fifties.

Furthermore, there is strong evidence that the long-term effect of communal and occupational hazards contributes to an increased risk of ill health not only among adults (parents, grandparents) but also among children.

Investigation of the cause-effect relationship between environmental contamination and the health condition of the population at risk is not an easy task because of two reasons:

1. environmental contaminants are accompanied by physical, biological and psychosocial factors which induce delayed health effects, and

2. routinely collected data on health status do not allow to identify directly high risk groups (children, the elderly, the sick) and the reference populations living in areas with low levels of environmental contamination.

The methodological approach proposed by the authors is aimed at making such identification feasible.

METHODS

Bearing in mind that the system of monitoring environmental hazards in Poland is incomplete and far from being perfect (11 – 13), it seems rather difficult to base environmental and health assessment on the dose-effect and dose-response relationships. The method applied in the present study employs some dose-related parameters which apply to chemical contamination or its effects such as environmental degradation, population's exposure, environmental health hazards.

The level of environmental health hazards were defined either as the indicator of a particular, chemical contamination, or its effect, per square measure unit of the area under study, or as the concentration of a chemical in the atmospheric air or other environmental medium (water, soil) (16). The urban and rural regions were considered separately owing to the different environmental hazards in either of them (17). It is worth noting that although urban regions are about 8 times smaller than rural ones, their population is about twice as large.

The relationship between negative health indicators and environmental contamination may be used as a retrospective method for relative risk assessment.

The attention is focused only on these indicators which are closely related with chemical contaminations resulting from human activities and posing the highest health risk (11 – 13). They include: the number of environment-hostile industrial plants, industrial equitoxic dust and gas emissions, industrial and communal wastes, untreated waste-water discharges to surface waters, forest damage, use of fertilizers and calcium, area covered by dumping grounds (11). People exposure was assessed by mean annual equitoxic concentration of major atmospheric pollutants (SO_2, NOx, dust) (11 – 13). Ecological characteristics of regions (voivodships) was analyzed, separately for urban (towns and suburbs and urban administration units) and rural regions (rural administration units).

The diagnostic indicators of environmental contamination were used for calculating a synthetic measure, based on the taxonomic model. This method was previously adopted when developing a synthetic measure of environmental contamination (16,17,18) the population health state (19) and in other studies on the aggregation of complex phenomena (20 – 28).

In order to aggregate different kinds of diagnostic indicators one must standardize the indices of the data matrix using the standardization of variables (21). Common methods of standardization bring all values of attributes to the defined range of values. Synthetic measures of complex phenomena are taking the values from 0 to 1 (16 – 21,28,29).

The synthetic measure of environmental health hazards (Ss), after Strahl, was calculated according to the following formula (16,28):

$$S_s = 1 - \frac{1}{m}\sum_{j=1}^{m}\frac{Y_{ij}\text{min}}{Y_{ij}}$$

where: Y_{ij} – diagnostic index, variable "i" in region "j"
Y_{ij}min – minimum value of index "i" in region "j"
m – number of variables in the set of values.

The synthetic measure of environmental health hazards in regions under study was compared with the negative family-oriented health indicators. In order to assign index values to the synthetic measure, the authors used the method described previously (1–4,16–19,21,29). The method is based on the division into three equal-number groups according to the following scheme. For each of the two kinds of regions a logarithm was calculated for the set of synthetic measure values as well as an arithmetic mean of the logarithmic values (Avg) and standard deviation (Std) was identified. Then, each set of data separately for the urban and rural regions was divided into three groups according to the index value attributed:

$$0 < Ss < Avg - 1/2\ Std$$

index 1, region with the lowest environmental contamination health risk

$$Avg - 1/2\ Std < Ss < Avg + 1/2\ Std$$

index 2, region with high environmental contamination health risk

$$Ss > Avg + 1/2\ Std$$

index 3, region with the highest environmental contamination health risk.

