International Journal of Occupational Medicine and Environmental Health, Vol. 7, No 2, 135–142, 1994

SPATIAL DISTRIBUTION OF NEGATIVE HEALTH INDICES IN ECOLOGICAL HAZARD AREAS IN POLAND

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Key words: Negative health indices, Synthetic measure of health indices, Relative risk of mortality, Distribution of negative health indices, Ecological Hazard Areas

Abstract. Spatial distribution of negative health indices (relative risk, synthetic measure) was demonstrated in 27 ecological hazard areas (EHAs) in Poland. For comparison reference areas were selected. The health indices were used for developing a general index of harmfulness characteristic for individual EHA.

The health status ranking in EHAs is useful in setting priorities for remediation.

INTRODUCTION

About ten years ago 27 ecological hazard areas (EHAs) were identified in Poland, chiefly for planning purposes. They cover 11% of the whole country and 1/3 of the population (3). The EHAs are highly differentiated not only because of their size and number of population but also in respect to contamination and degradation of the environment and exposure of the population to toxic substances. Consequently, negative health indices in those areas could reflect various conditions existing in each EHA.

Until now, the evaluation of such large areas from the ecological point of view has not been performed, chiefly because of lack of methods appropriate for such complex evaluation (1). This task has been undertaken by the Department of Environmental Health Hazard, the Nofer Institute of Occupational Medicine. The developed method is based on scoring of 12 selected parameters characterising the environmental pollution and degradation as well as exposure and health status of the population. The parameters characterising EHAs were selected in such a way that existing and available data were used and the uniform calculation method was

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applied for establishing of index values which allowed for obtaining comparable results. In turn such ranking will serve as a new tool for rational environmental quality management in Poland.

The aggregation of single index values of each parameter produces one general index of harmfulness. The general index classifies EHAs according to the most essential causes and effects of environmental contamination and it is used for ranking EHAs necessary for priority setting (1).

According to preliminary assumptions the model for aggregation of the individual index values was constructed in such a way that the health status indices play a predominant role in creation of the general index of harmfulness (1). They are recognised as the most essential parameters which characterise the EHAs.

Negative health indices, which are an important part of aggregation model were carefully selected. Various health indices were considered and compared in EHAs and reference "clean"areas (2). Those indicating the biggest differences were used for developing a synthetic measure by aggregation of single index values using Stahl's formula (6). Additionally, index of relative risk mortality was calculated (4, 5).

The EHAs are not uniform in their construction. For spatial evaluation, at least, the urban and rural regions should be distinguished and it is why the health indices were calculated separately for those two regions in each EHA. In each EHA and in the reference area, the population of urban region is related to administrative units of towns and quarters of towns. Spatial distributions of negative health indices provide an important information on environmental health and, at the same time they produce a territorial index for evaluation of EHAs in Poland. For this reason, we decided to present the spatial distribution of negative health indices as a cross-section of data from the year 1989.

MATERIALS AND METHODS

Ten million persons inhabiting urban and rural regions of EHAs, and 1.3 million persons living in reference "clean" areas were covered by the study. The percentage of towns and rural areas in all EHAs and in reference areas, populations living there and number of administrative units in urban and rural regions are given in Table 1.

The standard health indices were analysed in various variants and those showing the biggest differences between EHAs and references areas were selected for the construction of the synthetic measure. They are:

- low weight at birth rate (bellow 2500 g),
- infant mortality rate,
- excess mortality rate in men aged 40–59 years,
- mortality rate from cardiovascular diseases in persons aged 30–59 years,
- mortality rate from cardiovascular diseases in persons aged 60 years and above,
- mortality rate from cancer in person aged 60 years and above.

For the aggregation of the above indices the formula after Strahl (5) was adopted:

$$S_i = \frac{1}{m} \sum_{j=1}^{m} Y_{ij}' = \frac{1}{m} \sum_{j=1}^{m} \frac{Y_{min}}{Y_{ij}}$$

where: Y – selected variable,

Table 1. Characteristic of urban and rural regions in EHAs and in the reference area

