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Lead and Cadmium Content in Human Milk from the Northern Adriatic Area of Croatia

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Though occupational exposure to toxic metals (lead, cadmium) is well documented, harmful effects of environmental exposure to lower levels of these two metals is still under investigation. Most toxic metals are emitted by human activities and the atmosphere is the main transport route for these elements. According to some authors, 332 358 t of lead and 7570 t of cadmium were emitted in the atmosphere from anthropogenic sources in 1983 (Mignon et al, 1991). The principal source of lead is traffic, e.g. leaded petrol, still widely used in Croatia, as well as coal combustion, iron and steal production. Volcanic activity, zinc production and waste incineration are the main sources of cadmium (WHO, 1987). Recent study indicates that traffic could also be the main source of cadmium found along busy streets (Valerio et al., 1995).

Chronic lead exposure at low levels is associated with adverse health effects, especially in fetus and young children. An inverse relationship between the cord blood lead levels and mental development index on Bayley scale among children aged 1-2 years was found (Bellinger et al., 1990). The neurotoxicity of lead is due to the fact that placenta does not represent a barrier for transport of lead from mother's blood to fetus, while at the same time cadmium is retained by 40-50% (Goyer, 1990). In addition, during pregnancy and lactation mobilization of lead from bones is likely to occur resulting in increased concentration of lead in blood and breast milk with potential toxic effects on the fetus and the mother (Silbergeld, 1991). The toxicity of cadmium is less clarified, though some experiments with animals indicate changes in the brain antioxidant defence mechanism during pregnancies that may have serious implications in later life (Gupta et al, 1995). To assess environmental exposure of fetus and newborn to lead and cadmium numerous studies were undertaken to establish the concentration of lead and cadmium in umbilical cord blood (Rhains and Levalois, 1993; Rabinowitz and Finch, 1984). A renewed interest in breast feeding pointed out not only considerable benefits of breast milk due to composition and immunological properties, but also gave rise to concern about wide range of

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chemical contaminants found in human milk and their adverse effects on infants. In this work lead and cadmium levels in breast milk from nursing women living in the Northern Adriatic area of Croatia will be presented.

MATERIALS AND METHODS

During the period September 1995. - January 1996. a total of 29 breast milk samples were collected in the Rijeka Clinical Hospital, Department for Obstetrics and Gynecology. The milk samples were taken between 2 and 12 day *post partum*. All pregnancies were diagnosed as normal prior to the delivery. In the group studied 14 women were primiparous, 12 were at their second childbirth while only 3 women were at their third or higher delivery. Obstetric history and other relevant maternal and family information (age, residence, parity, gestational age, smoking habits) were recorded regularly during admission to the hospital, while birthweight, length and Apgar score at first and fifth minute subsequent the delivery were recorded at birth.

Samples of human milk (approx. 80 ml) were expressed directly into sterile glass containers previously soaked overnight in 1:1 nitric acid and well rinsed with bidestilled water. Five ml of samples were acid digested with 3 ml conc. HNO_3 (Merck) in a high performance microwave digestion unit MILASTONE HLS 1200 MEGA for 22 min. The digested samples were diluted to 10 ml with double distilled water. Lead and cadmium were determined by graphite furnace atomic absorption spectrophotometry and a PERKIN ELMER 2380 equipped with graphite furnace HGA 400 and autosampler AS 40. The atomization temperatures were 2260°C for lead and 2060°C for cadmium. The detection limit determined as three times the standard deviation of sample blanks were 1.0 µg/L for lead and 0.3 µg/L for cadmium. When calculating means and in statistical comparisons, the determined values were used irrespective of the detection limits.

All the statistical analyses were performed by the *Statistica,* version 4.0 statistical package. Non-parametric Mann Whitney test was used for group comparisons.

RESULTS AND DISCUSSION

Rijeka is an industrialized city of approx. 200,000 inhabitants situated in the Northern Adriatic area of Croatia. The Rijeka Clinical Hospital and its Department of Obstetrics and Gynecology provides medical assistance not only for the citizens of Rijeka but also to population whose residence is within a radius of approx. 100 km from the city, covering the whole Istrian peninsula, background mountain region and islands with different climatological and socio-economic status. The principal source of lead and cadmium in this region is traffic, as well as two power plants: one oil fired situated in the eastern suburb of Rijeka and another coal fired located approx. 50 km southwest, on the Istrian peninsula. Abrasive blasting operations carried out in four shipyards situated within the region are also local sources of airborne metals including lead and cadmium.

A summary of anthropometric measurements and concentrations of lead and cadmium is presented in Table 1.

