CADMIUM IN URINE OF CHILDREN AND ADULTS FROM INDUSTRIAL AREAS

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SUMMARY

Various human activities result in the release of significant quantity of cadmium to the environment. The study population included adults (230) and children (100) residing near the tobacco plant and a control group, unexposed to elevated cadmium concentrations, living in unpolluted area in the same city. Biomonitoring methods were used to assess the effects of contaminated air on the health of the public (urine samples). Ambient air samples were collected near the cadmium-related plant and in unpolluted area during the last ten years.

Values of cadmium concentrations in urine found in polluted area were in range of 0.05–0.42 μg/g creatinine for children and 0.15–1.96 μg/g creatinine for adults. The results indicated statistical significant age-dependent differences in urine cadmium concentration between polluted and unpolluted area for adults. Boys and men had significantly higher urine cadmium levels than girls and women, but in children there were no significant gender-dependent differences in cadmium excretion found out.

In conclusion, the results from the present study indicate that cadmium urine concentration in polluted area are very high, particularly in children.

Key words: cadmium, urine, air, exposure

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INTRODUCTION

Cadmium is an element that occurs naturally in the earth's crust and it is not usually present in the environment as a pure metal. Various human activities result in the release of significant quantity of cadmium to the environment. Exposure to cadmium has been linked to a wide range of adverse effects (1).

Human uptake of cadmium occurs via inhalation of air and the ingestion of food and drinking water. The total of absorbed cadmium is highly dependent on the route of exposure. Once cadmium enters the body, it is very strongly retained (2). Its biological half-life in the whole body exceeding 10 years (3).

The quantity of cadmium in urine is an indication of how much total cadmium is present in the body. The urinary excretion of cadmium is proportional to the body burden and is widely used as a dosimeter of lifetime exposure. The amount excreted daily by urine represents only about 0.005–0.010 % of the total body burden and increases up to 50–60 years of age. In persons not occupationally exposed to cadmium the urinary excretion is normally less than 2 μg/day (4,5).

The purpose of the present study was to assess effects of contaminated air in the vicinity of the tobacco industry on the cadmium concentration in urine of residents living in neighborhood and to compare these findigs with data from population living in unpolluted area and literature.

METHODS

The study population included adults and children residing near the tobacco plant and a control group, unexposed to elevated cadmium concentrations, living in unpolluted area in the same city. The general population was selected from each area under study and included man and women 18 to 75 year of age and children 4 to 6 year of age. The adults resided permanently in polluted and unpolluted areas for at least 20 years and all are nonsmokers and none of them had occupational exposure to cadmium. The children lived in areas investigated from their birth. The survey included 230 adult residents and 100 children.

Biomonitoring methods were used to assess the effects of contaminated air on the health of the public. Morning urine samples were collected in acid-washed polyethylene containers and were stored frozen (–20ºC) until transfer to the analytical laboratory in the Public Health Institute in Nis. A 2% random sample of specimen-collection containers were tested and certified "cadmium free." Investigators determined cadmium concentrations of urine by graphite-furnace atomic-absorption spectrometry (Perkin-Elmer Atomic-absorption spectrometers 1100 and Analysis 200), after acidification of urine (3). The detection limit (DL) for cadmium was 0.05 μg/l in urine. Whenever the assays yielded a negative finding for cadmium, the authors assumed the true value to be half the DL. Assay results below the DL based on urine analysis were found in 5% of participans.

Ambient air samples were collected near the cadmium-related plant and in unpolluted area during the last ten years in 24 hours samples which yielded a total of 505 ambient air samples in polluted and 295 samples in unpolluted area. Cadmium from the air was collected with absorb solution of sulfur acid and was detected by AAS.