Number of EHA	Name of area	Percent of EHA population inhabiting in		Percentage of EHAs area		Number of administrative units in	
		urban region	rural region	urban region	rural region	urban region	rural region
1.	Szczecin EHA	89	11	19	81	10	13
2.	Gdańsk EHA	90	10	21	79	15	15
3.	Poznań EHA	92	8	32	68	10	6
4.	Bydgoszcz-Toruń EHA	89	11	17	83	5	11
5.	Inowrocław EHA	73	27	7	93	5	5
6.	Konin EHA	65	35	11	89	4	8
7.	Włocławek EHA	84	16	15	85	2	4
8.	Płock EHA	90	10	26	74	1	2
9.	Legnica-Głogów EHA	72	28	6	94	12	29
10.	Wrocław EHA	95	5	39	61	8	4
11.	Bełchatów EHA	–	100	–	100	–	2
12.	Łódź EHA	92	8	47	53	9	4
13.	Tomaszów EHA	76	24	10	90	1	3
14.	Puławy EHA	57	43	13	87	3	7
15.	Chełm EHA	52	48	4	96	2	9
16.	Turoszów EHA	72	28	18	82	4	4
17.	Jelenia Góra EHA	85	15	57	43	5	3
18.	Wałbrzych EHA	91	9	46	54	7	3
19.	Częstochowa EHA	88	12	48	52	2	4
20.	White Basin EHA	74	26	12	88	2	7
21.	Tarnobrzeg EHA	59	41	13	87	8	19
22.	Opole EHA	82	18	35	65	8	7
23.	Rybnik EHA	78	22	45	55	6	11
24.	Myszków-Zawiercie EHA	100	–	100	–	4	–
25.	Upper Silesia EHA	94	6	70	30	31	15
26.	Kraków EHA	73	27	17	83	10	27
27.	Tarnów EHA	59	41	12	88	4	9
	Reference area	39	61	3	97	76	327

i – index of area,
j – index of health status parameter,
m – number of variable

The synthetic measure after Strahl has values from 0 to 1. Health status in EHA is better when the value of synthetic measure is lower.

The relative mortality risk (4, 5) was calculated as a ratio of standardised mortality rate (SMR) in the polluted EHAs and in the reference "clean " areas (2). Both health indices show relative values for urban and rural regions, separately, and are not comparable between urban and rural regions. The specification of EHAs is as follows: 1 – Szczecin, 2 – Gdańsk, 3 – Poznań, 4 – Bydgoszcz-Toruń, 5 – Inowrocław, 6 – Konin, 7 – Włocławek, 8 – Płock, 9 – Legnica-Głogów, 10 – Wrocław, 11 – Bełchatów, 12 – Łódz, 13 – Tomaszów, 14 – Puławy, 15

— Chełm, 16 — Turoszów, 17 — Jelenia Góra, 18 — Wałbrzych, 19 — Częstochowa, 20 — White Basin, 21 — Tarnobrzeg, 22 — Opole, 23 — Rybnik, 24 — Myszków-Zawiercie, 25 — Upper Silesia, 26 — Kraków, 27 — Tarnów.

The "clean" reference areas apply to the following voivodships: B — Białystok, BP — Biała Podlaska, C — Ciechanów, K — Krosno, Ł — Łomża, S — Siedlce, Z — Zamość (2).

Absolute values of the synthetic measure were divided into three groups using geometric mean (Avg) and standard deviation (SD) in the following way:

group 1 (index 1) — tolerable values (values > Avg + 1/2 SD) — areas of anthropopression,

group 2 (index 2) — excessive values (values from Avg + 1/2 SD to Avg — 1/2 SD) — areas of degradation,

group 3 (index 3) — inadmissible values (< Avg — 1/2 SD) areas of ecological disaster.

Relative mortality risk values were divided in the same way but the index values were calculated as follows:

index 1 — areas of anthropopression (values < Avg—1/2 SD),

index 2 — areas of degradation (values from Avg—1/2 SD to Avg + 1/2 SD),

index 3 — areas of ecological disaster (values > Avg + 1/2 SD).

In such a way all values were divided into three, almost equal ranges. The lowest index value 1 could be considered as admissible as such values are frequently found in "clean" reference areas.

RESULTS AND DISCUSSION

The values of relative risk of death and synthetic measure of negative health indices are illustrated in Tables 2 and, 3 and index values of these parameters are presented on the maps. On the maps urban and rural regions were not separated from the whole areas of EHA. Figs. 1 and 2 illustrate the situation in urban and rural regions, respectively. Distributions of values among EHAs show that in urban and rural regions all three levels of indices exist although index 3 value is most frequent in urban regions. This indicates a relatively worse situation in urban regions of EHAs as compared with urban region of reference areas. On the other hand, some urban regions are comparable with urban region in reference territories. These are EHAs which could be considered as not very much polluted.

