Research Article

Blood and Urine Lead Levels in Non-exposed Group

Sirivarasai J* , Kaorern S* , Wananukul W*, Srisomerarn P**

Abstract :

Objectives : To report blood and urine lead levels in non-exposed people and to study the effects of sex, age, smoking habit, alcohol consumption and socioeconomic variables on lead levels.

Materials and Methods: Blood and urine lead concentrations were analyzed by graphite furnance atomic absorption spectrophotometry. Urinary lead excretion was expressed per gram creatinine excretion.

Results : The average blood and urine lead levels ($\bar{X}\pm SD$) of all subjects (n=320 : 172-male and 148-female) were 5.55±2.51 µg/dL and 10.35±7.50 µg/gCr, respectively. Male has significantly higher blood lead level than female (6.18±2.56 vs 4.83±2.26 µg/dL, $p<0.05$), while urine lead was statistically lower (9.22±6.63 vs 11.59±8.20 µg/gCr, $p<0.05$). There was no association between increased blood and urine lead levels with age. Male with cigarette smoking and alcohol drinking had higher blood lead concentration (6.35±2.69 µg/dL and 6.41±2.44 µg/dL, respectively) than non-smokers and non-drinkers (5.39±2.45 µg/dL and 5.22±2.46 µg/dL, respectively). This differences were not found in urinary lead excretion. Subjects with the highest income had the lowest blood lead value.

Conclusions: Although the trend of the blood and urine lead in Bangkok population are lower than the previous studies, there is a need for continuous monitoring of lead exposure and its chronic effects in the population. **Bull Chiang Mai Assoc Med Sci 2002. 35: 89-99.**

Key word : Lead exposure

* Division of Clinical Pharmacology and Toxicology, Department of Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University.

** Research Center , Faculty of Medicine, Ramathibodi Hospital, Mahidol University.

บทคัดย่อ: ระดับตะกั่วในเลือดและปัสสาวะของคนปกติที่ไม่ได้สัมผัสกับสารตะกั่ว

จินตนา ศิริวราศัย*, สมิง เก่าเจริญ*, วินัย วนานุกูล*, พีระ ศรีสำราญ**

บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาระดับตะกั่วในเลือดและปัสสาวะของคนที่ไม่ได้ทำงานสัมผัสกับสารตะกั่วและศึกษาอิทธิพลของเพศ อายุ การสูบบุหรี่ การดื่มแอลกอฮอล์ และปัจจัยทางด้านการเงินและสังคมที่มีต่อระดับตะกั่วในร่างกาย

วัสดุและวิธีการ: ระดับตะกั่วในเลือดและปัสสาวะ วัดโดยใช้เครื่องมือ graphite furnance atomic absorption spectrophotometry ค่าของระดับตะกั่วในปัสสาวะรายงานในหน่วยของกรัมของครีเอตินิน

ผลการศึกษา: กลุ่มศึกษาจำนวน 320 คน เพศชาย 172 คน และเพศหญิง 148 คน อายุระหว่าง 17-55 ปี พบว่า ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของระดับตะกั่วในเลือดและปัสสาวะ เท่ากับ 5.55±2.51 ไมโครกรัม/เดซิลิตร และ 10.35±7.50 ไมโครกรัม/กรัมของครีเอตินิน ตามลำดับ เพศชายมีค่าเฉลี่ยระดับตะกั่วในเลือด (6.18±2.56 ไมโครกรัม/เดซิลิตร) สูงกว่าเพศหญิง (4.83±2.26 ไมโครกรัม/เดซิลิตร) อย่างมีนัยสำคัญ ($p<0.05$) ซึ่งตรงข้ามกับที่ตรวจพบในปัสสาวะ (ผู้ชาย : 9.22±6.63 และ ผู้หญิง : 11.59±8.20 ไมโครกรัม/กรัมของครีเอตินิน, ตามลำดับ, $p<0.05$) ไม่พบความสัมพันธ์ระหว่างการเพิ่มขึ้นของระดับตะกั่วในเลือดและปัสสาวะกับอายุที่เพิ่มขึ้น นอกจากนี้กลุ่มศึกษาเพศชายที่สูบบุหรี่และดื่มเหล้า มีระดับตะกั่วในเลือดสูงกว่ากลุ่มที่ไม่สูบบุหรี่และไม่ดื่มเหล้า (6.35±2.69 และ 6.41±2.44 ไมโครกรัม/เดซิลิตร, 5.39±2.45 และ 5.22±2.46 ไมโครกรัม/เดซิลิตร, ตามลำดับ) กลุ่มที่มีรายได้ต่อเดือนสูงที่สุด มีค่าเฉลี่ยระดับตะกั่วในเลือดต่ำที่สุด แต่ไม่พบความแตกต่างในปัสสาวะ

