Ecological monitoring of population mortality in Kaunas microdistricts with different levels of ambient air pollution 1992–1997

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Key words: atmospheric air pollution, crude mortality, standardized mortality rate, neoplasms, cardiovascular diseases.

Summary. In Lithuania, the mortality rate is constantly increasing. However, regional differences of mortality rates in a large industrial town were unexplored. The study was carried out in Kaunas, second biggest town of Lithuania with a well-developed industry, as well as high atmospheric air pollution. Harmful effects of the regional environmental complex (dustiness, carbon monoxide, sulfur and nitrogen dioxides) were evaluated by summarized pollution index. Causes of death were taken from certificates of death for 1992–1997. In the study, the 9th revision of International Classification of Diseases and the European age standard were used. Mortality was studied in three microdistricts with threefold differences in levels of air pollution. The age-adjusted death rate (SMR) from all causes in a relatively clean microdistrict – D3 (SMR=1720.5±60.4) is higher than the same indicator of microdistricts with developed industry – D1 (SMR=1446.5±102.1) or heavy traffic – D2 (SMR=1402.7±86.2). In terms of cause-specific mortalities, there is a prevalence of cardiovascular diseases and neoplasms. The SMR from circulatory system disorders (ICD–9 390–459) in D3 is equal 562±56.1, compared to D2 – 509.7±63.9 and D1 – 479.7±79.2. Neoplasms (ICD–9 140–239) are ranked second in the list of causes of deaths. They account for 244.8±32.0 per 100,000 population in D3, 184.4±40.8 in D2 and 221.1±47.6 in D1, respectively.

The overall mortality of the population did not relate to the levels of outdoor pollution. Circulatory disorders and neoplasms are the main cause of death. In a polluted micro district risk of death for a young person is higher, irrespective of accidents, injuries and poisonings.

Introduction
To evaluate the state of health of a population, mortality and morbidity rates are used. The mortality rate in Lithuania is high. The high mortality rate together with a low birth rate mean further social and demographic changes causing further decrease in population. Mortality rates show not only the state of health of the population, but also its social-economic status. The studies show differences in the population health indicators of one urban area’s different geographic locations (1, 2, 3). Mortality rates reflect not only social and demographic changes threatening to the natural increase in the population. Together with the social and economic conditions, ecological problems may have an important effect on the state of health. This would be especially true in large cities.

The purpose of this study is to evaluate the effect of air pollution on the state of health in population of Kaunas, the second largest city in Lithuania. For this purpose, the mortality indicators and ecological differences among certain micro districts were used.

Materials and methods
The chosen micro districts of the city
Three micro districts with different atmospheric pollution were chosen for the study. Petrašiūnai with a developed industry was referred to as micro district D1; Senamiestis with heavy traffic was referred to as micro district D2; and Šilainiai, dwelling blocks and relatively clean area, as micro district D3.

Accumulation and evaluation of the data
Using the data of the Population register, distribution of the inhabitants according to the age was assessed. Mortality was evaluated in all age groups (from 20 to over 65 years of age) and also at different age ranges, covering 5 years increment. The same assessments were performed.
separately in the male and female population. Mortality was analyzed, taking into consideration total mortality of the city’s population. Death certificates of 16,789 dead citizens (form 106/s) were the primary source of information for creating a database for the mortality study. During the study, an analysis was performed of the all-cause deaths, the deaths due to cardiovascular diseases (ICD-9 390-459), due to malignant neoplasms (ICD-9 140-239), due to diseases of the gastrointestinal tract (ICD-9 520-579), and due to external causes (ICD-9 E800-E999). The data of the year 1997 were additionally coded in accordance with the Tenth Revision of the International Statistical Classification of Diseases and Related Problems (ICD-10). The statistical data on mortality in the years 1992-1997, obtained from the Lithuanian Health Information Center, were employed in the study. The standardized mortality rates, expressed per 100,000 of population in a year, were calculated basing on the European population age structure.

The mass of the dust particles was determined by weighting procedure, whereas the standard photometric method was used to obtain the concentration of gases in the atmosphere (4).