Rural regions in EHAs were compared with rural regions in reference areas and some indices were found very high, chiefly in highly industrialised EHAs, but also relatively low values were frequent especially in less industrialised EHAs.

Taking into consideration relative risk indices in urban regions (Fig. 1), the highest values of indices occurred in 9 EHAs, and the highest values of synthetic measure were found in 11 EHAs. In rural regions (Fig. 2), the highest values of relative risk indices were found in 8 EHAs and the highest values of synthetic measure occurred in 8 EHAs.

Some areas of ecological hazard (urban or rural regions) could be compared to reference areas. Indices of relative risk mortality were of the same value in 8 urban regions and 9 in rural regions, whereas synthetic measure indices were at the same level as in reference areas in 8 urban and in 9 rural regions of EHA.

Table 2. Relative risk of death values in urban and rural regions of EHAs and in the reference area

Number of EHA	Name of area	Urban region	Rural region
1.	Szczecin	0.98	1.16
2.	Gdańsk	1.22	0.98
3.	Poznań	1.11	1.16
4.	Bydgoszcz-Toruń	1.04	1.06
5.	Inowrocław	1.15	1.29
6.	Konin	1.14	0.97
7.	Włocławek	1.19	1.24
8.	Płock	1.10	1.12
9.	Legnica-Głogów	1.07	1.04
10.	Wrocław	0.99	1.17
11.	Bełchatów	–	0.87
12.	Łódź	1.16	0.91
13.	Tomaszów	1.20	1.05
14.	Puławy	0.80	1.02
15.	Chełm	0.82	1.04
16.	Turoszów	1.07	1.07
17.	Jelenia Góra	0.99	0.94
18.	Wałbrzych	1.12	1.05
19.	Częstochowa	1.08	1.11
20.	White Basin	0.88	0.98
21.	Tarnobrzeg	0.92	1.03
22.	Opole	1.27	1.13
23.	Rybnik	1.14	1.05
24.	Myszków-Zawiercie	1.10	–
25.	Upper Silesia	1.19	0.86
26.	Kraków	1.12	0.99
27.	Tarnów	0.91	0.99
	Reference area	1.00	1.00

Table 3. Values of synthetic measure of negative health indices in EHA urban and rural regions

EHA number	Name of area	Urban regions	Rural regions
1.	Szczecin	0.738	0.431
2.	Gdańsk	0.780	0.512
3.	Poznań	0.729	0.427
4.	Bydgoszcz-Toruń	0.736	0.457
5.	Inowrocław	0.693	0.448
6.	Konin	0.754	0.569
7.	Włocławek	0.673	0.427
8.	Płock	0.768	0.477
9.	Legnica-Głogów	0.732	0.458
10.	Wrocław	0.723	0.493
11.	Bełchatów	–	0.680
12.	Łódź	0.651	0.454
13.	Tomaszów	0.723	0.601
14.	Puławy	0.822	0.676
15.	Chełm	0.899	0.493
16.	Turoszów	0.683	0.456
17.	Jelenia Góra	0.783	0.584
18.	Wałbrzych	0.676	0.394
19.	Częstochowa	0.732	0.448
20.	White Basin	0.865	0.523
21.	Tarnobrzeg	0.835	0.536
22.	Opole	0.723	0.462
23.	Rybnik	0.683	0.474
24.	Myszków-Zawiercie	0.670	–
25.	Upper Silesia	0.631	0.490
26.	Kraków	0.791	0.540
27.	Tarnów	0.729	0.545
	Reference area	0.847	0.660

It should be mentioned, that the values of relative risk indices and synthetic measure indices were not always the same in investigated areas, however the correlation coefficient was high, equal to r = 0.5. This differentiation was understandable as it was related with specific situation in each EHA, mainly with contamination, degradation of the environment and exposure of the population.

It seems that the relative risk index characterised better health status of the population, and the synthetic measure index reflected better the environmental hazard.

Negative health indices along with negative environmental indices were used for developing the general index of harmfulness. The health indices were applied in a form of a product. Such aggregation of environmental and health parameters does not increase the index of environmental factors in the case of the lowest value of health index. On the contrary, in the case of high health index, the general index was significantly increased. This is in agreement with the assumption that health factors should play a predominant role in evaluation of large areas of ecological hazard.