The same index method was used for perticularly negative health indicators based on relative risk coefficients (29) determined after the following formula

$$R = P(A)/P(B)$$

where: P(A) – coefficient of the rates of particular health problems in the areas with the highest level of environmental hazards
P(B) – respective coefficient value for the reference areas with low level of environmental hazards.

The A and B areas were selected following the analysis of the spatial distribution of contamination measures and environmental degradation by chemicals. The data was obtained from the routinely collected information, and taxonomic measure was developed on this basis. The A area covers south-western and central voivodshpis: Kraków, Katowice, Jelenia Góra, Wałbrzych and Łódź. The B area are the least contaminated northern and eastern, voivodships: Siedlce, Ciechanów, Biała Podlaska, Suwałki and Koszalin.

Two criteria of indicators selection were adopted: arbitrary criterion (R > 120%) and the criterion based on the determination of confidence interval for relative risk after Jędrychowski (30). Eventually, the following indicators were selected to evaluate negative family-oriented health effects in relation to environmental hazards: fraction of births with low birth weight (below 2500 g), mortality fraction of infants with low birth weight, and crude rate of male and female mortality in the 30–64 age group, per 10,000 persons. The values obtained were indexed following the method applied to evaluate the synthetic measure of environmental hazards.

RESULTS

Evaluation of environmental pollution

The index values assigned to the synthetic measures of environmental contamination in urban and rural regions are presented in Fig. 1.

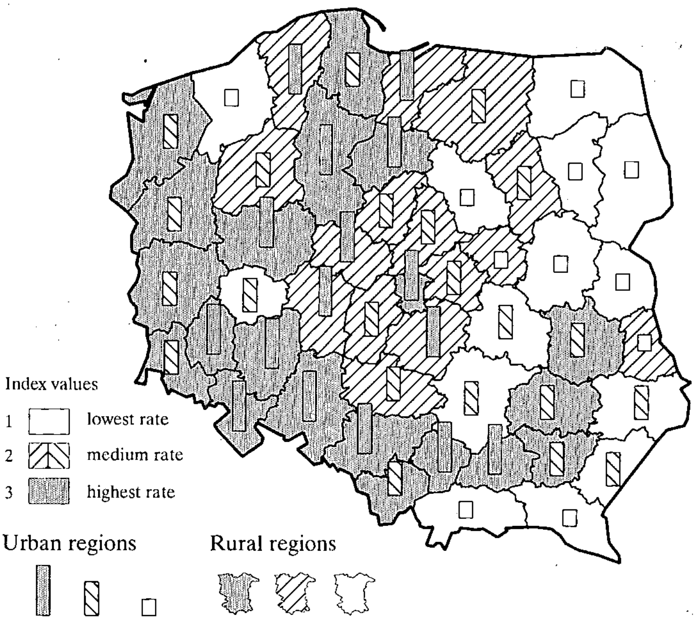

Fig. 1. The level of synthetic measure of environmental indicatores in the voivodships in Poland.

Index 3, applies to these areas where the impact of environmental contaminants could be manifested as an increase in the values of negative health indicators.

Index 1, the least contaminated areas and thus not affecting the health index values.

The urban regions with the highest level of contamination, selected using the index method, were found in 16 voivodships.

The similarly contaminated rural regions where found in 20 voivodships.

The highest values of synthetic measures (index 3), were found in both the urban and rural areas of the following voivodships: Bydgoszcz, Legnica, Łódź, Opole, Katowice, Tarnów, Toruń, Wrocław, Poznań, Kraków, Wałbrzych.

In index 2 areas with high environmental health risk such relationship was found in 8 voivodships, which constitutes 36% of the urban and 23% of the rural areas.

Index 1 group with the lowest level of environmental hazards, includes urban and rural regions in 8 voivodships.

Spatial distribution of the family health indicators

The rate of births with low birth weight is a measure of the reproduction pathology, determined by factors affecting parental and particularly maternal health (very young age), pre- and extramarital pregnancies, maternal diseases, working and living conditions and the related social status, smoking and alcohol drinking, dietary habits and congenital diseases.

