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Risk Factors for Lead Poisoning Among Adults People Living in Kinshasa, DR Congo

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Abstract

Lead (Pb) is recognized as one of the most toxic metals and causes acute and chronic disease. Human bio monitoring is an important tool for the evaluation of environmental exposure to contaminants. The aim of the present study was to determine blood lead level among Kinshasa's adults and the association between blood levels and some lifestyle factors. The total analytical sample size consisted of 190 adults aged from 20 to 72 years old (113 males and 77 females). The mean blood level was higher in males (103.38 ± 41.12 µg/L) compared to females (76.70 ± 34.70 µg/L) but not statistically significant difference were observed ($p>0.05$). Forty one percent of adults presented blood lead levels above 100 µg/L. Occupations with a potential risk of exposure to lead presented arithmetic's blood lead levels above 100 µg/L: Car mechanics (122.52 ± 40.46), Petroleum sellers (106.00 ± 56.26), Painters (138.22 ± 60.43), Car drivers (130.02 ± 42.42) and Welders (112.40 ± 6.97). Results of the present study showed that blood lead levels were not significantly associated with the distance of their homes from road traffic, drinking alcohol, using lead pots and smoking cigarettes.

Keywords: Risk factors • Lead • Poisoning • Adults • Kinshasa

Introduction

Lead (Pb) is recognized as one of the most toxic metals. Historically, there have been many reports of people suffering from lead toxicity throughout history, from the times of the Roman Empire, through the middle Ages and the Industrial Revolution. [1,2] With the increasing industrialization in the 19th century, scientific studies documented high levels of occupational exposure to lead in workers, who presented symptoms of acute and chronic diseases [3]. Exposure to inorganic lead (henceforth referred to as lead) in the environmental and occupational settings continues to be a serious public health problem. At high exposure levels, lead causes some undesirable effects such as encephalopathy, kidney damage, anaemia and toxicity to the reproductive system. Even at lower doses, lead produces alterations in cognitive development in children. A safe level of lead exposure has not been defined, as health risks associated with lead are found at ever-lower doses [4].

Pathways of human exposure to lead include contaminated air, water, soil, house dust, food, tobacco smoke and consumer products. Lead-containing paint can be a source of exposure in older houses where it was used for decoration. The addition of tetraethyl lead to vehicle fuel is formerly a major contributor to environmental lead exposure, but this source declines substantially across Europe and many other regions following the progressive removal of lead from petrol from the 1980s onwards (e.g. Council Directive 85/210/EEC and subsequent amendments [5].

In Democratic Republic of Congo, the leaded gasoline and leaded paint are remaining in common uses and little is known about lead exposure. There are also others potential sources of exposure to lead in Kinshasa area as lead food, lead drinking water pipes, recycle metal utensils. Some literatures show that vegetables cultivated along the side of the main roads of the city contained high lead levels [6-9]. There have been many reports on the blood lead levels of different populations around the world and just a few of them are reported on Congolese population as done by Tuakuila J, et al. [10] and Mputu MLC, et al. [11] Few of them show the correlation of blood lead levels and occupational exposure. Thus, the objective of this study is to determine the blood lead level (BLL) among different populations according to their occupational activities.

Materials and Methods

Study area

Kinshasa is a metropolitan area in the southwest of the DRC that spans 9,965 km^2 or 0.42% of the national territory. It is located to the west of the country between 3.9 and 5.1 degrees south latitude and between 15.2 and 16.6 degrees east longitude. It is bordered in the northeast and east by the province of Bandundu, to the south by the province of Kongo central, north-west and west by the Republic of Congo Brazzaville, a liquid boundary formed by part Congo River. It is divided into four districts and 24 municipalities. There are no industries in the place of study susceptible to release significant amounts of lead in the atmosphere. This study was conducted on adult population living in some urban cities of Kinshasa with predominance in Kimbanseke's and Ndjili's cities.

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Population

This study was conducted from November 2012 to May 2013. Participants were randomly selected from adults people according there occupations. Nine subgroups of population were concerned: Car mechanics, Students (A: from others universities and B: only from University of Kinshasa), Sellers around the road traffic, Petroleum sellers, Painters, Car drivers, Welders, Unemployed persons and persons with others occupations. The design of the study was approved by the ethical committee of Health Public School of the University of Kinshasa (UNIKIN) on 18 January 2013. Each participant was asked to fill-in a structured questionnaire and to sign a voluntary consent before all. The questionnaire consisted on factors such as age, gender, distance between house and road traffic, daily occupation, the use of lead pots, drinking alcohol and smoking. 190 adults were recruited.