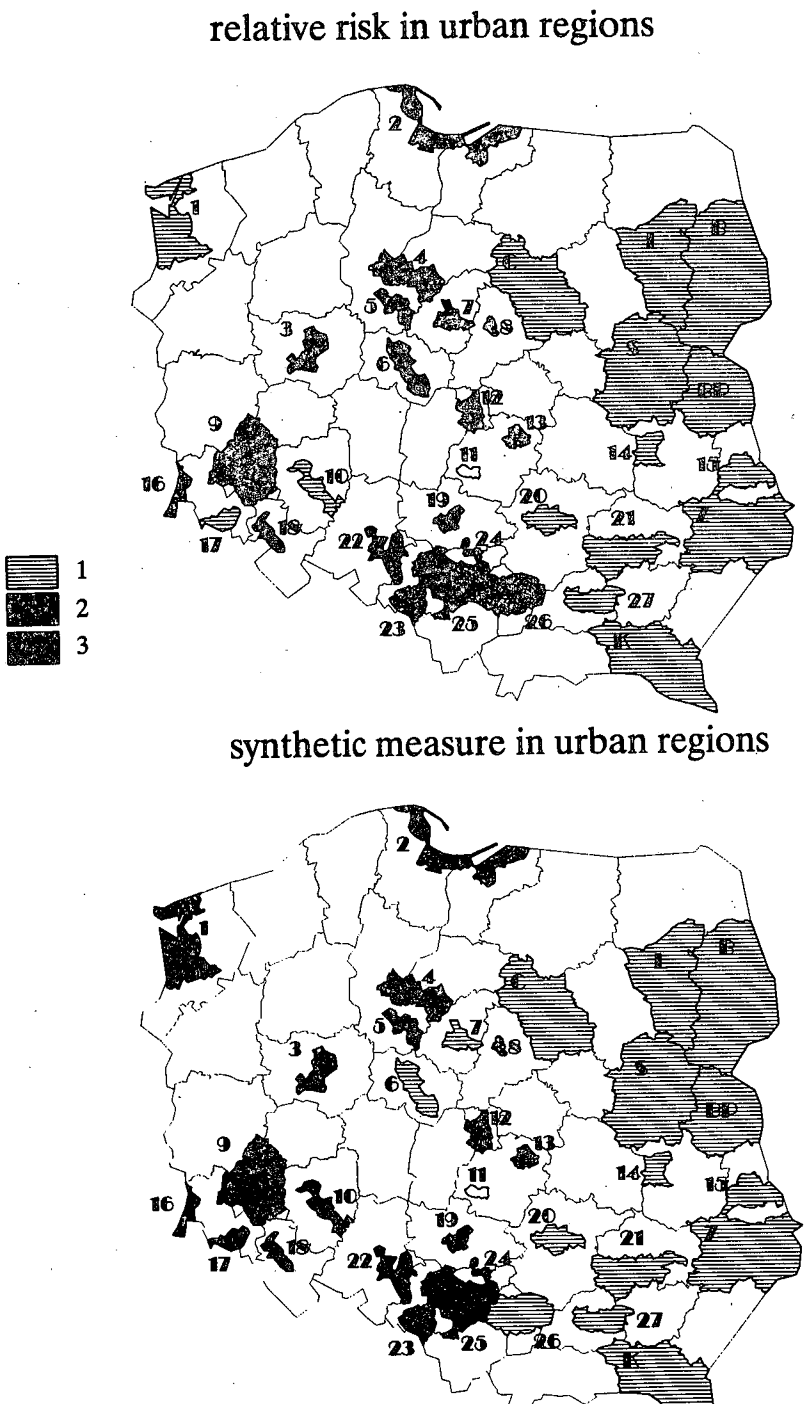

Fig. 1. Negative health effects in EHAs in 1989.