สรุป: การศึกษานี้พบแนวโน้มของการลดลงของระดับตะกั่วในเลือดและปัสสาวะของคนในเขตกรุงเทพมหานครเมื่อเปรียบเทียบกับการศึกษาอื่นที่ผ่านมา อย่างไรก็ตามการเฝ้าระวังและตระหนักถึงพิษของสารตะกั่วเป็นเรื่องสำคัญ และต้องมีการดำเนินการอย่างต่อเนื่อง เพื่อป้องกันอันตรายที่จะเกิดขึ้นต่อสุขภาพ **วารสารเทคนิคการแพทย์เชียงใหม่ 2545; 35: 89-99.**

คำหัส : พิษสารตะกั่ว

---

* หน่วยเภสัชวิทยาคลินิคและพิษวิทยา, ภาควิชาอายุรศาสตร์, คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี, มหาวิทยาลัยมหิดล

** สำนักงานวิจัย คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี, มหาวิทยาลัยมหิดล

Introduction

Environmental pollution occurs worldwide, including Thailand as a result of rapid industrial and economic development. The adverse health effects from heavy metals were reported widely. Lead toxicity was one of the major heavy metal poisoning in Thailand.

In general population (non-occupationally exposures), several sources of lead have been identified such as lead paints, trafffic exhaust fumes, atmospheric emission in industrial area, soil and foods. The principal routes of absorption are contaminated food via gastrointestinal tract and inhalation of tetramethyl lead in gasoline[1-3]. The level of lead in gasoline was declined from 0.45 mg/L in 1983 to 0.15 mg/L during 1990-1991[4], leading to lowing lead concentration in ambient air to < 1 $\mu g/m^3$. The decrease in exposure to lead from inhalation and ingestion of food contaminated by atmospheric lead deposition were reflected in falls of mean blood lead levels observed in several population studies[5-7].

Lead is toxic to several organ, including the nervous, hematopoietic, renal, endocrine and skeletal systems. The lead toxicity depends on the age of subject and the quantity of the dose[8-9]. The concentrations of lead in blood and urine have been widely used as an index of body burden of lead, diagnostic criteria of lead toxication and/or estimation of degree of exposure in epidemiological field and laboratory studies of lead toxicity[1-3,8,9]. Most studies in Thailand have only reported blood lead concentration[10-13]. One report described data on blood lead levels in normal (5.54 µg/dL) and risk group (7.60 µg/dL), and found the difference of lead levels in these groups[14]. Only a few researches studied both in blood and urine lead in general population[15]. Therefore, the aim of this study is to report blood and urine lead concentrations in non-exposed people and study the effects of sex, age, cigarette smoking , alcohol consumption and socioeconomic variables on lead levels. These results will be used for the background data and for further monitoring lead levels in general people, especially who live in Bangkok and metropolitan area.

Materials and Methods

Three-hundred and twenty healthy subject, aged 17-55 years, participated in the present study. All of them have normal renal function and non-occupationally exposed to lead. At the time of the study, they were interviewed about occupational and health profiles. Ten milliter of blood were collected and determined for hematocrit, urea nitrogen, creatinine and lead whereas 20 ml of urine samples were analyzed for lead, urinary analysis, and creatinine (by the method of Bauer JA[15]).

Lead concentration in whole blood, urine and quality-control specimens were analyzed by Zeeman graphite furnance atomic absorption spectrometer. Lead was measured at 283.3 nm by standard addition method. Certified

atomic absorption standard of lead was obtained from E. Merk, Darmstadt. Standard of low concentrations were freshly prepared by serial dilution with 20%(w/v) nitric acid. Bio-Rad lymphocheck and Seronorm trace elements whole blood and urine controls were performed for quailty control of lead determinations. Diammonium hydrogen phosphate was used as matrix modifier. Other analytical conditions and procedures were as previous described[17,18]. Urinary lead excretion was expressed per gram creatinine excretion.