Samples and analysis

Venous blood samples (5-7 ml) of each person were collected by a trained nurse. The puncture point was cleansed with alcohol, soapy water and then distilled water. Each sample was placed in a 10 ml lead-free Li-heparin tube. All samples were immediately refrigerated and shipped (8h travel time) to the laboratory of toxicology in Belgium (ULg), where they will be refrigerated at -20°C until they were processed. Blood lead was measured using inductively coupled plasma mass spectrometry (Agilent Technology 7500ce). The blood sample above 100µg/L was confirmed with a second analysis.

Data analysis

All data were introduced into a database built with the software Foxpro 2.5. The analyses were performed with the SAS V6.12 software package. The analysis of variance (ANOVA) and Student test were applied for the comparison of the difference of blood lead levels in different groups of adults. Since the blood lead levels were fitted in a log normal distribution, Geometric mean (GM) was used in the statistical analyses and $p < 0.05$ was considered as significant.

Results

There were one hundred and ninety adults enrolled in the present study. There were 113 men (59.70%) and 77 women (40.52%). Results indicated that blood lead levels were higher in men with arithmetic mean of 103.38 ± 41.12 µg/L than in women (76.70 ± 34.70 µg/L). In spite of it, there was significant gender difference for lead ($p>0.05$). On 190 adults enrolled, it was observed that 42% of participants had blood lead level ≥ 100µg/L (142.23 ± 26.00 µg/L), 47% of them between 50-100 µg/L and 11% with blood lead levels under 50µg/L (38.31 ± 10.12 µg/L). Stratified by occupation groups, higher arithmetic mean blood lead levels were found to persons with lead occupation risks (122.10 ± 40.97 µg/L) than others without this risk (80.64 ± 3.44 µg/L), but there was no significant difference for blood lead levels ($P>0.05$). Considering the occupations of each participant, it was observed that mechanics, Petroleum sellers, Painters, Drivers and Welders showed high arithmetic blood lead levels of 112.52 ± 40.46, 106.00 ± 56.26, 138.22 ± 60.43, 130.02 ± 42.82 and 112.4 ± 6.97 µg/L respectively. Students from others universities, sellers on road, unemployed persons and those with other occupations showed blood lead levels up to 80 µg/L whereas students of the University of Kinshasa showed an average of 51.25 ± 30.37 µg/L. Statistics analysis showed only a significant difference for blood lead levels among mechanics ($p<0.05$) than others occupations.

With regard to the frequency of level of lead impregnation, it was observed that 11.50% of the participant presented a blood level between 0-49 µg/L, 51.5% had blood lead levels between 50 and 90 µg/L, 27% had blood lead levels between 100 and 149 µg/L, 8% had blood lead levels between 150 and 199 µg/L while 2% presented a concentration between 200 and 250 µg/L. The recruited study women ranged in two groups according to childbearing age. There were 54 women (70%) aged ≤45 years old and 23 (30%)>45 years old. Higher blood lead levels were found among women aged up to 45 years (86.55 ± 35.80 µg/L) than those aged less than 45 years old (72.58 ± 33.39 µg/L). No significant difference was observed between there arithmetic blood lead values ($p>0.05$). Further analysis for the association between blood lead levels and some parameters (Figure 5) showed no significant association with the distance of their homes from road traffic, drinking alcohol, using lead pots, smoking cigarettes and the communes ($p> 0.05$) (Figure 1,2,4).

Discussion

Actually, blood lead level is well recognized for estimating the exposure of human to environmental lead. The results of our study showed a mean of

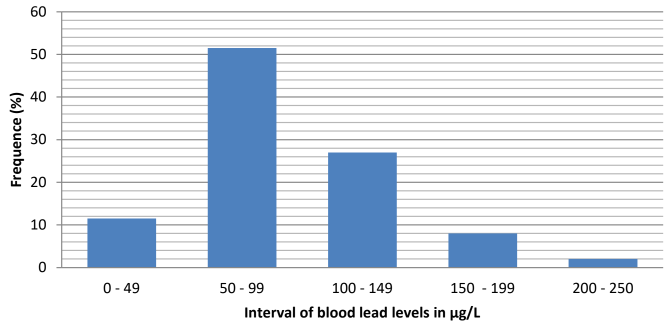

Figure 1. Frequency of lead detection (% samples) in blood samples from the studied population.

