THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI.
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 3 – 2012, ISSN 1453 – 083X

THE CONSEQUENCES OF HEAVY METALS IMPACT ON PRIMARY TEETH

Diana Daniela Daciana ZMARANDACHE, Rodica LUCA, Ioana-Andreea STANCIU, Cătălina FARCAȘIU
Paediatric Dentistry Department,
"Carol Davila" University of Medicine and Pharmacy, Bucharest
email: prelipceandaciana@yahoo.com

ABSTRACT

Since the metals deposited in the teeth during formation and mineralization processes are to a large extent retained, human teeth receive a considerable attention as indicators of heavy metal exposure. The objective of the present work was to assess the relationship between the concentration of lead from the hard dental tissues of schoolchildren's deciduous teeth and the prevalence of dental caries. In 2008, a cross-sectional study was conducted on 157 children: 90 children from an industrial urban area (44 boys and 46 girls), mean age 7.66±0.6 years and 67 children from a reference area (31 boys and 36 girls), mean age 7.75±0.6 years. For dental status evaluation there were determined mean values and standard deviation for the following parameters: the number of caries free children, the prevalence index (Ip), the decayed, missing, filled teeth/surfaces (dmft/s index) and the Significant Caries index (SiC30 and SiC10). A correlation was made between these indices and the heavy metals concentrations from the temporary teeth collected from the two areas, the data being obtained from Politechnica University, Bucharest, our partner in a CNMP project. Statistical analyses were performed using the SPSS program.

KEYWORDS: heavy metals, caries experience, primary teeth

1. Introduction

The subject of this paper – the consequences of the action of heavy metals on human teeth – brings to attention a topic that is probably not very commonly known within the technical world, but which could well be an interesting subject for interdisciplinary research.

It is common knowledge that disturbing actions of environmental factors during tooth formation (odontogenesis) may induce anomalies of dental hard tissues, known as tooth development anomalies [1-4]. These anomalies are evident at the moment of tooth eruption or become noticeable shortly afterwards and show that the subject was submitted to the negative influences of environmental factors during tooth formation [5,6].

It seems out of all environmental factors, heavy metals (lead-Pb, cadmium-Cd, magnesium-Mg, zinc-Zn and cooper-Cu) have a great impact on tooth formation and mineralisation, taking into account their capacity of accumulation in time in heavy dental tissues [7-10].

Like in a bone, calcium can be partially substituted by a small amount of heavy metals [11-15]. This process is well known and may also take place in a tooth structure [15]. This is rather a complex process that is affected by various factors including the chemical form of the metal and its binding sites, age, gender, genetic inheritance and environmental quality [16,17]. Thus, the levels of the metals in teeth can be used to estimate especially the long-term environmental exposure [18].

During the last years, the dynamic behavior of dental structures from areas with heavy metal risk became the subject of some papers mainly for evaluating environmental effects on vulnerable groups of children, as their exposure and susceptibility are greater than those of adults. Studies conducted in Bahrein upon 280 primary teeth found toxic concentration of lead in 35% of the teeth of the studied children.

The level of lead in the teeth was not influenced by the child's sex, nationality, area of residence or socio-economic status [19]. Studies conducted in Germany reported higher levels of lead in children living in urban areas, compared to those from suburban/rural areas. The highest concentrations were found in children living in the smelter area and in those whose parents are lead-workers. The same studies reveal that lead level depends on the period of time the subject spent in the lead-smelter area as well as on the degree of local environmental pollution, in essence on the lead content of the atmospheric dust fall-out around children's home [20, 21].

Various studies on the consequences of high levels of lead in the teeth reported possible connections with a higher level of caries [3, 22]. However, there is no convergence of opinions on the matter. Because of the divergences in the literature and scarcity of data on this subject among Romanian communities, an epidemiological investigation was made in order to determine the relationship between the concentration of lead present in the enamel of Romanian schoolchildren's deciduous teeth and the prevalence of dental caries. The two target groups were selected from an industrial area, an urban area with high pollution, and from a reference area, a rural area from the mountain region of Romania.