Results of the examinations were processed by mathematical and statistical methods. Arithmetic mean values (Avr), standard deviation (±SD), geometric mean (Geomean), medians (Me),

Table 1. *Cadmium concentration in air (ng/m³)*

Area	Polluted				Unpolluted			
Year	No. of samples	Avr	Me	C_{98}	No. of samples	Avr	Me	C_{98}
1995	54	64	50	111	12	10	7	20
1996	54	62	42	123	12	12	8	34
1997	54	72	58	140	12	7	4	39
1998	54	54	35	98	12	6	4	13
1999	20	12	10	34	5	5	3	13
2000	52	16	10	45	54	3	2	11
2001	55	45	31	78	54	3	2	9
2002	54	23	14	73	50	6	3	34
2003	54	12	10	45	30	5	4	23
2004	54	11	10	22	54	3	2	18
Total	505	34	28	140	295	5	3	35
t-test = 3.457 p-value < 0.05*								

*statistical significant differences. For acronyms see text.

Table 2. *Caracteristic of the examined population by age and gender*

Age	Polluted			Not polluted			Sum
	Gender			Gender			
	Male	Female	Total	Male	Female	Total	
4–6	19	11	30	42	28	70	100
18–24	11	16	27	15	8	23	50
25–44	18	10	28	13	14	27	55
45–64	28	27	55	14	16	30	85
65 and over	11	9	20	8	12	20	40
Sum	87	73	160	92	78	170	330

Table 3. *Cadmium concentration in urine (µg/g creatinine) in two areas*

Age	Area	Aver. value	Geomean	Value range	t–test	p–value
4–6	polluted	0.21	0.14	0.05–0.42	1.153	> 0.05
	not polluted	0.15	0.10	0.05–0.27		
18–24	polluted	0.45	0.31	0.15–0.72	1.315	> 0.05
	not polluted	0.30	0.21	0.05–0.53		
25–44	polluted	0.61	0.43	0.15–0.84	2.385	< 0.05*
	not polluted	0.34	0.27	0.10–0.62		
45–64	polluted	0.72	0.56	0.25–1.96	4.447	< 0.01*
	not polluted	0.40	0.27	0.15–0.88		
65 and over	polluted	0.69	0.49	0.21–1.82	3.709	< 0.01*
	not polluted	0.31	0.26	0.15–0.69		

*statistical significant differences

Table 4. *Cadmium concentration in urine (µg/g creatinine) according to age and gender*

Age	Area	Gender	Aver.value	t-test	p-value
Children	polluted	boys	0.23	1.177	> 0.05
		girls	0.18		
	not polluted	boys	0.16	1.169	> 0.05
		girls	0.13		
Adults	polluted	male	0.70	2.512	< 0.01*
		female	0.57		
	not polluted	male	0.29	2.184	< 0.01*
		female	0.40		

*statistical significant differences

value rang (min-max) and 98th percentiles (C_{98}) were calculated. Group were compared using Student's t-test. Statistical significance was set at p value < 0.05. The analysis was performed using statistical software SPSS® for Windows™, release 8.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

In Table 1 there are shown cadmium air levels measured in the areas surrounding the sources of cadmium – tobacco plant and in unpolluted area – background value. The level of cadmium in the air was considerably higher near the source of emission, compared with the background value. In the vicinity of the plant a large amount of cadmium was released in the air during the last ten years with an average value ranging between 11–72 ng/m³ and with 98th percentile value up to 140 µg/m³. In unpolluted area average value ranged between 3–12 ng/m³ and 98th percentile was 35 µg/m³. There is a statistical significant difference in air cadmium concentrations between these two areas (p-value < 0.05).

Age and sex caracteristics in the study population are shown in Table 2. A total of 330 people were examined for urine cadmium concentration, 160 in polluted and 170 in unpolluted area.

Table 3 presents value of cadmium assessed in urine from two areas. Children living near sources of cadmium emissions had an average value of cadmium in urine of 0.21 µg/g creatinine and geometric mean of creatinine was 0.14 µg/g. Children in unpolluted area had an average value of creatinine 0.15 µg/g and geometric mean of creatinine was 0.10 µg/g. There were no statistical significant differences in urine cadmium value between children in polluted and unpolluted area.

Creatinine adjusted urine cadmium levels were higher in adult residents of the polluted area and these increased with age up to 64 years and then decreased in people older than 65 years. Maximum average value of 0.72 µg/g creatinine and geometric mean value were observed among people aged 50–60 years living in the polluted area. There were statistical significant age-dependent differences in urine cadmium concentration between polluted and unpolluted area for people 25 years and older (p-value < 0.05 and < 0.01). A higher urine cadmium/creatinine level was associated both with age and gender (Table 4).