Results

Description of the atmospheric air pollution

The mortality was studied in 3 micro districts with different atmospheric air pollution. The anthropogenic environmental load in these micro districts of the city of Kaunas was determined after having evaluated the concentrations of dust, soot, nitrogen and sulfur dioxides, carbon monoxide, formaldehyde, and heavy metals (lead, zinc, chromium) in the atmospheric air (Table 1). It is shown in the table that a dangerous ecosituation was in the micro district D2 with heavy traffic, here highest concentrations of nitrogen dioxide, carbon monoxide, and lead prevailed, as well as in the industrial micro district D1, where the high concentrations of sulfur dioxide, carbon monoxide, and zinc were determined. In the dwelling blocks micro district D3, that was considered to be relatively clean, the dustiness exceeded the permissible level and the amount of soot in the air was increased.

In order to quantitatively compare the pollution of the atmospheric air in the chosen for the study micro districts, the environmental pollution was evaluated by calculating the summarized environmental pollution index in accordance with the methods recommended by the Lithuanian Environment Protection Agency (5). It was revealed that the summarized atmospheric pollution differed almost threefold among the studied micro districts (Fig. 1).

Standardized mortality rates

In order to diminish the influence of the annual stochastic fluctuations, the mortality in the years 1992-1997 was analyzed. The rates were calculated and compared separately for males and females, and for both genders together. In Table 2, the crude and standardized mortality rates in chosen micro districts are shown. Table 2 shows that the crude mortality rate (expressed per 100,000 of population) in the polluted micro districts is significantly greater than in the relatively clean micro district. Depending on the character of source of pollution, it exceeded (p<0.001) from 1.14 to 1.5 times the analogous rate in the relatively clean micro district. After having evaluated the different distribution of inhabitants according to their age and having standardized the mortality by the age standard of the European population, the mortality risk did change. After the performed standardization according to the age, the earlier supposition of the increased mortality risk due to the pollution of the atmospheric air was not confirmed, as the standardized mortality rates (SMR) changed in all

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Normal values</th>
<th>Petrašiūnai, D1</th>
<th>Senamiestis, D2</th>
<th>Šilainiai, D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dustiness, mg/m³</td>
<td>0.15</td>
<td>0.14436</td>
<td>0.14146</td>
<td>0.27311</td>
</tr>
<tr>
<td>NO₂, mg/m³</td>
<td>0.04</td>
<td>0.02293</td>
<td>0.06262</td>
<td>0.02800</td>
</tr>
<tr>
<td>CO, mg/m³</td>
<td>3.0</td>
<td>1.45266</td>
<td>1.54866</td>
<td>0.94166</td>
</tr>
<tr>
<td>SO₂, mg/m³</td>
<td>0.05</td>
<td>0.01809</td>
<td>0.00933</td>
<td>0.00357</td>
</tr>
<tr>
<td>Formaldehyde, mg/m³</td>
<td>0.003</td>
<td>0.00528</td>
<td>0.00432</td>
<td>0.00136</td>
</tr>
<tr>
<td>Soot, mg/m³</td>
<td>0.05</td>
<td>0.01400</td>
<td>0.01616</td>
<td>0.01798</td>
</tr>
<tr>
<td>Lead, mg/m³</td>
<td>0.0003</td>
<td>0.00027</td>
<td>0.00041</td>
<td>0.00014</td>
</tr>
<tr>
<td>Manganese, mg/m³</td>
<td>0.001</td>
<td>0.00048</td>
<td>0.00100</td>
<td>0.00001</td>
</tr>
<tr>
<td>Zinc, mg/m³</td>
<td>0.05</td>
<td>0.00146</td>
<td>0.73130</td>
<td>0.00000</td>
</tr>
<tr>
<td>Chromium, mg/m³</td>
<td>0.0015</td>
<td>0.00014</td>
<td>0.00010</td>
<td>0.00003</td>
</tr>
</tbody>
</table>

Data of the Kaunas Public Health Center, 1993.
the studied micro districts. The standardized mortality rate of the inhabitants in the relatively clean dwelling micro district significantly \((p<0.001)\) exceeded the analogous rates in the industrial micro district and in the micro district with heavy traffic, by 18.9 and 22.7 \%, respectively.