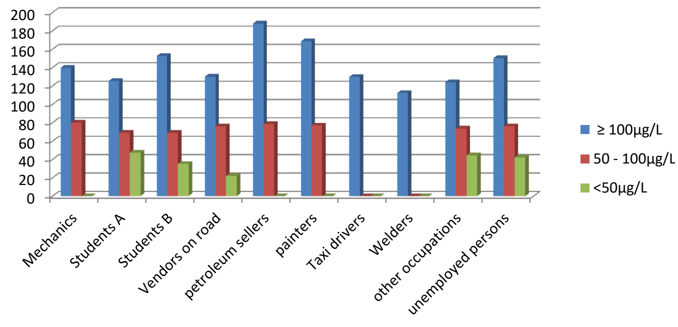

Figure 2. Blood lead levels according to tolerances by occupations.

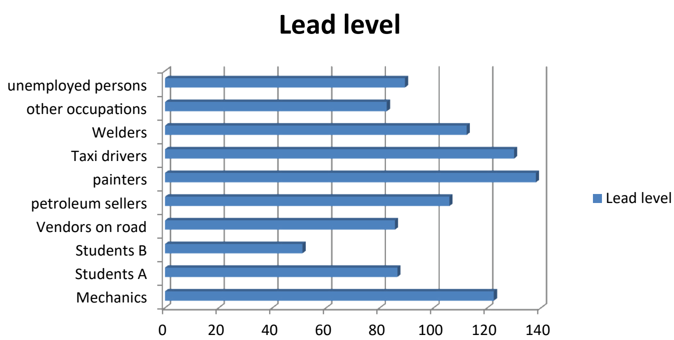

Figure 3. Blood lead levels among stratified groups of participants.

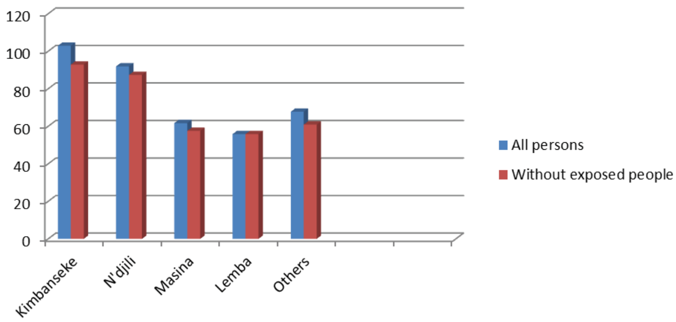

Figure 4. Blood lead levels by commune of habitation.

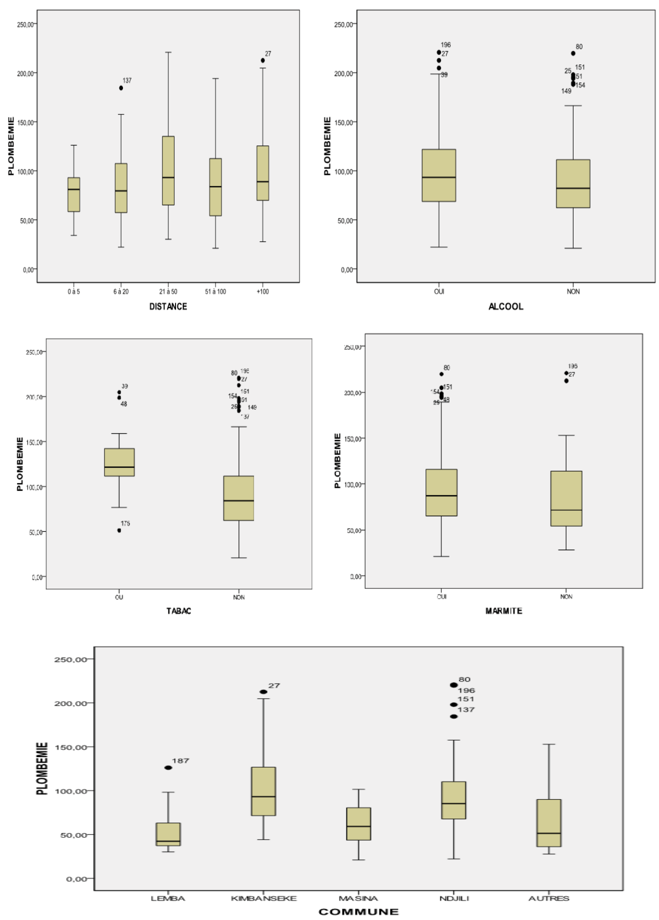

Figure 5. Blood lead levels estimation according to some influences.