2. Material and methods

An epidemiological, cross-sectional study was conducted upon first and second grade schoolchildren attending random schools from those towns. Sample 1 consisted of 90 children from Bucharest (44 boys and 46 girls), mean age 7.66±0.6 and median age 7.75 years. Sample 2 consisted of 67 children from Pătârlagele (31 boys and 36 girls), mean age 7.75±0.6 and median age 7.75 years (Figures 1, 2 and Table 1). The 6-7 years old is one of the ages recommended by WHO for children oral health evaluation because at this age primary dentition is in total functionality.

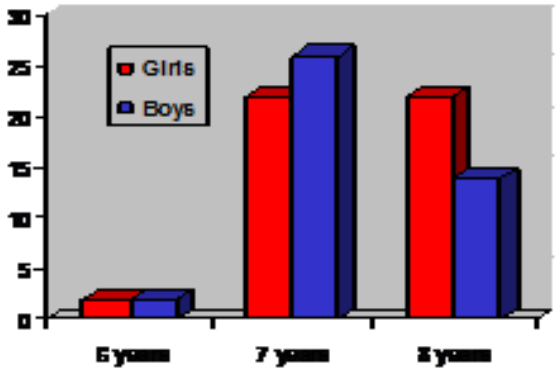

Fig. 1. *Sample 1- Age and sex distribution*

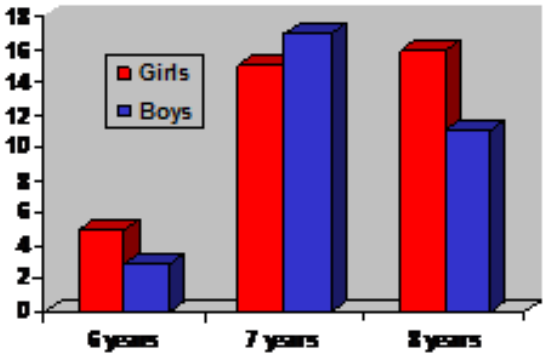

Fig. 2. *Sample 2- Age and sex distribution*

Written consent was obtained from the local public health authorities of the cities included in the study, from the local administration authorities and from the school authorities. The school authorities obtained the written informed consent from the parents of the recruited children.

The clinical examination was carried out in the school classes, using plain mouth mirrors, ball-ended dental probes under natural optimal light. Standard infection-control protocols were followed [23].

The World Health Organization (WHO) criteria were used for the caries diagnosis and registration [6]. Dental caries was diagnosed at the caries into dentine, using a visual method without radiography, fibre-optic transillumination, or compressed air. Enamel and precavitated lesions were excluded. The data were registered on individual charts: the presence and distribution of caries, fillings and missing teeth due to caries.

For caries experience evaluation there were determined:

- the number of caries-free children;
- the prevalence index (Ip);
- the dmft/dmfs indices – the sum of the number of teeth/surfaces decayed, missing/extracted or filled because of decay.

After the data were gathered and centralised, we analised if there are any differences regarding the heavy metals concentration in the primary teeth belonging to the children born and raised in the two urban areas (Bucharest and Patarlagele). The primary teeth, extracted due to their exfoliation, were collected by the dentists from the local school dental clinic, in the same year whith the examination. The heavy metals concentration were determined by the Politechnica University, Faculty of Applied Chemistry and Materials Science, our partner in a CNMP (National Centre of Management Programs) project. In this project, the "Carol Davila" University of Medicine and Pharmacy Bucharest, represented by the Paediatric Dentistry Department, provided the

primary teeth that were analysed, those teeth being collected during the exfoliation period.

The primary teeth belonged to all morphological types (incisors, canines and molars), were sound teeth and also decayed teeth.

Data were analyzed by using the statistical package SPSS v. 16.0. Associations of variables were tested by means of ANOVA unifactorial tests and Independent sample t-test at the 5% level of significance.

For heavy metal level determination an ELAN DRC-e induced plasma coupled spectrophotometer was used (ICP-MS). This method is a type of mass spectrometry that is highly sensitive and capable of the determination of a range of metals and several non-metals at concentrations below one part in 10^{12} (part per trillion) [24-26].