The standardized mortality rates in these micro districts were calculated separately for men and women. The results of the calculations are presented in Table 3. It shows that the highest female mortality was determined in the relatively clean micro district, and it significantly \((p<0.001)\) differed from the mortality rates in the other two micro districts. The standardized all-cause mortality for males in the dwelling blocks micro district was equal to 1558.1 (per 100,000 of population in a year), which was by 6\% higher than the analogous mortality rate in the micro district with heavy traffic and by 4\% higher than in the industrial micro district \((p<0.001)\), whereas the male mortality rates determined in the micro districts with increased atmospheric air pollution did not differ. The comparison of the male and female mortality rates revealed a significantly higher male SMR. The ratio between the male and female mortality rates depended on the studied micro district - it was equal to 1.86 in the micro district D3 and to 2.24 in the micro district D2.

**The structure of mortality**

A more detailed analysis enabled us to reveal the structure of mortality of the urban inhabitants in the years 1992-1997. A specific cause-related mortality was calculated in the groups of diseases defined in accordance with the 9
th revised International Classification of Diseases. During analysis of the structure of deaths, it was determined that most of the inhabitants of the chosen micro districts died from three main causes - cardiovascular diseases, malignant neoplasms, and external causes. In the total mortality structure of the studied micro districts, they made 84.5\% of all the death cases. In all the micro districts, the deaths due to cardiovascular diseases made the largest group of

\[\text{Table 2. All-cause mortality rates in different atmospheric air pollution microdistricts in Kaunas (1992-1997)}\]

<table>
<thead>
<tr>
<th>Microdistrict</th>
<th>Gender</th>
<th>Total</th>
<th>Crude mortality rates per 100,000 of population</th>
<th>Standardized mortality rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>men</td>
<td>CMR 95% PI</td>
<td>SMR 95% PI</td>
</tr>
<tr>
<td>Petrašiūnai, D1</td>
<td>232</td>
<td>30</td>
<td>1309.0</td>
<td>1169.9–1484.6</td>
</tr>
<tr>
<td>Senamiestis, D2</td>
<td>337</td>
<td>34</td>
<td>1432.4</td>
<td>1273.0–1591.8</td>
</tr>
<tr>
<td>Šilainiai, D3</td>
<td>613</td>
<td>61</td>
<td>1219.8</td>
<td>1127.4–1312.2</td>
</tr>
</tbody>
</table>

\[p<0.001 – between mortality rates of selected microdistricts; p<0.001 – between male and female mortality rates; CMR – crude mortality rate per 100,000 of population in a year.\]
deaths comprising on average 48.9% of them (Fig. 2). Malignant neoplasms took the second place in the list of causes of death, comprising on average more than one fifth (21.6%) of all the deaths. The deaths from external causes made less than one fifth (14%) from all the deaths. During analysis of the diseases in the micro districts, it was determined that in the dwelling blocks area D3, the mortality was significantly higher, because of cardiovascular diseases, malignant neoplasms, and diseases of the gastrointestinal tract, than in the industrial micro district D1 and in the micro district with heavy traffic D2, whereas the greater number of deaths due the external causes was revealed in the industrial micro district. In the dwelling blocks micro district, the standardized mortality rate due to cardiovascular diseases (ICD-9 390-459) amounted to 562 (per 100,000 of population in a year), and it was significantly higher (p<0.001) than analogous rates in the micro district with heavy traffic (509.7 per 100,000 of population in a year) and the industrial micro district (479.7 per 100,000 of population in a year). The mortality of the inhabitants from malignant neoplasms (ICD-9 140-239) ranged from 244.8 (in the micro district D3) and 221.1 (in the micro district D1) to 184.4 (in the micro district D2) per 100,000 of population (p<0.001). The comparison of the standardized mortality due to traumas, poisoning and other external causes (ICD-9 E800-E999) in the studied micro districts (SMR_D1 = 205.4, SMR_D2 = 138.9, SMR_D3 = 137.0 per 100,000 of population) revealed that the inhabitants of the industrial micro district died from the external causes about one and a half times (1.48-1.50) more often (p<0.001) than the inhabitants of the other two micro districts. Although there were no sufficient data concerning the diseases of the gastrointestinal tract (ICD-9 520-579) as well as the results of chemical analysis of the drinking water, it is pos-

| Table 3. Standardized by age all-cause mortality in male and female groups |
|---------------------------------|-------------|-----------------|-------------|-------------------|
| Microdistrict                   | Moterys     | Vyrai           |
|                                 | SMR (abs. values) | 95%CI            | SMR (abs. values) | 95%CI            |
| Petrašiūnai, D1                 | 745.8 (232)  | 662.0–829.6     | 1495.7 (310)*    | 1307.3–1684.1    |
| Senamiestis, D2                 | 656.3 (337)  | 594.7–717.9     | 1470.6 (344)     | 1299.4–1641.8    |
| Šilainiai, D3                   | 837.4 (613)  | 781.7–893.2     | 1558.1 (651)     | 1437.9–1678.3    |