Statistical Analysis

The results were presented as mean ±SD. Differences between means were analyzed by t-test and the analysis of variance. Significant differences of various parameters were accepted at p-value of less than 0.05.

Results

Three-hundred and twenty non-exposed subjects in this study consisted of 172-male and 148-female, and average age of each group were 31 and 32 years, respectively. General characteristics were shown in Table 1. The mean±SD of blood lead level in all subjects was 5.55±2.51 µg/dL with a range of 1.86-17.85 µg/dL. The mean urine lead was

Table 1. Characteristics of the subjects (Mean ± SD, %)

	Male	Female
Age,year	31±9	32±8
Body weight, kg	72.9±9.0	74.2±10.7
Height,cm	168.9±5.8	157.3±4.8
Systolic blood pressure, mmHg	123.1±13.8	116.5±15.0
Diastolic blood pressure, mmHg	79.2±9.0	74.1±10.7
Hematocrit, %	46.5±3.5	39.7±3.8
Blood lead, µg/dL	6.18±2.56	4.83±2.26
Urine lead, , µg/gCr	9.22±6.63	11.59±8.20
Educational level, %		
Matayomsuksa or lower	43.5	31.0
College of Occupation	28.2	29.0
Bachelor or higher	28.3	40.0
Occupation, %		
Student	45.9	9.5
Government official	4.1	4.7
Private official	50.0	85.8
Income/month, %		
< 5,000 Baht	18.5	14.7
5,000-20,000 Baht	34.0	38.0
20,001-40,000 Baht	40.0	25.3
>40,000 Baht	7.5	22.0

10.35±7.50 µg/gCr (range 0.77-36.50 µg/gCr). Male had significantly higher blood lead level than female (6.18±2.56 vs 4.83±2.26 µg/dL, $p<0.05$) but urine lead values were lower (9.22± 6.63 vs 11.59±8.20 µg/gCr, $p<0.05$). All subjects were divided into four groups according to age. Subjects with aged 31-40 year had the highest level which was significantly higher blood lead level than group of 21-30 and 41-55 years while there was no statistical difference in urine lead between all aged groups. (Table 2)

Table 2. Blood and urine lead levels in different aged group (Mean±SD)

Age range (year)	Number	Blood lead, µg/dL	Urine lead, µg/gCr
17-20	39	5.40±2.40	9.10±6.99
21-30	102	5.13±2.37[a]	10.46±7.84
31-40	133	6.06±2.77	11.14±7.76
41-55	45	5.15±2.16[a]	9.00±6.17
All aged	319	5.55±2.51	10.35±7.50

[a] significant different when compared to a group of age 31-40 year, $p<0.05$.

It was found that some significant differences of blood and urine lead levels between age groups in male, but not in female. In the same range of age group of male and female, there were significant difference of blood lead values observed only in aged 31-40 and 41-55 year and urine lead levels in aged 17-20 and 21-30 year (Table 3).

The influence of cigarette smoking, alcohol consumption and socioeconomic variables on blood and urine lead levels were reported in Table 4. There were significant differences in blood lead levels between male with and without cigarette smoking (6.35±2.69 vs 5.39±2.45µg/dL, $p<0.05$) and having alcohol intake (6.41±2.44 vs 5.22±2.46 µg/dL, $p<0.05$). Urine lead levels were found no statistical differences on these variables. There was 18% of smoking group who were alcohol drinkers whereas 29.6% of those having alcohol intake were cigarette smokers. Subjects with both smoking and drinking (20 cases) had blood lead level (6.40±2.98 µg/dL) as nearly the same level as only smoker or drinker (6.35±2.69 and 6.41±2.44 µg/dL).