blood lead level equal to 93.27 ± 41.3 µg/L (MG=84.12 µg/L) with values ranging from 21.03 to 220.70 µg/L. Our average was lower than observed by Tuakila among in Kinshasa between 2003 and 2004 (M.G=120 µg/L) [11]. This observed blood lead level average seemed very higher with the average values observed in some developing countries: 15.60 µg/L in 2005 in USA, 48 µg/L in 2005 Belgium, 13.4 µg/L in Sweden and 49 µg/L in Croatia [6,12-14]. So, our results confirmed the impregnation in Kinshasa by environmental lead. In addition, 42% of adults had mean blood lead levels ≥100 µg/L, which was an average of 142.23 ± 26.00 µg/L (M.G=134.40 µg/L; IC 95%: 126,03–142,76). This prevalence found was lower than that found by Tuakuila J. (63%) [12]. It was observed that 46.84% of participant had between 50–100 µg/L (M.G=73.85 µg/L; IC 95%: 70.59–75.85) and 2% with double of the blood lead level reference value of 100 µg/L from CDC [15].

Our study also showed that men had a higher mean blood lead level ((103.24 ± 41.42 µg/L) than women (76.70 ± 34.70 µg/L). This was still right even if exposed men with their occupations were excluded (90.20 ± 36.70 *vs* 76.70 ± 34.70). There were no significant difference observed between there arithmetic blood lead values (p>0.05). These results were in agreement with those found in the literature [13,16,17]. This was due to difference in kinetic's absorption between gender and the lower ratio of haematocrit among women than men [16]. Men, with the higher average blood lead were very exposed to reproductive toxicity as observed by Spomenka, et al. [18]. They observed that at low-level exposure to lead (median 49 µg/L, range 11-149 µg/L), a significant Pb-related increase in immature sperm concentration, in percentages of pathologic sperm, wide sperm, round sperm and short sperm, in serum levels of testosterone and estradiol and a decrease in seminal plasma Zn and in serum prolactin [19].

Participant living Kimbanseke's city showed an average of blood lead level higher than Ndjili's citizen (92.91 ± 34.03 µg/L *vs* 87.40 ± 39.77 µg/L) with no significant difference (p>0.05). This allowed us to notice that these participants live in the same environment constraints. Actually, at suburban's cities of Kinshasa is developing industries of recuperated metals. Pots from those industries could be among lead contamination sources. Our results showed that 88.5% of study's population was using those pots with an average blood lead level lightly high than those without those pots (93.58 ± 41.42 µg/L *vs* 90.93 ± 51.82µg/L). This was still right even if participant with exposed occupations were excluded (86.54 ± 36.50 *vs* 76.25 ± 47.24). There were no significant difference observed between their arithmetic's blood lead values (p>0.05).

Water, particularly acid or less mineralized water, could be an important source of lead exposure. Then, 10 µg/L was fixed by WHO as the limit lead value of lead in drinking water [6,20]. Our study established no correlation between blood lead level and type of drinking water (p>0.05). Thus, water is not a trivial source of lead intake for adults of this study. We observed also no correlation between cigarettes and alcohol consumption ((p>0.05) even if some authors established positive influence of smoking tobacco and alcohol to blood lead level among adults [20]. Our results seemed similar to that found by Kuliczkowski K [21] The impact of lead was significant in pregnant woman, both for the course of risk pregnancy (risk in particular of pregnancy-induced hypertension and pre-eclampsia, intrauterine growth restriction, preterm delivery and spontaneous abortion) and for the foetus (impact on the psychomotor development of the child in coming). Lead freely passes the placental barrier. At birth, the blood lead of the mother and the child are very similar. Thus, the CDC advises, for women of childbearing age, not to exceed

Table 1. Characteristics of the blood lead levels of participants.

