Exposure to lead and cadmium of children living in different areas of North-West Germany: results of biological monitoring studies 1982–1986*


Medizinisches Institut für Umwelthygiene an der Universität Düsseldorf, Auf'm Hennekamp 50, D-4000 Düsseldorf 1, Federal Republic of Germany

Summary. Between 1982 and 1986 several surveys were carried out to determine the levels of lead and cadmium in blood, urine, and shed deciduous teeth (incisors only) of children living in rural, suburban, urban, and industrial areas of North-West Germany. Blood lead (PbB) and blood cadmium (CdB) were measured in about 4000 children. In rural, suburban and urban areas the median PbB levels vary between 5.5 and 7 μg/dl, with 98th percentiles varying between 10 and 13 μg/dl. The median CdB levels are between 0.1 and 0.2 μg/dl, with 95th percentiles between 0.3 and 0.4 μg/l. Children from urban areas have significantly higher PbB levels than children from rural and suburban areas. Regarding CdB no differences could be detected. Children living in areas around lead and zinc smelters, particularly those living very close to the smelters, have substantially increased PbB and CdB levels. Children from lead worker families also have substantially increased PbB and CdB levels. The lead levels in shed milk teeth (PbT) were determined in about 3000 children. In rural, suburban and urban areas the median PbT levels are between 2 and 3 μg/g, with 95th percentiles between 4 and 7 μg/g. Children from urban areas have significantly higher PbT levels than children from rural and suburban areas. The highest PbT levels (on a group basis) are in children from non-ferrous smelter areas. The median levels of lead in urine (PbU) are between 6 and 10 μg/g creatinine, with 95th percentiles between 20 and 30 μg/g creatinine. Children from polluted areas have higher PbU levels than children from less polluted areas. The median levels of cadmium in urine (CdU) are in the order of 0.1 μg/g creatinine, with 95th percentiles being in the range of 0.5 and 1.0 μg/g creatinine. Girls have higher CdU levels than boys. There are no differences between groups of children from different areas. Children from lead worker families have higher PbU and CdU levels than otherwise comparable children. The results of the present studies indicate a further decrease of PbB in children from North-West Germany since the CEC blood lead campaigns carried out in 1979 and 1981. The decrease of lead exposure also seems to be reflected by a decrease of tooth lead levels.

Key words: Lead exposure – Cadmium exposure – Children – North-West Germany

Introduction

There is general agreement that children are a population at increased risk with respect to lead exposure and adverse health effects resulting from increased lead exposure. The reasons for this may be summarized as follows:

- children have behavioural characteristics (outdoor activity, less concern for hygienic conditions, oral activities), which increase the risk of undue lead exposure;
children eat and drink more per unit of body weight than adults, and so the relative lead intake is greater than in adults;

- lead absorption in the gastrointestinal tract is higher in children than in adults;

- among children there is a greater prevalence of nutritional deficiencies (e.g. iron, vitamin D), which may enhance the absorption of lead from the gastrointestinal tract;

- haematological and neurological effects of lead occur at lower thresholds in children than in adults.

Since 1982 we have performed several blood lead surveys among children living in different rural, urban and industrial areas of North-West Germany. In total, blood lead levels of more than 4000 children were determined. We also analysed the lead levels in shed milk teeth and urine samples. Whereas lead in blood and urine are indicators of relatively recent exposure, the analysis of mineralizing tissues, specifically deciduous teeth, provides an assessment of internal exposure integrated over a longer period of time. Additionally, we determined the cadmium levels in blood and urine. The objective of these surveys was to obtain data on the current background levels of the above mentioned biological exposure indices in child populations of North-West Germany and to determine the influence of some constitutional and environmental factors on these indicators of exposure. Moreover, the surveys were aimed to assess to what extent critical blood lead levels occur in child populations of these areas.

**Subjects and methods**

*Study areas and their environmental pollution by lead and cadmium*

The surveys were carried out in eleven cities of North-Rhine Westfalia and in Nordenham, a seaport city located in northern Germany. Borken, Dülmen, and Goch are small cities without industrial sources of lead and other metals located in rural areas north and north-west of the Ruhr area. The children living in these areas may be considered as reference populations with presumably low lead exposure.