Table 1. Characteristics of the sample

Characteristic	N	C	Range	Median
Mothers				
Age (y)	29	28.9 ± 6.5	17 -45	27.0
Parity	29	1.8±1.2	1 -7	2.0
Weight gain (kg)	26	13.9±4.0	7 - 22	13.5
Gestation (wk)	29	39.3 ± 1.9	36 - 41	40
Pb (μg/L)	29	7.3 ± 8.3	0.3 - 44.0	5.0
Cd (μg/L)	29	2.54 2.06	0.46 - 9.10	1.80
Newborns				
Birthweight (g)	29	3231±488	2200-4400	3180
Length (cm)	29	50.0± 2.0	46.0 - 53.0	50.0
Apgar score(1/5min)	30	8.5±1.2/ 9.5±0.9	5 - 10 / 7 - 10	

Lead in milk is better absorbed into the body than in other dietary components. Lead levels in breast milk are normally lower than lead levels in milk based infant formulas. In human milk from industrialized countries, average background levels of lead are probably between 5-20 µg Pb/L while in the heavily polluted areas they may be up to 20 times higher (Sonawane, 1995). The results of a study undertaken in Mexico reported a mean level of lead in breast milk of 62 µg Pb/L, ranging from 9 to 350 µg Pb/L in women living near metal smelter (Nahimira et al., 1993). A recent study from Sweden indicates much lower lead content in breast milk at 6 weeks after delivery from a smelter area with mean value of 0.9±0.4 µg Pb/L, while in the control group the average value was O.5±0.3µg Pb/L. Such a low content of lead in breast milk is not only the result of drastic reduction of lead emission from 1970 to 1990, but also to the consumption of leaded free petrol. In the WHO/IAEA collaborative study the median milk lead levels in the six participating countries ranged from 2.0-17.8 µg Pb/L (Palmiger Hallen et al, 1995).

The lead concentrations in human milk samples collected in the Rijeka Clinical Hospital are in the range of 0.3 -44.0 µg Pb/L with a mean of 7.3 ± 8.3 µg Pb/L. The corresponding median value is 5.0 µg Pb/L. The obtained results are within the range reported in the WHO/IAEA collaborative study, but are higher comparative to the Swedish results.

The results of non-parametric Mann Whitney test for group comparisons regarding mothers' age, parity, residence and smoking habits are presented in Table 2. Although mean concentration of lead in women aged ≤ 25 y was higher compared to the group with > 25 y of age, this difference is not statistically significant (p>O.05) and is contrary to the expectation that women with more than 30 y of age would have higher lead levels (Silbergeld, 1991). Of 29 women studied, 14 were primipareous and had somewhat lower concentrations of lead in breast milk compared to women with two or more deliveries, but the difference is not significant (p>O.05). According to the results of this study, smoking habits do not have influence on the lead content of breast milk (p>0.05). This finding is in accordance with the results obtained in Sweden (Palmiger Hallen et al., 1995).

Table 2. Lead and cadmium levels in human milk (µg/L)

		Lead		Cadmium	
	N	range	C	range	C
Age					
≤ 25 y	10	0.5 - 44.0	10.4± 13.1	0.5 - 9.10	2.95 ± 2.72
> 25 y	19	0.3 - 12.0	5.7± 3.5	0.5 - 5.5	2.32 ± 1.67
Parity					
Primiparous	14	0.5 - 12.4	5.8 ± 4.2	0.5 - 12.4	2.54 ± 2.52
Multiparous	15	0.3 - 44.0	8.7 ± 10.8	0.5 - 5.5	2.54 ± 1.62
Residence					
Rijeka	13	2.9 - 44.0	10.6 ± 10.5 *	0.5 - 5.5	2.58 ± 1.75
Region	16	0.3 - 19.0	4.7± 4.8	0.5 - 9.1	2.50 ± 2.34
Smoking habits					
Smokers	7	0.5 - 19.0	5.7 ± 6.7	0.7 -9.1	3.27 ± 2.80
Nonsmokers	22	0.3 - 44.0	7.9 ± 8.8	0.5 -5.5	2.31 ± 1.79

* significant at p<0.01

The only statistically significant difference in this study was obtained regarding women's residence. Mothers living within city area had higher concentration of lead in breast milk ($p < 0.01$), compared to those living in smaller towns and settlements within the region. This difference is most likely due to the higher traffic density within the city whose complex orography favourites the accumulation of pollutants in lower troposphere. Annual means of airborne lead concentrations in the city center are 0.054-0.151 $\mu g/m^3$ (Alebic-Juretic, 1996; Institute of Public Health, 1994, 1996) and are within air quality guidelines (WHO, 1987). It should be emphasized that the sampling point is situated 30 m above busy street, while higher concentrations may be expected on the street level. Airborne lead concentrations are considerably lower at the remote site of Istrian peninsula with annual means of 0.013 - 0.026 $\mu g/m^3$ (Alebic-Juretic, 1996; Institute of Public Health, 1993, 1994).

