Exposure of Children to Persistent Organic Pollutants: Hearing Impairment and Dental Enamel Damage

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Introduction

Persistent organic pollutants, known as POPs, are the most dangerous toxic chemical substances released into the environment through a variety of human activities. They persist in the environment, bioaccumulate through the food web and have adverse effects on the health of ecosystems, wildlife, and people. Specific effects of POPs can include cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system. Some POPs are also considered to be endocrine disrupters, which, by altering the hormonal system, can damage the reproductive and immune systems of exposed individuals as well as their offspring; they can also have developmental effects.

Children are uniquely vulnerable to toxic chemicals in the environment to which they are exposed since the fetal and neonatal period via placental transfer and breast milk and later mainly by food. The different susceptibilities of children to chemicals compared to adults are probably due to behavior, pharmacokinetics, developmental stages, and body fat content. It is hypothesized that *in utero* and early childhood exposures to POPs with endocrine disrupting properties may be responsible, at least in part, for decrease in neurobehavioral performance, hearing impairment, dental enamel damage, increasing incidence of congenital malformations of the reproductive organs, and improper timing of puberty onset.

Eastern Slovakia, in particular the Michalovce district, has been recognized as one of the areas in world most heavily polluted with several POPs. The Chemko chemical plant in Strážske, Eastern Slovakia, manufactured 22,000 metric tons of polychlorinated biphenyls (PCBs), accompanied by polychlorinated dibenzodioxins and polychlorinated dibenzofurans between 1959 and 1984. PCBs are a class of 209 industrial chemicals that are very persistent environmental contaminants. Due to inadequate measures related to environmental protection, the water in the effluent canal from the plant was drained into a nearby river and contaminated the adjacent riparian areas. High PCBs levels were found in samples from environment and from the general population living in the district. Recent data on environmental contamination, body burden, incidence of malignancies and other health outcomes for this area is available (Pavuk 2004; 2003; Langer 2003a; 2003b; 2002; Hertz-Picciotto 2003). This "experimental setting in nature", involving as much as about 100000 exposed human subjects, has attracted international scientific teams and several research projects (EU and NIH) are ongoing in this area. Data gathered so far on more than 2000 adults and 430 eight- to nine-year-old children indicate a possibility to construct exposure-response relationships for endpoints such as diabetes

frequency, neurobehavioral performance, hearing impairment, thyroid gland dysfunction, dental enamel defects and immuno-modulation (Trnovec 2003). The objective of this paper is to share scientific information on associations between exposure to PCBs and hearing and dental enamel impairments.

The so far published data on PCBs and hearing are based mainly on animal observations. Low-frequency auditory impairments have been documented in PCB exposed rats, including elevated behavioral auditory thresholds and decreased amplitude and prolonged latency auditory evoked brain stem responses (Lasky 2002 and for other information sources see http://www.foxriverwatch.com/hearing_pcb_pcbs.html). Two papers only relate to humans: The first is reporting PCB-associated increased thresholds at two of eight frequencies on audiometry, but only on the left side, and no deficits on evoked potentials or contrast sensitivity in 7-year-old children prenatally exposed to seafood neurotoxicants (Grandjean 2001). The other paper is on hearing impairments in boys of fish-eating mothers, but no individual PCB exposure data were available (Rylander 2000).

The data on effects of PCBs on teeth are rather scarce. In Taiwan, mothers who ate rice oil contaminated with PCBs gave birth to children with a variety of birth defects: increased incidence of natal teeth, skin discoloration, abnormal fingernails, swollen gums with teeth that chipped easily, teeth prone to increased dental cavities, lower birth weights and smaller general size (Miller 1985, Rogan 1988, Gladen 1990). It follows from another study that long-term environmental exposure of children to PCBs may cause developmental effects of tooth enamel, mainly to demarcated and diffuse opacities and hypoplasia (Jan 2000).

Materials and Methods

Four hundred thirty 8 and 9 years old children were examined for organochlorine and toxic metal levels in serum, cognitive and hearing functions, tooth enamel damage, and thyroid morphology and function. The hearing was examined by tympanometry, pure tone audiometry, auditory brainstem response and transient evoked otoacoustic emissions. Dental examination was focused on oral hygiene, gingival health, developmental defects of enamel and caries, demarcated and diffuse opacities and hypoplasia. Questionnaires on prenatal development of child, birth and infancy and early childhood, lifestyle, smoking, drinking of alcohol and consumption of drugs, dietary habits, social and health status of family were completed.