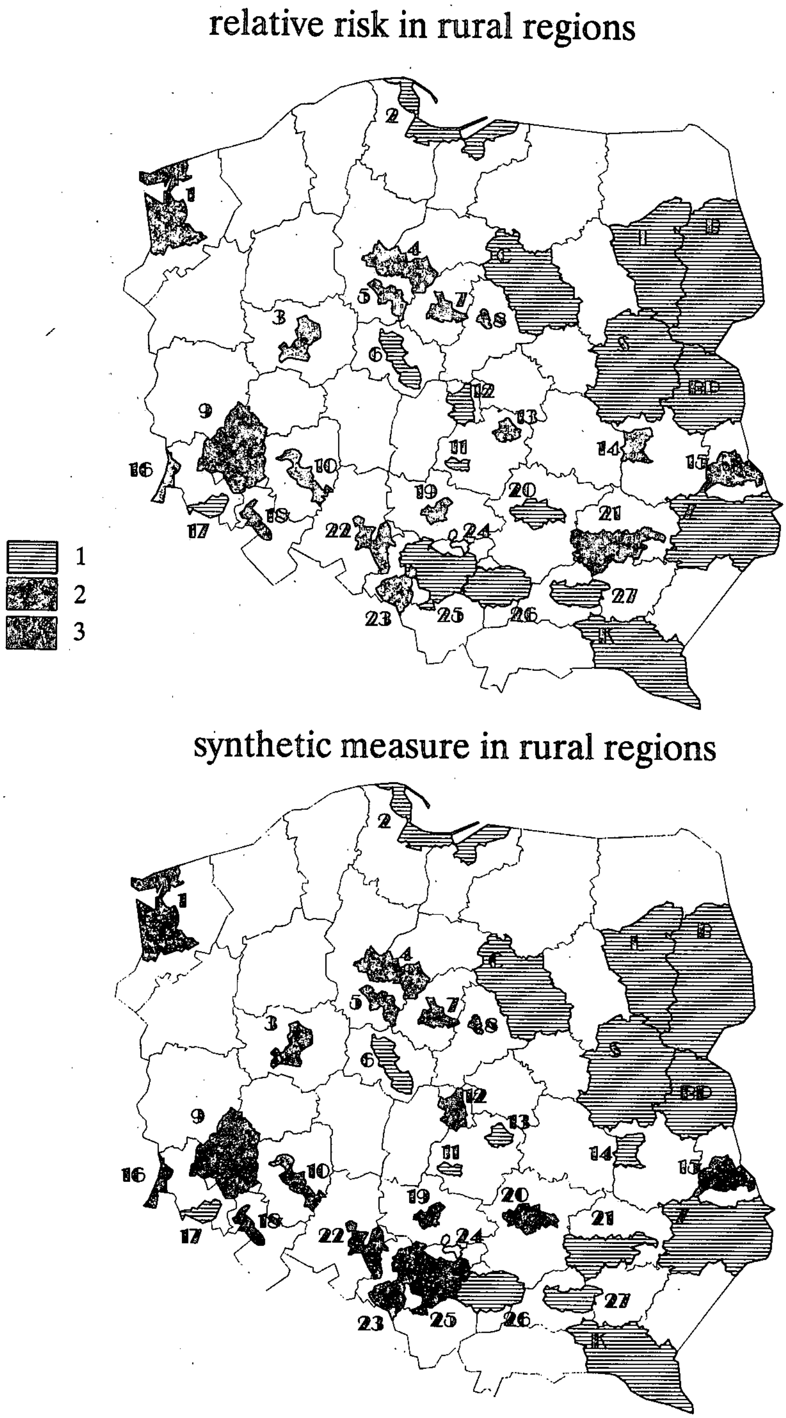

Fig. 2. Negative health effects in EHAs in 1989.

CONCLUSIONS

1. The selected health indices are well applicable for scoring evaluation of health situation in large areas of ecological hazard.
2. Some EHAs existing in Poland are comparable with reference areas in view of health situation.
3. The selected health indices are useful for developing the general index of harmfulness in EHA.
4. The health status ranking in investigated areas creates the basis for setting priorities for improvements.

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Received for publication: July 13, 1993
Approved for publication: April 28, 1994

ERRATUM

In the text of the paper "Spatial distribution of negative health indices in ecological hazard areas in Poland" by Dutkiewicz T, Kończalik J, Andryszek Cz and Rachański D, published in the Int J Occup Med Environ Health 7(2), 135-142, 1994, the following amendments should be made:

page 137 and Table 3

The lower values of synthetic measure indicate worse health status of the population.

Fig. 1 and Fig. 2

Owing to the technical reasons, the differences between index group 2 and index group 3 cannot be identified on the maps. In Fig. 1 the areas no 3, 4, 8, 9, 16, 18, 19, 24, 26 refer to the relative risk group (index value 2), and the areas no 3, 8, 17, 19, 22, 23, 24 refer to the synthetic measure group (index value 2). In Fig. 2 the areas no 4, 9, 13, 14, 15, 16, 18, 21, 23 refer to the relative risk group (index value 2), and the areas no 4, 5, 9, 12, 15, 20, 22, 23, 25 refer to the synthetic measure group (index value 2). The remaining areas marked in black refer to index group 3.