* – p<0.076 vs heavy traffic microdistrict; p<0.001 – between mortality rates of the selected microdistricts and male vs female groups.

Fig. 2. Mortality from the main causes of death in the selected microdistricts in Kaunas
sible consider, based on the literature (6, 7), that the higher mortality due to these diseases - 40 (per 100,000 of population in a year) - in the residential district D3 in comparison with the mortality rate in the micro district D1 (35.6 per 100,000 of population; p<0.05) and the analogous rate in the micro district D2 (33.2 per 100,000 of population; p<0.01) sooner could be attributed to the poor quality of the used drinking water or unhealthy nutrition than to the intensity and character of the pollution of atmospheric air. The analogous calculations were performed in all the rest cause of death groups, although the volume of six-year statistical data was insufficient to obtain the reliable results concerning population mortality.

Pollution of the atmospheric air and the age of the deceased

The mortality data in the classes of main causes of death were assessed according to age of the deceased. The number of the deceased (per 100,000 of population) was calculated in all the analyzed age ranks for the four earlier mentioned groups of diseases. After excluding the deaths conditioned by the external causes, the cumulative distribution of the main causes of death of the employable age population is presented in Fig.3. It shows that an accumulation of people, who died before the age of 55 years per 100,000 population in the studied micro districts significantly differed. The comparison of the micro district-specific changes of mortality rates in the age ranks revealed a higher percentage of the deceased in the total number of deaths in all the presented age ranks in the industrial micro district and micro district with heavy traffic than the analogous percentage in the dwelling blocks micro district. In the industrial micro district, 34.7 % out of the total number of deceased died before the age 55 years; in the micro district with heavy traffic, 30.4% out of the total number of the deceased died in the same age, whereas the analogous index in the dwelling blocks micro district was equal to 24.8% (p<0.05). With the age the micro district-specific differences diminished and in the senior age they became statistically insignificant. The comparison of the obtained results of the study revealed a tendency to die at the younger age among people living in the environment with polluted atmospheric air, i.e. the inhabitants of relatively polluted specific are at increasing risk to die in younger (30-55-year) age.

Discussion

The summarized and processed data of the measurements of the concentration of particulate dust and gases in the atmospheric air of the city of Kaunas yielded a database for evaluation of specific features of local air pollution in Šilainiai, a micro district of multistory apartment houses; Petrašiūnai, an industrial micro district, and in the Senamiestis, a micro district with heavy traffic. There were revealed sufficiently distinct differences among the investigated micro districts in concentrations of particulate matter in the atmospheric air, the nature of the pollutants and the summarized atmospheric air pollution index. It was anticipated that there should be corresponding health responses to the existing intensity of the pollution.

Mortality analysis has shown that the largest part of the deaths in the micro districts in Kaunas city was destined by the three main causes of demise - cardiovascular disorders, malignant neoplasms, and various external effects. They made 84.5 per cent of all deaths in these micro districts, while in the whole country they accounted for 87.3 per cent of deaths (8). Consequently, the all-cause standardized mortality rates in Kaunas as well as entire Lithuania were sufficiently high. According to the statistical data, in 1999, the standardized mortality rate in Lithuanian population in accordance with the European standard was equal to 1373.8 in males and to 703.2 in females per 100,000

Fig.3. Cumulative distribution of mortality from main causes of death, with exclusion of external causes, in the employable population
of population (8). In Kaunas, the analogous indices were ranged depending on the micro district from 656.3 to 837.4 in females and from 1470.6 to 1558.1 in males per 100,000 of population in a year. In the micro districts of Kaunas, cardiovascular disorders, as the main cause of death, accounted for 48.9 per cent of all the deceased, whereas in the whole country they resulted 54.8 per cent of deaths. In 1999, in Lithuania deaths from malignant neoplasms made 19.4 per cent, whereas in the studied micro districts, on average 21.6 per cent. Corresponding risk of death from traumas, poisonings and other external causes was similar in Kaunas and in all the country, 13.2 and 14.0 per cent, respectively. Thus, it is possible to conclude that the structure of mortality in the population of the studied micro districts corresponds to the distribution of causes of death in the whole Lithuanian population (8, 9, 10, 11), as well as in the population of many other European countries (12), however, it is regrettable that the inhabitants of Lithuania die twice as often as the people of the European Union.