Variables	Number of children (%)	Values (arithmetic mean ± standard deviation)	Values (geometric mean)
Blood lead level by references			
≥ 100µg/L	80 (42.10)	142,23 ± 26.0	134.4
50 - 100µg/L	89(46.84)	75,04 ± 4.09	69.28
<50µg/L	21(11.05)	38.31 ± 10.12	33.32
By sex			
Male	113(59.47)	103,38 ± 41.12	95.15
Female	77(40.52)	76,70 ± 34.70	69.84
By professional occupation			
Mechanics	31(16.31)	122.52 ± 40.46	116.32
Students A	15(7.89)	86.55 ± 33.70	81.1
Students B	20(10.52)	51.25 ± 30.37	45.5
Vendors on road	34(17.89)	85.71 ± 29.64	80.77
Petroleum sellers	10(5.26)	106.00 ± 56.26	96.72
Painters	10(5.26)	138.22 ± 60.43	128.7
Drivers	10(5.26)	130.02 ± 42.82	125.6
Welders	10(5.26)	112.4 ± 6.97	112.22
Unemployed persons	26(13.68)	89.40 ± 40.80	81.82
Other occupations	24(12.63)	82.68 ± 28.91	77.97
By potential risk			
Person in risk	71(37.36)	122,10 ± 40.97	115.71
Person without risk	119(62.63)	80,64 ± 3.44	73.66
Of women by occupation			
Students A	6(7.79)	63.74 ± 10.50	63.04
Students B	10(12.98)	41.65 ± 14.14	39.5
Sellers on road	31(40.25)	85.60 ± 30.35	80.43
Unemployed persons	22(35.06)	84.06 ± 43.73	76
Other occupations	8(10.38)	80.86 ± 37.01	73.94
Of women of childbearing age			
≤45 years old	54(70.13)	72.58 ± 33.39	66.3
> 45 years old	23(29.87)	86.55 ± 35.80	79.37

A. Students from others universities **B.** Students of university of Kinshasa a blood lead level of 100µg/L. Lauwerys R, et al. [6] and Chang S, et al. [22] demonstrated the role of low blood lead levels on the risk of infertility in women [22].

The results of our investigations showed that 70% of women of childbearing age had an average blood lead level below not only this threshold value but also the average content of women of menopausal age (72.58 ± 33.39 µg/L *vs* 86.55 ± 35.80 µg/L). These results were in great agreement with those found in the USA between 1999-2010 [23] and can be explained by the fact that menopause causes a greater release of lead, [24] and there were no significant difference observed between their arithmetic's blood lead values (p>0.05). Thus, we were able to express our fear about the infertility of Congolese women despite because of this average of blood lead level which was at least double that found by Chang S, et al. [22] About the daily occupation of the participants, our investigations, summarized in (Figure 3), revealed three levels of exposure: the high level of exposure (mechanics, taxi drivers, welders, painters and petroleum sellers), the average level of exposure (students of other universities, vendors along the main roads, unemployed persons and persons with other occupations) and the low level of exposure (students of the University of Kinshasa). The calculated odds ratio showed that the risk of having blood lead level up to 100 µg/L was 5.5 times higher among mechanics than among other socio-professional categories (OR=5.5).

This was still preliminary and to be confirmed in future studies because of the size of our sample and specially the low number in certain subgroups did not allow us to draw reliable conclusions. In addition, we can wonder about the selection bias induced by the recruitment method. But we thought that the different environment of these three groups is for many. The applied statistics had shown an even weak correlation between the blood lead level and the occupation (p=0.0495 < 0.05). These results allowed us to note that the University of Kinshasa would seem to be among the least polluted environments in Kinshasa. It should be noted that the students in the University of Kinshasa were only recruited from the Faculty of Pharmaceuticals Sciences and were all in the second cycle. Thus, they passed much of their time at University than elsewhere. However, one of twenty of them showed a blood lead level up to 100 µg/L (152.80 µg/L) (Table 1).

Conclusion

The blood lead levels from adults with risk occupational were remarkably higher than to other adults with an average mean up to the criterion of lead poisoning. 47% of participants had blood lead levels between 50 and 100 µg/L and 11% with blood lead levels under 50 µg/L. 42% of participants had high frequency impregnation of lead. Participants of Kimbanseke city had high blood lead levels than Ndlili's citizen. Blood lead level was higher in painters than in the others professional occupations. University of Kinshasa was found to be the less polluted environment in Kinshasa among the selected areas studied. This study confirmed a relatively important lead impregnation of the Kinshasa population and showed only a significant association between blood lead levels on mechanic occupation. Those BLLs values expressed us to fear about infertility of Congolese women, a negative impact in pregnant women and the reproductive toxicity in Congolese men.

Conflict of interest

The authors report no conflict of interest.

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