Results and Discussion

Frequency diagram of serum concentration of sum of PCBs in 433 8-9 years old children is shown in Figure 1. The mean PCB serum concentration of 528 ng/g serum lipids indicates a high exposure in comparison with western population. E.g. a much lower average PCB concentration of 107 ng/g serum fat was reported for Belgian adolescents (Den Hond 2002). Biological endpoints shown in this paper were related to percentiles of serum concentration of sum of PCBs. The median concentration was 321 ng/g serum lipids and the corresponding 25^{th} and 75^{th} percentiles were 175 and 618 ng/g serum lipids, respectively. The maximum PCBs serum concentration found was 6477 ng/g serum lipids. Figure 2 shows the results of pure tone audiometric screening (average for both ears). The hearing threshold was significantly higher in

children of the upper median compared to the lower median of PCBs serum concentration for 4 frequencies. The results of evaluation of transient evoked otoacoustic emissions are shown in Figure 3. Percentage of children not reaching the arbitrary limit (< 60% of normal) at the frequency of 4 kHz was plotted against quartiles of PCBs concentrations. It can be seen that the % of children out of limit increases with increasing PCBs concentrations and that both ears are involved approximately two times more frequently than one ear only. In examination of the auditory brain stem response, the % of children for which the absolute latency of wave 5 was out of limits (5.4 – 5.8 ms) increased with increasing PCBs concentrations (Figure 4). It is shown in Table 1 that children of the 10^{th} decile of PCBs serum concentration (mean 2049 ng/g serum lipids) have a mean inner ear pressure of -241 daPa, which is lower if compared to a mean inner ear pressure of -157 daPa found for children of the 1.-9. deciles (mean PCBs serum concentration 362 ng/g serum lipids). Decreased inner ear pressure is a clinical sign of inner ear inflammatory processes. It was suggested that higher incidence of otitis media and bronchitis may be a result of influence of PCBs on immunity. Dental examination of our children has shown that the percentage of their permanent teeth with demarcated opacities is increasing with increasing PCBs serum concentration (Figure 5). The same trend was also found for the first permanent molars for demarcated opacities (Figure 6)

Summary

In 433 children born and living in an area heavily polluted with PCBs and other organochlorine substances accompanying their production an association between prevalence of hearing impairment and dental enamel damage and PCBs serum concentration was found.

In particular with regard to hearing: 1. The pure tone audiometry revealed a higher threshold for the frequencies 0.25, 0.5, 1, and 4 kHz in children of the upper median of PCBs serum concentration as compared to the lower median, 2. the children of the upper quartiles of PCBs serum concentration did not reach the arbitrary limit of the 4 kHz amplitude in the transiently evoked otoacoustic emissions test , 3. in the examination of the auditory brainstem response, the children of the upper quartiles of PCB serum concentration revealed higher percentage of ears with absolute latency of the wave 5 out of limit as compared with lower concentration quartiles, and 4. in children of the 10^{th} decile of PCBs serum concentration a lower inner ear pressure was found as compared to the 1.-9. deciles.

Dental examination has shown that the prevalence of demarcated opacities in permanent teeth and especially in the first permanent molar teeth was higher in children of the upper quartiles of the PCBs serum concentration as compared to the lower quartiles.

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Figures and table

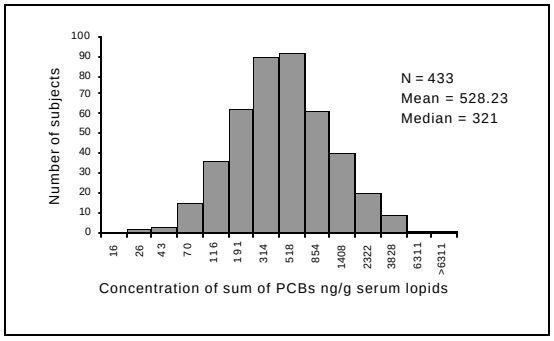

Figure 1 Frequency diagram of serum concentration of sum of PCBs, semilogarithmic presentation