Another group of factors includes environmental contaminants and their health hazards which are mostly responsible for the rate of births with low birth weight.

The highest rates were noted in 13 urban and 18 rural regions (Fig. 2). The lowest values were recorded in 14 urban and 13 rural regions.

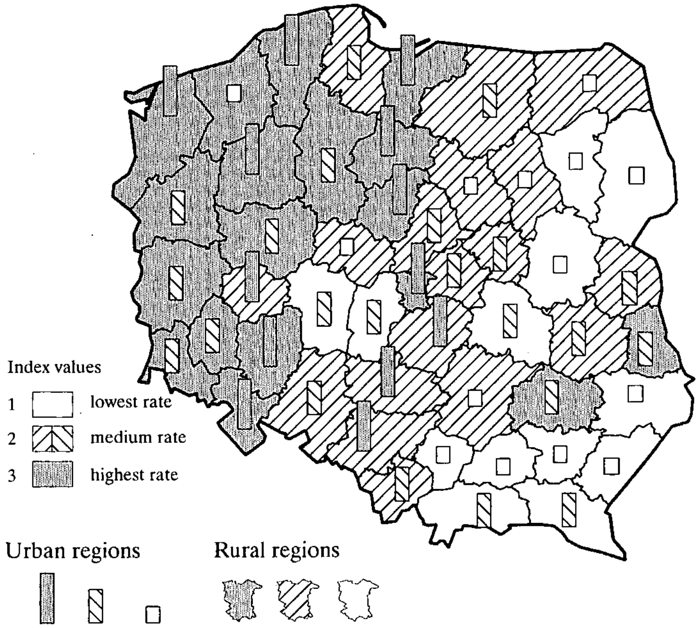

Fig. 2. Fraction of births with low births weight (<2500 g).

Mortality of infants with low birth weight depend not only on availability and efficiency of paediatric care but also on family living conditions. The highest values of mortality rate in this group of infants were found in 16 urban and 14 rural regions (Fig. 3). These, however, are voivodships with a relatively low environmental contamination, but with worse standard of paediatric care and the worse socio-economic conditions, when compared with other regions of the country.

A characteristic feature of mortality in Poland is co-called "premature death". Both in the 1993 report of the National Demographic Commission (6) and in the Bejnarowicz study (7) as well as in our earlier reports (10) it was stressed that the upward tendency in the general mortality rate observed in 1966–1985, was mainly due to the increased number of premature deaths (mostly of males) in the 39–64 age group. Accordingly, this indicator was selected as one of the environmental hazards to be investigated. Bejnarowicz reports that 92.5% of premature male deaths in the 45–64 age group was caused by cardiovascular diseases (54.8%), malignant neoplasms (27.5%) and injury and poisoning (10.2%).

An analysis of spatial distribution of regions with the highest rates of premature deaths suggested a possible impact of environmental contamination on the level of this parameter (Fig. 4). Particularly stressed should be the proportion of premature

