ENVIRONMENTAL EPIDEMIOLOGY ANALYSIS OF HEALTH EFFECTS OF ADVERSE ENVIRONMENTAL FACTORS IN THE POPULATION OF INDUSTRIAL TOWNS OF THE MIDDLE URALS
(based on materials of studies conducted in 1998-2008)

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Conclusive establishment of health effects of adverse environmental factors (anthropogenic or natural contamination of the environment in particular) is one of the bases of the analytical section of the system of socio-hygienic monitoring (SHM). Such links are used within SHM immediately in the study areas and during substantiation of generalized “exposure – response” relationships necessary for prognostic risk assessments.

The most important distinctive features of the modern methodology of environmental epidemiology studies that are based on common principles of epidemiology of non-infectious diseases include selecting the design adequate to tasks and conditions of the study; using a sufficiently powerful mathematical (biostatistical) apparatus of data analysis (mainly different variants of the regression analysis); considering multiform associated factors not only to eliminate effects of confounders but also to detect them as possible health risk factors; evaluating the extent of uncertainty of results and conclusions of a particular environmental epidemiology study. Russian hygienists have been implementing these principles only since late 1990s.

Activities of our team¹, first in association with American and British epidemiologists (J.D. Spengler, H. Ozkaynak, J.J. Jaakkola, T. Fletcher, S. Pattenden, et al.) within the framework of the Project for Environmental Management in Russia supported by the World Bank and then independently within the structure of the Ural Regional Center for Environmental Epidemiology (URCEE), Ekaterinburg Medical Research Center for Prevention and Health Protection in Industrial Workers and Sverdlovsk Regional Rospotrebnadzor Office contributed to that.

In the cross-sectional study we assessed the link between health of population and ambient air pollution. In 12 areas of 9 towns of the Sverdlovsk Region and the town of Cherepovets, the Vologda Region, we conducted a continuous annual monitoring of air pollution with PM₁₀, PM₂.₅, sulfur dioxide, and nitrogen dioxide. Detailed personified information about respiratory signs, diagnoses and supposed personal risk factors in 6 thousand elementary school children was collected using a specially developed questionnaire filled out by parents of those children. The regression analysis of the pooled database proved an important role of a large number of personal risk factors; for the first time it demonstrated specific differences between relevant sets of personal risk factors for chronic cough (or diagnosed bronchitis) and wheezing other than with cold (or diagnosed bronchial asthma). In this study, with adjustment for personal risk factors most significant for a certain sign of respiratory pathology (like smoking of adults and mother’s smoking during pregnancy), we demonstrated a significant relationship between the probability of respiratory pathologies in children residing in this or that area and the annual average level of air contamination with fine particles and sulfur dioxide.

Later on the database developed in this cross-sectional study was used in the meta-analysis performed with our participation within the international project PATY (Pollution and the

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Young: combined analysis of cross-sectional studies of respiratory health of children and air pollution) that supported our basic results.

In the longitudinal environmental epidemiology study based on the time-series analysis it was demonstrated that the exacerbation of respiratory signs and symptoms in children could be a response to fluctuations in the level of air pollution. This study included elementary schoolchildren from Nizhni Tagil and was based on daily records of respiratory and allergic symptoms made by parents and a continuous monitoring of air pollution with suspended particles and irritating gases in the center of the dwelling area. The regression data analysis helped establish adverse effects even of relatively small average daily peaks of pollution (not exceeding, as a rule, established maximum permissible concentrations) on acute reactions of the upper and lower air passages in elementary and secondary schoolchildren. Principal results of this study are consistent with findings of similar works published abroad, even though the latter showed concentrations of dust particles, higher and in a wider range than in our study.

An important advantage of the time-series analysis is that it does not always require specially organized monitoring to obtain data both on exposure of population and developing adverse effects since it allows the retrospective use of available routine air pollution monitoring and official records of health effects (death cases in particular). We, for example, demonstrated the link between daily mortality of population in Ekaterinburg and Nizhni Tagil and variations of registered concentrations of suspended particles and some gaseous air pollutants, many of which are typical of towns with developed ferrous industry, including ore agglomeration, a complete metallurgical cycle and coke production. One of important aspects of this study is a practical equality of the value of the mortality risk function and the gradient of concentration of the airborne dust with available published results of the meta-analysis of results of similar foreign studies, which allows us to use them in risk assessment projects.

With an important role of direct adverse health effects of polluted ambient air, in some important respects there may prevail the role of primary (with industrial wastes and effluents) or secondary (with sedimentary suspended particles) persistent accumulation of toxicants in soils and water reservoirs and, consequently, in foodstuffs. In conditions of the mining and industrial Urals this primarily concerns toxic inorganic compounds of lead, arsenic, cadmium, chromium, manganese, vanadium, fluoride, and some other elements. For instance, during the monitoring of lead in various environmental media the mathematical modeling of its intake by preschool children showed that the contribution of ambient air in the accumulated dose of this metal was only tenths of percent, the contribution of drinking water – a few percent, whereas the contribution of foodstuffs was as high as 70-80 % and that of soil and dust through dirty hands – about 20 %.