Education and income were considered as affecting factors on lead levels in this study population. The result showed no correlation between both of blood and urine lead levels

Table 3. Lead concentration in blood and urine of male and female subjects (Mean±SD)

	Age range (year)	Male	Number	Female	Number
Blood lead	17-20	5.32±1.77	30	5.67±2.88	9
(µg/dL)	21-30	5.20±2.06	47	5.06±2.62	55
	31-40	7.03±2.85*[a,b]	47	4.80±2.09	58
	41-55	6.58±2.33*[b]	19	4.11±1.29	26
	All aged	6.18±2.56*	171	4.83±2.26	148
Urine lead	17-20	7.83±5.89*	30	13.32±8.99	9
(µg/gCr)	21-30	8.45±6.12*	47	12.19±8.74	55
	31-40	10.72±7.48[a]	47	11.65±8.13	58
	41-55	7.94±4.61	19	9.67±6.98	26
	All aged	9.22±6.63	171	11.59±8.20	148

[a] significant different when compared to a group of age 17-20 year, $p < 0.05$

[b] significant different when compared to a group of age 21-30 year, $p < 0.05$

* significant different when compared to a female subjects, $p < 0.05$

among different educational levels whereas there was a significant difference in blood lead between the groups of lower (20,001-40,000 Baht/month) and higher income (>40,000 Baht/month) (5.98±2.80 vs 4.96±2.37 µg/dL, $p < 0.05$).

Discussion

Blood lead is widely regarded as the most available indicator of recent exposure to lead and it is thus appropiated for use in studies of the relative importance of the lead to which people are currently exposed to different sources from the environment.

Blood lead of subjects in this study was 5.50±2.51 µg/dL. It was comparable to data on the blood lead concentrations of adults in others countries; e.g. in Denmark, the median blood lead of non-exposed people was 7.50 µg/d[19] and in Taiwanese general population was 6.50 µg/dL[20]. Healthy Thai population in Bangkok (between 1994-1995) had the mean blood lead level of 7.11 µg/dL[13]. Currently, Sansrimahachai *et al.*[14] presented the average blood lead levels in general people and traffic policemen were 5.54 and 7.60 µg/dL, respectively. The downward trend in blood lead level

Table 4. Lead in blood and urine -related to various variables (Mean±SD).

	Number	Blood lead (µg/dL)	Urine lead (µg/gCr)
Living location :			
Bangkok	213	5.57±2.55	10.00±7.60
Bangkok metropolitance area	106	5.52±2.43	11.06±7.28
Smoking habit* :			
Non-smoking	116	5.39±2.45	10.59±7.83
Cigarette smoking	55	6.35±2.69[a]	9.32±5.73
Alcohol consumption* :			
Non-drinking	82	5.22±2.46	10.61±8.02
Alcohol-drinking	89	6.41±2.44[b]	9.64±5.81
Educational level :			
Matayomsuksa or lower	120	5.68±2.39	10.18±7.85
College of Occupation	91	5.55±2.50	11.23±7.19
Bachelor or higher	107	5.44±2.66	9.89±7.34
Income/month :			
< 5,000 Baht	46	5.20±2.64	10.22±7.60
5,000-20,000 Baht	100	5.69±2.46	11.48±8.05
20,001-40,000 Baht	90	5.98±2.80	10.35±7.01
>40,000 Baht	41	4.96±2.37[c]	9.46±7.46

* analyzed only in male group.

[a] Significant difference when compared to a non-smoking group, $p<0.05$.

[b] Significant difference when compared to a non drinking group, $p<0.05$

[c] Significant difference when compared to a group of income 20,001-40,000 Baht/month, $p<0.05$

could be explained by three factors : an increased public awareness of lead sources and lead toxicity, a decreasing amount of lead in food and a reduction in the gasoline content.

Lead is eliminated mainly through urine (75-80%) and to a lesser extent (probably about 15%) by gastrointestinal excretion. Other routes (hair, nails, sweat) account for less than 8%[1,2,9]. It was mentioned that urine lead concentration

was more reliable indicator of exposure to organic lead (tetraethyl lead in gasoline) than blood lead level[21]. In this study, the mean urinary output of lead per gram creatinine was 10.35 ±7.50 µg in all subjects, 9.22±6.63 µg in male and 11.59±8.20 µg in female. There was statistical difference in urine lead level between male and female. Studying in Belgium, urinary lead excretion of middle aged people (with no occupational exposure) was 14 µg/gCr[22], in unexposed Italian workers was 20 ±g/24 hr[23] whereas in Czehoslovakia an average urine lead of 52 µg/L was found[24]. In addition, Staessen, et al.,[25] reported the difference of urinary lead between sex (6.69 µg/gCr in male and 6.0 µg/gCr in female) as well as in blood lead concentration due to the higher exposure to lead in male than in female. Data of urine lead concentration in general Thai people is limited. A study by Wananukul *et al.*[15] showed the mean of urine lead level in male healthy subjects of 11.11± 6.72 µg/gCr . In case of different urine lead levels between male and female subjects, we noted that it was difficult to determine a biological explanation for this difference which might resulted from diurnal variation, degree of environmental exposure or food consumption. In this study, we used the creatinine value for controlling or decreasing the effect of diurnal variation in each subject and for the influence of environmental exposure by detailed of past/ current occupations and inhabitant area presented in questionnaire.