3. Results

3.1. Caries experience

The prevalence index, Ip, had very high values for both samples, in the urban area being 80%. The dmft index was 4.21±3.43, and the dmfs index 8.83±8.31 (Table 1).

For the second sample, the Ip was 82.5% the dmft index was 7.09±4.15, and the dmfs index was 16.31±11.9 (Table 1).

The differences between the data were statistically significant ($p<0.05$).

Table 1. *Caries experience indices for both samples*

Index	Sample 1	Sample 2	
Ip (%)	80	82.5	*SS*
Caries free (%)	20	17.5	*SS*
dmft	4.21±3.43	7.09±4.15	*SS*
dmfs	8.83±8.31	16.31±11.9	*SS*

3.2. Heavy metals concentration in primary teeth

Our results were compared with those reported by the Department of Bioengineering and Biotechnology. The amount of heavy metals was determined for the extracted primary teeth, for each sex and for enamel and dentine. The tables below present the mean values obtained by our partner, because they calculated the concentrations for each kind of teeth (molars, canines and incisors).

The heavy metal concentrations were generally higher in Bucharest than at Patarlagele.

Regarding the heavy metal concentration for both sexes, the values were higher for the boys than for the girls.

Taking into consideration the concentration of the two layers, enamel and dentine, the amount of heavy metals from the enamel was higher than the dentine, although those metals are normally deposited mostly in the dentine [26].

Table 2. *Heavy metal concentration in enamel-boys [26]*

Area	Mn	Cu	Zn	Cd	Pb	Hg
	[ppm]					
Urban	30.5	44.03	36.13	57.21	38.32	29.6
Rural	24.04	45.5	25.7	37.16	15.6	10.74

Table 3. *Heavy metal concentration in enamel-girls [26]*

Area	Mn	Cu	Zn	Cd	Pb	Hg
	[ppm]					
Urban	42.5	56.16	51.06	38.14	38.56	28.16
Rural	11.05	53	5.95	46.5	5.2	9.35

Table 4. *Heavy metal concentration in dentin-boys [26]*

Area	Mn	Cu	Zn	Cd	Pb	Hg
	[ppm]					
Urban	26.46	33.48	26.17	39.55	16.5	12.45
Rural	10.07	34.72	10.05	22.1	2.1	5.42

Table 5. *Heavy metal concentration in dentin – girls[26]*

Area	Mn	Cu	Zn	Cd	Pb	Hg
	[ppm]					
Urban	35.7	45.84	41.7	28.24	16.64	17.2
Rural	9.7	45.05	5.2	39.15	4.95	8.25

In order to see if there is an association between the caries experience and the heavy metal concentration, the ANOVA test was used.

No statistical association was found between caries experience and the amount of heavy metals in these teeth (Table 6, $p>0.05$).

Table 6. *ANOVA test results*

Correlated parameters	ANOVA-p
Mn	0.56
Cu	0.72
Zn	0.85
Cd	0.76
Pb	0.32
Hg	0.25

4. Discussion

There are few studies in Romania regarding the impact of heavy metals on hard dental tissues. In this respect, the purpose of our study was to analyze if there is any correlation between the heavy metal content in the enamel and dentine of primary teeth and caries prevalence from a polluted area and a reference area.

Based on human and animal studies, a number of 6 types of elements have been proposed in the literature, depending on their cariogenicity. This proposal which summarized the cariogenic effect of many of the minerals included in the cariostatic group some elements like F and P, and placed various heavy metals, such as Mn, Sn and Zn, in the range of middle cariostatic [27-29]. Other elements like Al, Ni and Fe are treated as caries inert, while some other aggressive heavy metals, like Cd and Pb are defined as caries promoting.

No defined reference values exist in the literature for the concentrations in dental enamel that would reflect a condition of lead poisoning or, furthermore, would relate to enamel defects and caries.

The studies in the Brazilian literature have established reference values only for blood and have reported the importance of verifying lead levels as a routine examination. However, blood measurements indicate acute lead contamination, thus differing from dental enamel, which indicates past contamination [30].