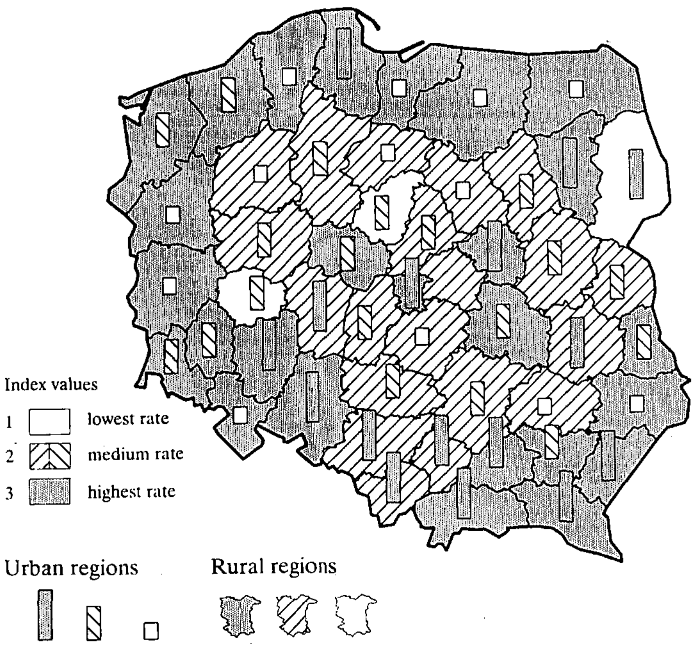

Fig. 3. Mortality of infants with low birth weight (<2500 g).

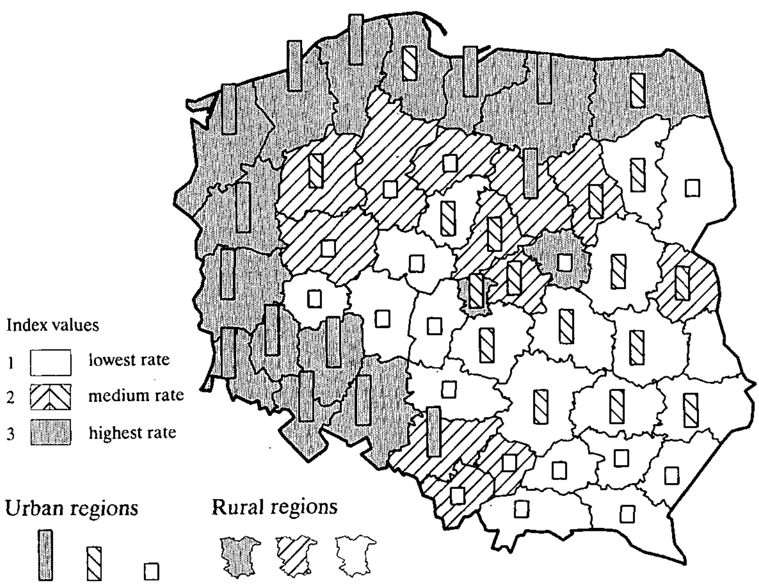

Fig. 4. Premature deaths in the 30–64 age group.

deaths in 14 urban and 16 rural regions of the voivodshpis. These high values may also be associated with occupational hazards among males in urban regions, e.g. in the mining and maritime industries.

The lowest rate of premature deaths was noted in 17 urban and 21 rural regions with relatively favourable environmental conditions.