Many epidemiological observations have reported a relationship between lead exposure and age[5,6,19,20]. Lead accumulation in body has been increased with age. In this study, there were no association between increasing of lead levels and age (Table 2). Comparison between sex with four aged group, the results showed some significant differences which is comparable to the study in Germany[26]. Age has some influences on lead level for not withstanding the consistency higher lead concentration in men (Table 4). In addition, differences in blood and urine lead levels observed between population groups may reflect different degree of lead exposure, variation in lead absorption or in the metabolic response to lead or a combination of these factors.

The association between blood and urine lead levels and the demographic variables were observed in this study. Urban population were recognized as being at risk for excessive exposure to lead. Bangkok has problems of pollution by heavy metals. Pavittranon[11] reported higher blood lead concentration of people in Bangkok than in other provinces and the other study in Lumphun province was 3.70 µg/dL (range 1.4-8.2 µg/dL)[12]. But in this study, people living in Bangkok and surrounding area of Bangkok have no difference in blood and urine lead levels.

Other published reports revealed effects of cigarette smoking and alcohol consumption on blood lead level[26-28]. We analyzed these

effects only in male since all female studied were neither smoking nor drinking alcohol. As expected, smoking male had significantly higher blood lead concentration than non-smokers but this difference was not found in urinary lead excretion. Increasing lead levels in smokers is due to lead in cigarette providing an additional source of lead exposure. Smoking raises hematocrit values and may depress lung clearance mechanism; making higher capacity of blood for carrying lead [26-28]. In addition, there was statistically increased blood lead in male having alcohol intake than those of non-drinkers. It was possible that alcohol consumption tended to affect lead accumulation and excretion[29,30].

The income and educational factors were mentioned that high income and educational people should have lower lead exposure because of less exposure due to better environment[4-7,26]. In this report, the highest income subjects had lowest blood lead level and significanty different from the group of lower income 20,001-40,000 Bath/month. There was no statistical correlation in lead concentration and educational levels.

From our study, blood and urine lead levels in non-exposed population tended to be lower than the past and both levels were in acceptable range. However, the awareness of lead toxicity must be realized in order to prevent adverse health effects among Thai population. Further study should concern in affecting factors on lead levels (sex, age, cigarette smoking and alcohol consumption).

References

1. Goyer RA. Toxic effects of metals. In : Klassen CD (ed). Cassarette & Doull's Toxicology. The basic science of poison. 5th edition. New York: McGrew Hill, Inc., 1996.
2. Ellenhorn MJ, Barcelorx DG. Metals and related compound. In : Medical Toxicology: Diagnosis and treatment of human poisoning. New York : Elsevier Science Publishing Co. Inc, 1988.
3. World Health Organization. International programme on chemical safety. Environmental health criteria 85. Lead. Geneva : WHO,1992.
4. Srianuyata S. Environmental pollution in Bangkok : stress to everyone. Thai J Toxicol 1994; 10: 34-40.
5. Elwood PC. Changes in blood lead concentrations in women in Wales 1972-1982. Br Med J 1983; 286: 1553-55.
6. Elwood PC, Toothill C. Further evidence of a fall in blood lead levels in Wales. J Epidemiol Comm Health 1986; 40: 178-80.
7. Elinder CG, Friberg L, Lind B, et al. Decreased blood lead levels in residents of Stockholm for the period 1980-1984. Scand J Work Environ Health 1986; 12: 114-20.