One of the critical health effects of lead is mental retardation in children with serious remote behavioral and mental effects in older age. Our environmental epidemiology studies conducted in Krasnouralsk, Pervouralsk, Kirovgrad and Kushva, showed a rank correlation between the prevalence of mental retardation (detected by psychological testing) and the frequency of occurrence of elevated blood lead concentrations (PbB) in preschool children. This frequency, just like the average PbB value in the group of children surveyed in the certain town, agrees well with the results of modeling, which confirms the determining role of environmental lead contamination. However the regression analysis showed that at the personal level the PbB value also depended on some personal risk factors related to child’s habits, his living conditions and nutrition, and the probability of mental retardation – not only on the PbB level but also on some personal risk factors of social and genetic character, including mother’s smoking during pregnancy.

It should be noted that in another environmental epidemiology study conducted in Pervouralsk, Revda, Sredneuralsk, and Sysert with preschool children involved we found a significant correlation between environmental lead and cadmium burden as assessed by concentrations of these metals in urine and the probability of preclinical manifestations of kidney pathologies, a high prevalence of which is observed in industrial towns of the Sverdlovsk
Region. This relationship remains significant when adjusted for other risk factors of this pathology.

Special attention is paid to children’s health due to the fact that risks from industrial pollution of the environment are especially high in younger age because some anatomic and physiological characteristics and behavioral habits of children make them more sensitive to adverse effects than adults in equal conditions of environmental pollution. For instance, the respiratory volume, consumption of food and drinks per unit of body weight in children is higher than that in adults and so the absorbed doses of toxicants from air, water and foodstuffs are much higher, too. The hazard of exposure to toxic metals and other persistent pollutants from soil through dust (due to the low breathing area) and dirty hands (due to playing on the ground and poor hygienic habits) is significantly higher than in adults. Not the least important is a higher sensitivity to toxic effects inherent to the growing and developing organisms, and the damage caused to the processes of growth and development has an adverse effect on the following life and health, thus undermining labor resources of the nation.

When studying relationships between hazardous exposures and human health at different periods of a man’s development and life (starting from conception and fetal growth), each period must be considered in connection with the previous ones, even though it is characterized by its own distinctive features of sensitivity to adverse factors. In particular, any factor having an adverse effect on pregnancy and fetal growth can affect the postnatal development and health of the child. The postnatal development can be also affected by some latent effects of adverse factors that affected the fetus, even if these effects were not obvious at birth. Environmental factors must be considered in combination with many other personal risk factors.

These theoretical prerequisites found proof in our environmental epidemiology study based on the follow-up of a cohort of women with the gestational age of 20-22 weeks from Ekaterinburg, Pervouralsk, and Revda. We showed that, even against the background of industrial contamination of the environment, medical, obstetrical and many other personal risk factors, especially smoking (even passive smoking) during pregnancy, were important determinants of adverse characteristics of the course of pregnancy and also of poor anthropometric characteristics and status of the newborn. Factors of the same character, and sometimes the same factors also affect health and growth of the infant. On the other hand, some adverse indices of its health and development may be treated as delayed or extended effects of factors that affected the fetus. In this respect our epidemiologic study showed that apart from special importance of smoking during pregnancy some adverse effects of toxic metals on fetal growth could be established, just like the deficit of physiologically important microelements (iron, calcium, copper, etc.). For example, the higher is the level of cord blood lead, an indicator of intrauterine intoxication of the fetus, the higher is the probability of diseases of the urinary system in a 1-year old child.

In connection with above mentioned studies of adverse effects of exposure to toxic metals it should be especially noted that in the majority of cases the assessment of this exposure based on indicators of environmental pollution and on the population level is supplemented by the assessment of the toxic burden by means of biological monitoring of their concentrations in blood (including cord blood) or urine.

An important environmental epidemiology problem is detection of most significant cancer risk factors in the population groups where the risk incidence rate is permanently higher than the regional average. We considered a similar problem in the town of Karpinsk for lung, colon, and breast cancer. We found a significant effect of a complex of population and personal risk factors, particularly the exposure to carcinogenic PAH. In this connection it is important to note that the major source of exposure to carcinogenic PAH specific of Karpinsk is a large number of coal burners. Out of well-known personal risk factors for lung and colon cancer we found evidence of role of smoking and alcohol abuse, and for breast cancer – of some specific risk factors related to the reproductive function and breast feeding.
Thus, results of the majority of our environmental epidemiology studies demonstrate the importance of assessing not only the role of environmental pollution but also of other risk factors that are truly significant for each specific disorder in a certain population group. Insufficient attention to this task may lead to excessive focusing of attention only on environmental risk factors and underestimating the role of some personal risk factors that can be even more important, and thus – to one-sided and poorly effective strategy of risk management.

From the point of view of evidence-based medicine, of great importance is the link between epidemiologic studies and experimental toxicology studies, the tasks of which depend on epidemiologic findings. For instance, epidemiologic data on combined nephrotoxicity of lead and cadmium were then proved in animal experiments. In the experiment the combination of environmental toxicants specific for environmental pollution in Karpinsk showed high genotoxicity at the macromolecular level. Some health disorders in people of a rural area of the Sverdlovsk Region, the hypothesized link of which with effects on the environment of the monazite concentrate storage base was proved in a specially designed epidemiologic study, set the task of establishing the nature and extent of toxicity of monazite dust, which was solved experimentally. Thus, the evidence-based establishment of the link between adverse indices of public health and this or that adverse multimedia exposure on the basis of environmental epidemiology assessments with experimental toxicology studies is a reliable prerequisite for the search for preventive actions aimed at weakening adverse effects of these exposure (biological prevention).