The heavy metal content in the deciduous teeth was higher in children's primary teeth from the polluted town than the reference area.

The heavy metal content was bigger in enamel than in dentine.

Nonetheless, no relationship was found between any of the lead concentrations analyzed in the present study and caries experience in the deciduous teeth, but there is a correlation between these concentrations and local pollution.

It is needed to point out that there are many factors, including nutrition and socio-economic problems which may affect the caries experience and oral health in general and therefore a correlation is very difficult to be established.

Our results are in agreement with previous studies made in Piracicaba, Sao Paulo, on preschool children, which also found no correlation between the heavy metal content in high polluted areas and caries experience or enamel hypomineralisation [29].

Also in Poland no data was found that would give evidence of a relationship between the Cd, Cr, Cu, Fe, Mg, Zn, K, Ca and Mg concentrations in the decayed tooth roots and the sound teeth [29].

5. Conclusions

Many studies on this topic are needed, with focus on children from the same social category or other polluted areas in order to see if there is a correlation between caries experience and heavy metals.

References

[1]. F. Gil, A. Facio, E. Villanueva, M.L. Pérez, R. Tojo, A. Gil - *The association of tooth content with dental health factors,* Sci Total Environ (1996);192:183-91.

[2]. A.H. Brook, J.M. Fearne, J.M.Smith - *Environmental causes of enamel defects,* Symposium on Dental Enamel, 1996, Ciba Foundation. Proceedings. New York: John Wiley & Sons, (1997).

[3]. J.D. Spouge - *Developmental Abnormalities of Enamel,* Oral Pathology, C. V. Mosby Comp., Saint Louis, (1973):145-165.

[4]. R.Luca - *Criterii de alegere si modalitati de tratament in unele distrofii ale smaltului, (Chosing criteria and treatment terapy in some enamel defects),* Stomatologia (Bucuresti), (1996); XLIII (3-4):67-71.

[5]. R. Luca, D. Constantinescu - *Consideratii etiopatogenice asupra hipoplaziilor de smalt de cauza locala (Etiopathogenic considerations on enamel local hypoplasia),* Buletin informativ al Asociatiei Romane de Ortodontie Nr. 2 (Cursuri si lucrari stiintifice a filialei "ANRO" Bucuresti, 1995 si cel de al II-lea Congres "ANRO"), Ed. Medicala , Bucuresti: 13-16.

[6]. R. Luca, *Conceptii actuale asupra amelogenezei (Actual conception on amelogenesis),* Revista Nationala de Stomatologie (1998); I: 44-49.

[7]. V.E. Gomes, R.F. Gerlach, M.L.R. Sousa, F.J. Krug - *Concentração de chumbo em dentes decíduos de pré-escolares de Piracicaba, SP, Brasil — Estudo Piloto. Lead Concentration from enamel preschool children from Piracicaba, SP, Brazil-Pilot study* Rev Odonto Ciência (2003);18:3-7.

[8]. V.E. Gomes, M.L.R. Sousa, F.Jr. Barbosa, F.J. Krug, M.C.P. Saraiva, J.A. Cury, R.F.Gerlach - *In vivo studies on lead content of deciduos teeth superficial enamel of preschool children,* Sci Total Environ (2004); 320:25-35.

[9]. P. Malara, J. Kwapulinski, B. Malara - *Do the levels of selected metals differ significantly between the roots of carious and non-carious teeth?* Science of the Total Environment (2006); 59: 369-373.

[10]. I. Demetrescu, I.D. Iordachescu, D. Ionita, S. Manea - *Proceedings of Bioceramics 21 Conference*, Key Engineering Materials (2009); 35: 396-398.

[11]. R.F. Gerlach, A.P. Souza, J.A. Cury, S.R.P.Line - *Effect of lead, cadmium and zinc on the activity of enamel matrix proteinases in vitro,* Eur J Oral Sci (2000);108:327-34.

[12]. T.J.Simons - *Cellular interactions between lead and calcium,* Br Med Bull (1986); 42:431-434.