Although, there was no information on the workplace and living environment of the deceased in the statistical data concerning mortality data of the population that could allow to evaluate the causal relationship with the above-mentioned environmental factors, it should be noticed that significantly higher mortality rate due to local external causes determined in the industrial micro district than in the other two studied areas was most probably conditioned by the increased number of accidents at the workplace, bankrupt of industrial enterprises, and social environment formed by a difficult economic situation in this country, but not by the intensity of pollution of the outdoor environment and the nature of the pollutants.

There was revealed an unexpectedly high all-cause standardized mortality rate in Ilainiai micro district with the lowest air pollution index. Having additionally studied the significant micro district district-depending differences in the cardiovascular disorder (ICD-9 390-459) and malignant neoplasms (ICD-9 140-239) death cause groups, a general tendency was revealed that population mortality rates do not depend on the intensity of complex atmospheric air pollution, but they depend on the kind of the pollution. Such a character of micro district-depending mortality was also confirmed by the studies of the other authors. Some Australian investigators determined that the daily all-cause and cardiovascular mortality increase was related to the average elevations of solid particle and ozone concentration (13). Such dependence between the concentration of the particles and daily mortality was compared with the cases of analogous dependence presented in the other international reports (14, 15). On the other hand, it should be noted that increased mortality due to respiratory disorders was related to elevation of the average level of nitrogen dioxide in the atmospheric air. The employed by the Australian investigators a model of air pollutant mixture has shown that the link between the concentration of solid particles in the air and all-cause death rate or mortality due cardiovascular disorders is independent of the nitrogen dioxide- and ozone-caused effects. Although specific biologic mechanism of these increases in mortality rate is still unclear (16), some possible mechanisms have been supposed, which could explain the toxic effect of the inspired solid particles upon the tissues of the lungs, the functional disturbances of which can be sufficient to accelerate the lethal outcome in chronically-ill and sensitive patients.

The study carried out in Kaunas has shown that the revealed micro district-depended differences are not conditioned by the intensity of physical and/or chemical pollution of the atmospheric air. Local background pollution of the atmospheric air and its differences in a large industrial city are not sufficiently high that the defensive mechanisms of human body would not be able to compensate the effects of changing throughout the time and dispersing in the air streams the environmental pollution.

The elucidated during the investigation the interdepartmental barriers have shown the necessity of the national registers encompassing the data concerning public and environmental health for carrying out investigations health effects depending on multi-factors and for prediction of the environmental health changes in the urban population.

Conclusions

1. Based on the results of the study, it is possible to conclude that cardiovascular diseases and malignant neoplasms still continue to be the main causes of death in the depended districts of the city with different anthropogenic load, and that the mortality of this urban population is conditioned by the nature of pollutants, but not by intensity of pollution.

2. In all the studied micro districts mortality rates of the males were significantly higher than those of the females.

3. The problem in the polluted micro district is the risk to die in a younger age. The risk to die for the people still being employable, before the age of 55 years, is significantly higher in the polluted micro districts than in the relatively clean one, if the deaths from external causes are excluded from the statistical analysis.

4. The data concerning correct individual identification, mortality and morbidity, environmental situation, living and workplace conditions of the resident population should be joined into an integral information system, as the developed national registers are indispensable for carrying out epidemiological studies and for prediction of the changes in environmental health of the urban population.

Gyventojų mirtingumo stebėsena 1992–1997 metais Kauno miesto mikrorajonuose

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Raktas:
aplinkos oro tarša, mirtingumas, standartizuotas mirtingumo santykinis, vėžys, širdies ir kraujagyslių ligos.


References


Received 28 May 2002, accepted 10 June 2002