Bottrop (about 114000 inhabitants), Essen (about 640000 inhabitants), Gelsenkirchen (about 300000 inhabitants), Herne (about 180000 inhabitants), and Lünen (about 85000 inhabitants) are industrial cities located in the Ruhr area, in which motor traffic exhaust represents the major source of lead. There are a number of metallurgical plants in these areas, but the lead and cadmium emissions from these plants are insignificant.

Duisburg (about 550000 inhabitants) and Dortmund (about 600000 inhabitants) represent two of the most important centers of iron and steel production in Europe. In Duisburg, there also exist a large lead zinc smelter as well as a number of other metallurgical plants processing lead and other non-ferrous metals. Additionally, a large copper smelter was in operation in this area until 1983. The lead emission from industrial sources was estimated to be about 800 tons/year in the 1970s (MAGS 1977). At present, they are estimated to be about 220 tons/year (MAGS 1985). The emission of cadmium and its compounds was in the order of 6 tons/year and is currently estimated to be about 2.7 tons/year (MAGS 1977, 1985). In the Dortmund area, the lead emission from industrial sources (mainly from iron and steel production) was estimated to be 130 tons/year in the 1970s (MAGS 1978). Due to pollution control and a substantial reduction of iron and steel production, the emission of lead decreased to, at present, about 65 tons/year (MURL 1986). The emission of cadmium from industrial sources is insignificant (<1 ton/year). In both areas the lead emission from motor traffic exhaust is estimated to be 50 to 60 tons/year.

The Stolberg area (about 57000 inhabitants) is known to be highly polluted by lead, cadmium and other non-ferrous metals due to the presence of several primary lead and zinc smelters in operation since the 19th century. A number of these plants have been closed down in recent years. At present, a large primary lead smelter represents the major source of lead and cadmium emissions. The lead emission from this smelter was about 35 tons/year in the 1970s and has been reduced to, at present, about 18 tons/year. The cadmium emission is in the order of 0.5 tons/year (MAGS 1975, 1983). Since 1972 several studies have been carried out to screen the population, mainly children, for undue lead and cadmium exposure (Einbrodt et al. 1974; Rosmanith et al. 1975a, b; Ewers et al. 1982, 1984, 1985). Nordenham is a medium-sized seaport in Northern Germany with about 33000 inhabitants. Pollution problems arise from a lead zinc smelter located near the city. The surrounding areas are largely rural. Lead intoxication of cattle has a long history in this area. The most recent incident occurred in 1972. Since then the Federal Health Agency has been active in screening the population of any signs of undue lead exposure and possible health consequences (Thron et al. 1984; Winneke et al. 1985).

The degree of environmental pollution by lead and cadmium has been recorded in some of the above mentioned areas for several years by means of a monitoring network maintained by the State Agency for Immission Control (Landesanstalt für Immissionsschutz NW, LIS). The monitoring activities include the measurement of lead, cadmium, and other environmental contaminants in air, dust fall-out, top soil and plants. Whereas the contaminant levels in dust fall-out and soil are measured by means of a 1 x 1 km monitoring network, air and plant contaminants are measured by means of a 4 x 4 km monitoring network. The results have been published by the State Agency for Immission Control (see “Schriftenreihe der Landesanstalt für Immissionsschutz NW”). The means and ranges of lead and cadmium fall-out (PBd and CdD, respectively) are summarized in Table 1. It should be noted that, in the polluted areas (Duisburg, Nordenham, Stolberg), there are large variations of the contaminant levels, particularly with regard to lead and cadmium in dust fall-out and soil. Especially around the smelters high levels of lead and cadmium in dust fall-out ranging up to 6000 µg Pb/m²d and 30 µg Cd/m²d have been recorded. The annual means of lead and cadmium in air vary between 0.2 and 0.5 µg Pb/m³ and 1 and 5 ng Cd/m³ respectively, and do not differ very much between the study areas. Close to the smelters, however, significantly increased levels have been measured.