Fewer investigations were carried out on cadmium in human milk. The reported results vary widely but average background levels are likely to be <2 µg/L, although levels ten times higher are also quoted. Cadmium levels in human milk are similar to those in cow's milk. In the WHO/IAEA collaborative study the median cadmium levels were in the range of < 1 to 6.07 µg Cd/L. The results of the recent study on cadmium levels in breast milk 6 weeks after delivery indicate the mean cadmium concentration of 0.06 µg Cd/L, while the difference in concentration between smelter and control area was not significant (Palmiger Hallen et al., 1995).

The concentrations of cadmium in breast milk collected in Rijeka Clinical Hospital were in the range of 0.45-9.10 µg Cd/L, with an average value of 2.54 ± 2.06 µg Cd/L. The obtained median value is 1.80 µg Cd/L, and is within the range quoted in WHO/IAEA collaborative study but higher than the cadmium levels in human milk obtained in Sweden (Palmiger Hallen et al, 1995).

The results of Mann Whitney test for group comparisons of cadmium levels in milk regarding mothers' age, parity, residence and smoking habits are reported in Table 2. In neither case was a significant difference found ($p > 0.05$), not even between smokers and nonsmokers although a tendency towards higher cadmium concentration in smokers is observed, similarly as in the Swedish study (Palmiger Hallen et al). The mean concentrations of cadmium in breast milk within the groups (except smoking habits) are in the close range of 2.26-2.95 µg Cd/L. This could be the result of uniform and low ambient levels of cadmium that are in the range of 0.6 - 2.7 ng/m^3 (as annual mean) in the city center and at the remote location (Alebic-Juretic, 1996; Institute of Public Health, 1993-1995).

REFERENCES

Alebic-Juretic A (1996) Airborne metal concentration in the Northern Adriatic Region (Croatia). Fresenius Environ Bull., in press

Bellinger D, Leviton A and Sloman J (1990) Antecedents and correlation of improved cognitive performance in children exposed *in Utero* to low levels of lead. Environ Health Perspect 89:5-11

Goyer R.A. (1990) Transplacental transport of lead. Environ Health Perspect 89: 101-105

Gupta A, Gupta A and Shukla GS (1995) Development of brain free radical scavenging system and lipid peroxidation under the influence of gestational and lactational cadmium exposure. Hum Exp Toxicol 14:428-433

Institute of Public Health Rijeka (1993,1994) Air quality in the vicinity of the Plomin power plant, Annual reports (in Croatian)

Institute of Public Health Rijeka (1994, 1996) Air quality within Rijeka Bay area, Annual reports (in Croatian)

Mignon C, Morelli J, Nicolas E and Copin-Montegut G (1991) Evaluation of total atmospheric deposition of Pb, Cd, Cu and Zn to the Ligurian Sea. Sci Total Environ 105:135-148

Nahimira D, Saldivar L, Pustilnik N, Carreon GJ and Salinas ME (1993) Lead in human blood and milk from nursing women living near a smaller in Mexico City. J Toxicol Environ Health 38:225-232

Palminger Hallen I, Jorhem L, Json Lagerqvist B and Oskarsson A (1995) Lead and cadmium levels in human milk and blood. Sci Total Environ 166: 149-155

Rabinowitz M and Finch H (1984) Cadmium content of umbilical cord blood. Environ Res 34:120-122

Rhainds M and Levallois P (1993) Umbilical cord blood lead levels in the Quebeck City area. Arch Environm Health 48:421-427

Silbergeld EK (1991) Lead in bone: Implications for toxicology during pregnancy and lactation. Environ Health Perspect 91:63-70

Sonawane BR (1995) Chemical contaminants in human milk: An overview. Environ Health Perspect 103:197-205

Valerio F, Pala M, Piccardo MT, Lazzarotto A, Balducci D and Brescianini C (1995) Exposure to airborne cadmium in some Italian urban areas. Sci Total Environ 172:57-63

WHO Regional Office for Europe. WHO Regional Publications, European Series (1987) No 23, Air Quality Guidelines for Europe, Copenhagen, p. 200, 242