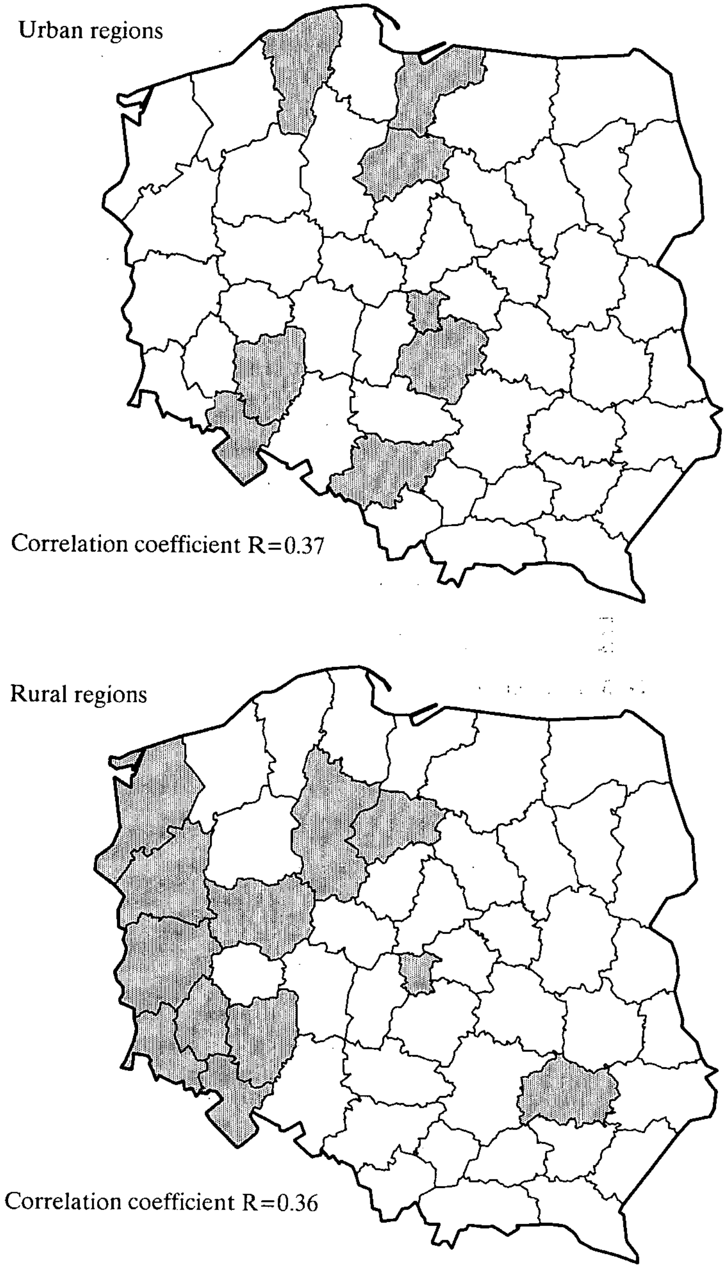

Fig. 5. Concomitance of the highest index values of the synthetic measure of environmental hazards and the fraction of the births with low birth weight (<2500 g).

The relationship between the synthetic measure of environmental hazards and negative health indicators

In order to evaluate the extent to which environmental contamination and degradation are responsible for negative family-oriented health indicators, the