8. Landrigan PJ. Current issue in the epidemiology and toxicology of occupational exposure to lead. Environ Health Perspect 1990; 89: 61-6.
9. Nagid R. Lead. In: Goldfrank LR, Flomenbaum NE, Lewin NA, et al. Goldfrank's Toxicologic Emergency. 5th ed. Philadelphia : Appleton 7 Lange, 1995.
10. Sukonathanman U, Thaveesin P. Blood and urine lead levels of people living among the main streets in some area of Bangkok metropolis. Chula Med J 1987; 31: 785-90.
11. Pavittranon S, Teeyapant P. A report on blood lead level in Thai population 1987-1992. Bull Dept Med Serv 1995: 37: 11-7.
12. Taveerapong S, Sripirom V, Sriburi H, Panjaburi B. Blood lead levels in normal people and workers in factories of the northern industrial estate. Bull Chiang Mai Assoc Med Sci 1999; 32: 3-9.
13. Sansrimahachi V, Vattakavikrant S, Komindr A. Blood lead level in normal Thai population in Bangkok B.E. 1994-1995. Bull Dept Med Serv 1996; 21: 215-9.
14. Sansrimahachai V, Vattakavikrant S, Sasivimolkul W. Blood lead levels in Bangkok traffic policemen. J Health Science 2001; 10: 91-6.
15. Wananukul W, Sirivarasai J, Sriapha C, et al. Lead exposure and accumulation in healthy Thai : assessed by lead levels, EDTA mobilization and heme synthesis-related parameters. J Med Assoc Thai 1998: 81: 110-6.
16. Bauer JD, Ackerman PG. Method in clinical chemistry. In: Clinical laboratory methods. New York : The C.V. Mosbly Company,1974.
17. Subramanian KS, Meranger JC. Rapid electrothermal atomic absorption spectrometric method for cadmium and lead in human whole blood. Clin Chem 1981; 27: 1866-71.
18. Subramanian KS, Meranger JC, Mackeen JE. Graphite furnace atomic absorption spectrometry with matrix modification for determination of cadmium and lead in urine. Anal Chem 1983: 55: 1064-7.
19. Granjean P, Hollnage H, Hegegard L, Christensen JM, Lassen S. Blood lead-blood pressure relations : alcohol intake and hemoglobin as confounders. Am J Epidemiol 1989; 129: 732-9.
20. Chu NF, Lion SH, Wu TN, Ko KN, Chang PY. Risk factors for high blood lead levels among the general population in Taiwan. Eur J Epidemiol 1998; 14: 775-81.
21. Protor NH, Hughes JP. Chemical harzards of work place. Philadelphia: JB Lippincott Co., 1978: 467-9.
22. Bernard A, Buchet JP, Roles H, Masson P, Lauwerys R. Renal excretion of protein and enzymes in workers exposed to caddmium and lead. Eur J Clin Invest 1979; 9: 11-22.
23. Boscolo P, Salimei E, Adamo A, Porcelli

G. Effects of environmental lead levels on the urinary kallikrein excretion of exposed worker. Life Sci 1977; 20: 1715-22.

24. Chmielnicka J, Komsta SE, Szynanska JA. Arginase and kallikrein activities as biochemical indices of occupational exposure to lead. Br J Ind Me 1981; 38: 175-8.
25. Staessen J, Bulpitt CJ, Roles H, et al. Urinary cadmium and lead concentrations and their relation to blood pressure in a population with low exposure. Br J Ind Med 1984; 41: 241-8.
26. Hense HW, Filipak B, Novak L, Stoppler M. Non-occupational determinants of blood lead concentrations in a general population. Int J Epidemiol 1992; 21: 753-62.
27. Sharp DS, Benowitz NL, Osterloh JH, Becker CE, Smith AH, Syme SL. Influence of race, tobacco use, and caffeine use on the relation between blood pressure and blood lead concentration. Am J Epidemiol 1990; 131: 845-54.
28. Grasmick C, Huel G, Moreau T, et al. The combined effects of tobaccco and alcohol consumption on blood lead levels. Int Arch Occup Environ Health 1981; 48: 391-7.
29. Pirkle JL, Schwarz J, Landis JR, et al. The relationship between blood lead levels and blood pressure and its cardiovascular risk implications. Am J Epidemiol 1985; 121: 246-58.
30. Micciolo R, Canal L, Maranelli G, Apostoli P. Non-occupational lead exposure in northen Italy. Int J Epidemiol 1994; 23: 312-20.