Boys and men had significantly higher urine cadmium levels than girls and women, but in children there were no significant gender – dependent differences in cadmium excretion. It was also observed that male subjects in polluted and unpolluted areas had significantly elevated values compare with female residents.

DISCUSSION

Cd remains an environmental pollutant of continued concern. According to WHO data in (5) general population of uncontaminated areas assuming an air cadmium concentration of 10 ng/m^3 in the air and a daily inhalation rate of 15 m^3 for an adult, the average intake of cadmium from the atmosphere would be 0.15 μg, of which about 25%, i.e. 0.04 μg, will be absorbed. In contaminated areas Cd may reach level of 0.5 μg/m^3, which would lead to a daily inhalation of 7.5 μg and absorption of about 2 μg. Also, it is suggested that major route of exposure to cadmium for the non-smoking general population is via food and the contribution from other pathways to total uptake is small (6).

However, our data are quite contrarywise. Earlier investigation in the same area point out that in our city the inhalation is the major route of exposure and contributes to the total daily absorption with 67% in non-smoking general population and absorption via inhalation is about 3.75 μg/day (7,8). In our investigation the study population had the same exposure via food and drinking water and only difference ascertained was in cadmium air concentration, so cadmium air concentration had great impact on the total daily intake and absorption rate.

Breathing air with lower levels of cadmium over long periods of time results in a build-up of cadmium in the kidney and that may result in kidney disease. Other effects that may occur are lung damage and fragile bones (9). Effects from long-term low--level exposure to cadmium are hard to determine with the many other factors that may come into play. Therefore, we wanted to match up data from our area with literature data and found out what we can expect with urine cadmium level observed in our population.

Detected cadmium concentration in urine was compared with concentration of the participants in the Third National Health and Nutrition Examination Survey (NHANES III 1988–1994) in USA. The arithmetic mean value for urine cadmium in the U.S. population was 0.48 μg/g creatinine (10). Based on this estimates they conclude that about 2.3% of the U.S. population have urine cadmium concentrations higher than 2 μg/g creatinine, and 0.2% have concentrations higher than 5 μg/g creatinine, the current World Health Organization health-based exposure limit.

In our study arithmetic mean value for urine cadmium in polluted area was 0.63 μg/g creatinine and in unpollued 0.35 μg/g creatinine, but we did not detect concentration greater than 2 μg/g creatinine and value higher than the current WHO health-based exposure limit was not detected either.

Values detected by us were higher than in Australian urban population (11) and in German Environmental Survey (12) where the geometric mean for cadmium in urine of adults were 0.35 μg/ g creatinine. In our study we found out higher value.

Higher cadmium concentration in urine (13, 14) than in our general population was found in the area of Nagasaki, Japan (geometric mean = 6.3 μg/g creatinine) and in the Czech Republic (15) where the median urine Cd level was 0.59 μg/g creatinine in adults and 0.37 μg/g creatinine in children. In our study median urine cadmium level for children was 0.17 μg/g creatinine.

Several studies point out that women had higher cadmium concentration in urine than men (10, 16), because of iron status, but in our study male subjects in all age groups had higher concentration, and determined differences for adults were statistical significant. In our study we found out that concentration rises up to 60 years and then decreases.

During the past decade, numerous studies of both occupationally and environmentally exposed populations have shown that tubular proteinuria occurs at doses of urinary cadmium of 2–4 μg/g creatinine. The findings indicate (19) that early renal effects in the general population may occur at urine cadmium concentration above 2.0 μg/g creatinine. Furthermore, cadmium exposure in childhood may have stronger impact on the renal function, particularly tubular reabsorption than does the exposure of an adult organism (17–21).

Since the full biologic significance of these findings is not known, exposure of children to toxic heavy metals should be reduced to a minimum.

In conclusion, the results from the present study indicate that cadmium urine concentration in polluted area are wery high, particularly for children. Therefore, measures should be taken to reduce exposure to cadmium in the general population, including lowering emision from point source of cadmium – tobacco plant.

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