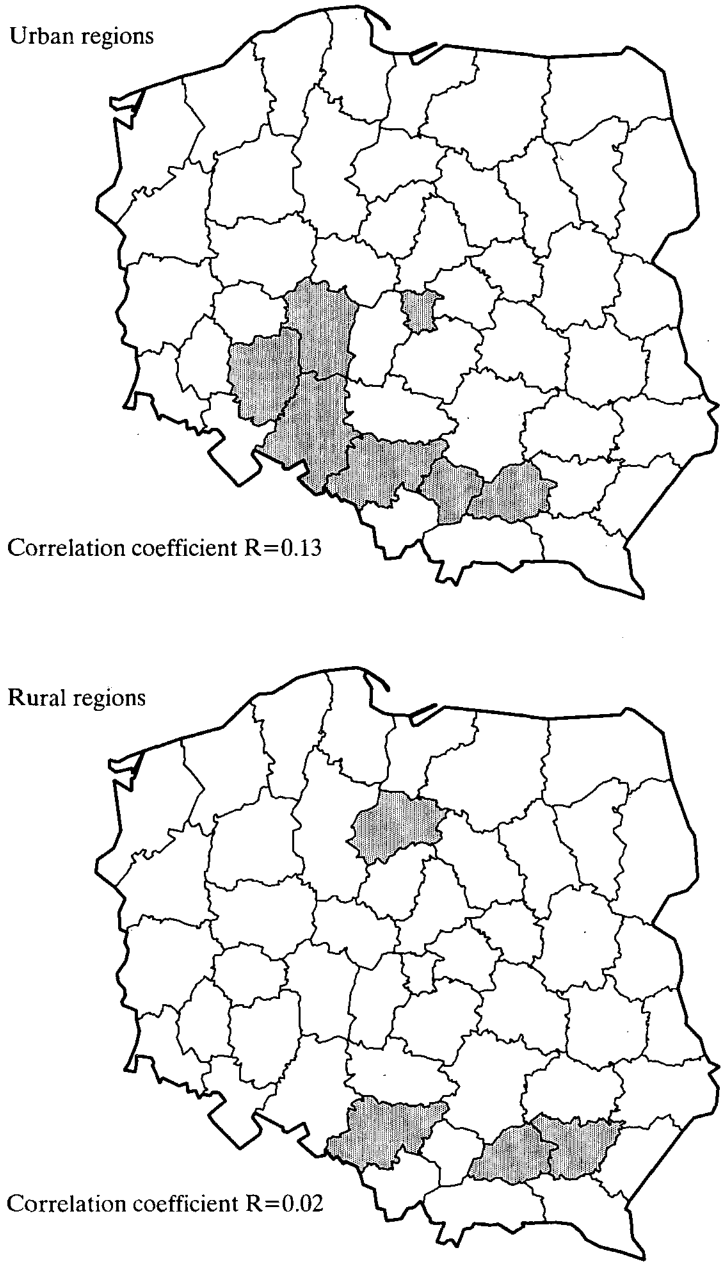

Fig. 6. Concomitance of the highest index values of the synthetic measure of environmental hazards and mortality of infants with low birth weight (<2500 g).

correlation between the synthetic measure of environmental hazards and rates of births with low birth weight, mortality of infants with low birth weight and premature deaths of males and females in the 30 – 64 age group in urban and rural regions was analyzed. Moreover, the relationship between the synthetic measure and each of the selected negative health indicator was investigated.