[13]. G. Boivin, P. Deloffre, B. Perrat, G. Panczer, M. Boduelle, Y. Mauras - *Strontium distribution and interactions with bone-mineral in monkey iliac bone after strontium salt (S-12911) administration,* J Bone Miner Res (1996); 11:1302–11.

[14]. J. Kwapulinski, B. Brodziak, M. Bogunia - *Relative change of elements in human osseous tissue,* Bull Environ Contam Toxicol (2003); 70:1089–96.

[15]. M. Manea-Krichten, C. Patterson, G. Miller, D. Settle, Y. Erel - *Comparative increases of lead and barium with age in human tooth enamel, rib and ulna,* Sci Total Environ (1991); 107:179–203.

[16]. H.M. Tvinnereim, R. Eide, T. Riise - *Heavy metals in human primary teeth: some factors influencing the metal concentrations,* Sci Total Environ (2000); 255:21–7.

[17]. E. Burguera, Z. Romero, M. Burguera, J.L. Burguera, H. de Arenas, C. Rondon - *Determination of some cationic species in temporary teeth,* J Trace Elem Med Biol (2002); 16:103–12.

[18]. B. Nowak, H. Kozlowski - *Heavy metals in human hair and teeth,* Biol Trace Elem Res (1998); 62:213–28.

[19]. F.al-Mahroos, F.S. Al-Saleh - *Lead Levels in Deciduous Teeth of Children in Bahrain,* Ann Trop Paediatr (1997); 17(2): 147-154.

[20]. U. Ewers, A. Brockhaus, G. Winneke, I. Freier, E. Jermann, U. Kramer - *Lead in Deciduos Teeth of Children Living in a Non-ferrous Smelter Area and a Rural Area of the FRG,* Int Arch Occup Environ Health (1982); 50(2): 139-151.

[21]. A. Brockhaus, W. Collet, R. Dolgner, R. Engelke, U. Ewers, I. Freier, E. Jermann, U. Kramer, N. Manojlovic, M. Turfeld - *Exposure to Lead and Calcium of Children Living in Different Areas of North-West Germany*, Results of Biological Monitoring Studies 1982-1986. International Arch Occup Environmental Health, (1988); 60(3): 211-222.

[22].G.E. Watson, B.A. Davis, R.F. Raubertas, S.K. Pearson, W. H. Bowen - *Influence of maternal lead ingestion on caries in rat pups,* Nature Med (1997); 3:1024-5.

[23].World Health Organization - *Oral Health Surveys: Basic Methods.* 4th ed. Geneva: W.H.O. Library Cataloguing in Publication Data; (1997).

[24]. I.Demetrescu, R. Luca, D. Ionita, D.Bojin - *ICP/MS in evaluation heavy metal influence on the behavior of natural temporary teeth,* Key Engineering Materials (2009); 396-398: 175-178.

[25]. M. Prodana, R. Luca, F. Miculescu, D.Bojin - *A new approach in evaluation surface properties of natural temporary teeth from high polluted area,* Key Engineering Materials (2009); 396-398: 21-24.

[26]. I. Demetrescu, R. Luca, D. Ionita, M. Prodana - *The evaluation of heavy metals concentration of temporary teeth from areas with different pollution level,* Molecular crystal and Liquid Crystals (2010); 523: 73-81.

[27]. M. Prodana, A Meghea, G Stanciu, R. Hristu - I.Demetrescu, *Aspects of correlation between the surface analysis and heavy metal content in temporary teeth from areas with various pollution levels of Romania,* International Journal of Environmental Science and Development (2010); 1: 47-52.

[28]. K. Bercovitz, D.Laufer - *Carious teeth as indicators to lead exposure,* Bull Environ Contam Toxicol (1993); 50: 724-729.

[29]. J. M. Navia - *Prevention of dental caries: Agents which increase tooth resistance to dental caries,* International Dental Jorunal (1972); 22:427-440.

[30]. V. E. Gomes, R.S. Wada, J.A. Cury and Rosário de Sousa M - *Lead level, enamel defects and dental caries in deciduous teeth,.* Rev Saude Publica (2004); 38(5):1-6.