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Environmental burden of disease due to lead in urban children from Silesia, Poland

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Abstract

We performed environmental burden of disease (EBD) assessment of the neurotoxic effects of lead in the Polish urban children, in accordance with the WHO guidelines. The EBD assessment was based on the data on blood lead levels (BLL) of more than 8500 children from the lead biomonitoring programme conducted in the urban centre of the Upper Silesia Province, Poland between 1993 and 2000. In order to make the EBD assessment region specific, in the projections to years 2001 and 2005 we used 4% annual decrease in BLL, derived from the earlier analysis of the Silesian BLL data instead of the WHO proposed 7.8%. Mean BLL in the Silesian children projected for the year 2001 was higher (4.9 μg/dL) than the corresponding value for the WHO EurB region (3.9 μg/dL). The incidence rate of mild mental retardation (MMR) in the Silesian children was twice as high as in the EurB region for the year 2001, meaning more than two additional cases of MMR due to lead exposure per 1000 children aged 0–1 year, compared with 1 in 1000 children in the EurB region.

Keywords: Environmental burden of disease; Lead; Urban children; Silesia; Poland; Management of environment and health

1. Introduction

The idea of sustainable development locates human health at the centre of international agenda. Associations between health, environment and sustainability are already reflected in the policies and strategies of the developed countries. However, methods and tools for quantification of these relationships are not sufficiently developed.

It is a common understanding that if health issues are to become a part of decision making process, they need to be substantiated in the specific and measurable way. The health risk assessment (HRA) methodology (U.S. EPA, 1986a,b) has been widely applied as a tool for risk management. In Poland this approach has been implemented in a variety of projects (Biesiada, 2000, 2001; Biesiada et al., 1999, 2001; Biesiada and Sokal, 2003). The HRA approach has certain limitations, the most severe being that it is developed predominantly for chemical hazards. Another disadvantage is that dose–

Abbreviations: ABLL, adjusted BLL; BLL, blood lead level; DALY, a disability adjusted life year; EBD, environmental burden of disease; GBD, Global Burden of Disease; GM, geometric mean; GSD, geometric standard deviation; HRA, health risk assessment; IF, impact fraction; IQ, Intelligence Quotient; MMR, mild mental retardation; SD, standard deviation; WHO, World Health Organization; YLD, years lived with disability; YLL, years of life lost due to premature death.

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response relationships for most of the agents subject to HRA come from animal studies and suffer from uncertainties inherent to interspecies extrapolation. Moreover, HRA does not refer explicitly to the actual health status of the exposed population, i.e. the HRA report is usually concluded with estimates of excess risks caused by factors considered.

Challenging the above mentioned limitations of HRA and in the quest for developing a uniform methodology covering also non-chemical factors, alternative method of quantifying environmental health impact has been proposed. The so-called Environmental Burden of Disease (EBD) concept developed by the WHO was used in the 2002 World Health Report (WHO, 2002) and has been promoted in several monographs for national and regional applications (Fewtrell et al., 2003; Prüss-Üstün et al., 2003).

The EBD methodology allows to express health impacts of environmental exposures using a quantitative measure called "disability adjusted life year" (DALY). This approach provides a useful tool to support knowledge based decision making and prioritisation of actions in public health. The recent WHO contribution to the Fourth Conference of Ministers of Health and Environment (Valent et al., 2004a) and the related publication in Lancet (Valent et al., 2004b) prove that EBD approach is becoming a recognised methodology in the field of environment and health.

The aim of the present paper is to apply the WHO guidelines (Fewtrell et al., 2003) to perform assessment of EBD due to lead exposure in children living in the urban centre of the Upper Silesia Province, Poland. We used the data on blood lead levels (BLL) collected during the extensive lead biomonitoring programme conducted by the Institute of Occupational Medicine and Environmental Health between 1993 and 2000.

Since the EBD methodology is relatively new, in fact under development in many aspects, we start with rudimentary description of EBD concept and the detailed methods of EBD assessment due to lead exposure. Then materials and results are presented, followed by discussion and conclusions.

2. Environmental burden of disease — methodology in brief

The EBD approach is based on the Global Burden of Disease (GBD) concept (Murray and Lopez, 1996; Murray et al., 2000). The GBD study constitutes the most comprehensive and consistent set of estimates of mortality and morbidity by age, sex and region ever produced. It also introduces a summary measure of population health, so called disability-adjusted life year (DALY), a unit combining years of life lost due to premature death (YLL) and years lived with disabilities (YLD): DALY = YLL + YLD.

The YLL basically corresponds to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. To estimate years lived with disability (YLD) on a population basis, the number of cases is multiplied by the average duration of the disease and a weight factor that reflects severity of disease on a scale from 0 (perfect health) to 1 (death). By expressing the difference between actual situation and an ideal one, when everyone lives in perfect health up to the age of standard life expectancy, DALY is measuring health gaps in the population as opposed to health expectancies (Hyder et al., 1998). Therefore, DALY reveals the potential for improvement, which is a relevant issue for public health policy.

The disease burden approach provides an opportunity to compare health losses due to different diseases or risk factors. The WHO supports the idea of the national burden of disease studies and provides guidelines and software tools (Mathers et al., 2001; WHO, 2001).

Environmental Burden of Disease, which reflects the fraction of disease burden due to environmental factors, is based on the concept of attributable risk, known for long in epidemiology (Last, 2001). The EBD assessment requires the following input data for each risk factor:

1. Distribution of levels of exposure to the risk factor in population, quantified as fractions of population P_i allocated in the defined exposure categories (labelled by i)
2. Exposure–response relationship for the risk factor, given either as genuine relationship (in our case as the loss of IQ points in BLL category) or as relative risks (RR) for each exposure category
3. Disability Adjusted Life Years lost due to disease(s) related to the studied risk factor or, if not available, other epidemiological data (such as mortality rates or disease incidence).

The distribution of the population exposure (1.) and the exposure–response information (2.) are combined into attributable risk called impact fraction (IF). The impact fraction is then multiplied by the burden of disease for given disease in order to get the EBD estimate. If the exposure–response relationship exists in a functional form, it is used to convert the exposure into respective health measures, e.g. incidence rates, mortality rates, etc.