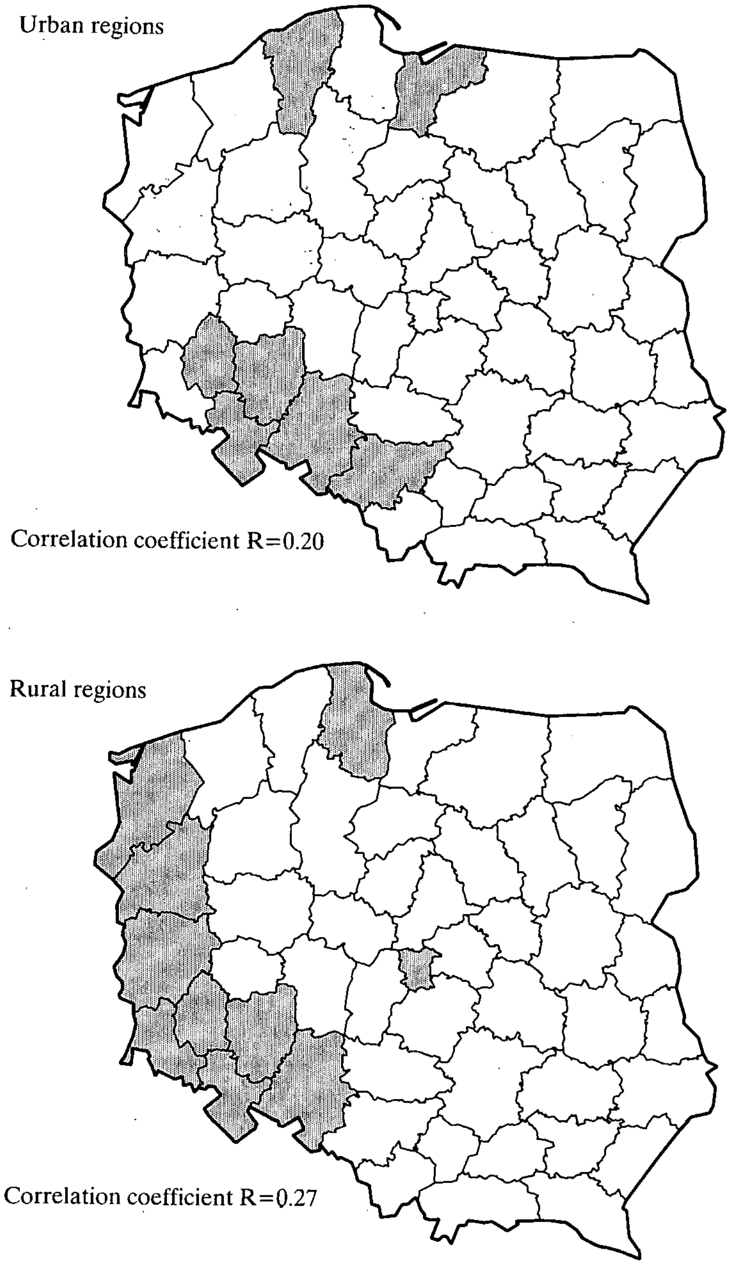

Fig. 7. Concomitance of the highest index values of the synthetic measure of environmental hazards and the fraction of premature death.

Figure 5 presents the relationship between the environmental contamination and fraction of births with low birth weight. The highest values were found in 8 urban regions of the following voivodships: Słupsk, Elbląg, Toruń, Łódź, Piotrków, Wałbrzych, Wrocław and Katowice, the correlation coefficent amounting to 0.37 (the grey areas in Figs. 5, 6, 7 represent the highest index value).

A high correlation coefficient (0.36) was also found in rural regions. The highest index of environmental hazards and the fraction of births with low birth weight was observed in 12 voivodships: Szczecin, Bydgoszcz, Toruń, Gorzów, Poznań, Zielona Góra, Łódź, Jelenia Góra, Legnica, Wałbrzych, Wrocław and Tarnobrzeg. As depicted above, the highest index values in this respect refer to both the urban and rural regions of the Toruń, Łódź, Wałbrzych and Wrocław voivodships where the high level of environmental hazards may affect the population's health. This finding seems to be even more likely as there are no differences between the voivodships in the microclimate, population density and structure of employment, therefore high pollution is the only common feature.

Figure 6 illustrates the correlation between the highest index values of environmental hazards and the mortality of infants with low birth weight in particular voivodships. This correlation was found in urban regions of the southern voivodships: Wrocław, Kalisz, Opole, Katowice, Kraków and Łódź and in rural regions of the Bydgoszcz, Katowice, Rzeszów and Tarnów voivodships. Low correlation coefficients — 0.13 for the urban regions and 0.12 for rural ones confirm previously discussed low correlation between environmental contamination and mortality of infants with low birth weight. It seems that the long-lasting high level of environmental contamination may influence the value of this health indicators only in the Katowice voivodship.

Figure 7 presents the correlation between synthetic measure of environmental hazards and the index values of premature deaths of males and females in the 30—64 age group. The correlation coefficient was found to be 0.20 for the urban regions and 0.27 for the rural ones, which could indicate a relationship between this health indicator and environmental contamination with chemicals. The urban regions with the index 3 values were found in 2 northern voivodships: Słupsk and Elbląg and 5 south-western voivodships: Legnica, Wałbrzych, Wrocław, Opole and Katowice. In the rural regions the highest index values apply to the Gdańsk, Szczecin, Gorzów, Zielona Góra, Jelenia Góra, Legnica, Wałbrzych, Wrocław, Opole and Łódź voivodships. The effect of environmental contamination on fraction of premature deaths was found in the voivodships where the highest index values refer both to the urban and rural regions, i.e. in the Legnica, Wałbrzych, Opole and Wrocław voivodships.

CONCLUSIONS

1. The synthetic measures of the multi-compartmental environment can be used for an analysis of spatial distribution of environmental characteristics over large country areas (urban and rural regions).

2. Variations of the selected negative family health indicators were found in all the 49 voivodships and in urban and rural regions of a particular voivodships and were not always related to the chemical contamination of the environment.

3. The highest correlation between the synthetic measure of environmental hazards and selected health indicators applied to rates of births with low birth weight (R = 0.37) and premature deaths (R = 0.20) in urban regions, for the fraction of births with low birth weight (R = 0.36) and the rate of premature deaths (R = 0.27) in rural regions.

4. The spatial distribution of family-oriented health indicators should be considered in planning improvements and preventive activities.

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