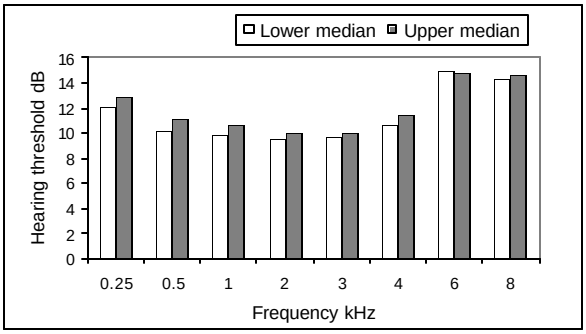

Figure 2 Audiometric screening, average for both ears, (n=430) T – test: p = 0.009 (0.25 kHz), p = 0.006 (0.5 kHz), p = 0.027 (1 kHz), p = 0.05 (4 kHz)

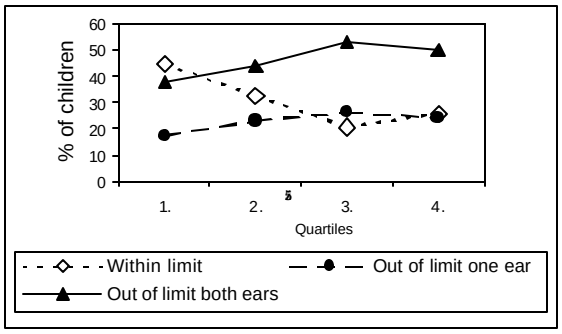

Figure 3 Otoacoustic emissions, % of children not reaching the limit (<60% of normal), frequency 4 kHz, (n=343). X^2 test: p = 0.032

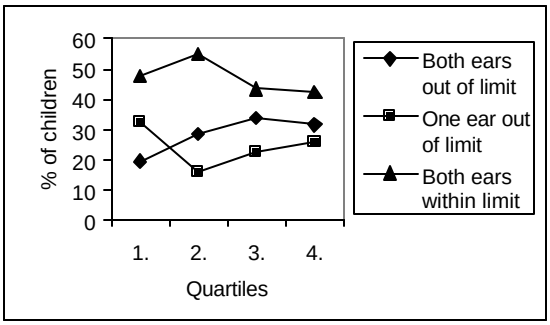

Figure 4 Auditory evoked potentials: Auditory brainstem response, absolute latency of wave 5, % of children within/out of limits (5.4 – 5.8 ms), (n = 428). C^2 test: p = 0.046

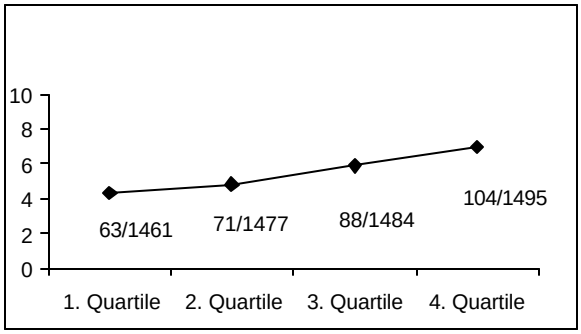

Figure 5 Permanent teeth, enamel defects. % of teeth with demarcated opacity on buccal surfaces X^2 test: p < 0.01; 1.Q vs. 4.Q p < 0.05

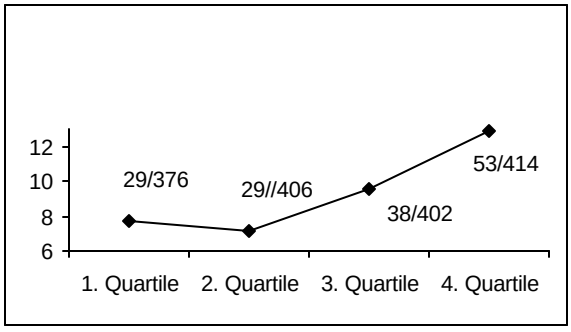

Figure 6 First permanent molars, enamel defects. % of surfaces with demarcated opacity X^2 test: p < 0.05; 2.Q vs. 4.Q p < 0.05

Table 1 Tympanometric examination

	N ears/children	PCB serum concentration ng/g lipids			Ears with <-100 daPa N	Inner ear pressure daPa	
		Range	Mean ±SD	Median		Mean± SD	Median
Deciles 1-9	776/388	18-1211	362.25± 263.2	291	58 (7.47%)	-157.16*± 61.39	-140
Deciles 10	86/43	1212-6477	2049.6± 1065.4	1687	7 (8.14%)	-240.71*± 132.87	-180

Acknowledgement

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