JIRESH-Biotech

Journal of Innovation and Research in Health Sciences & Biotechnology: Open Access

Volume 1, Issue 1, September 2015 http://jiresh-biotech.edmgr.com

Original Article

Lead and Mercury Pollution in Breast Milk in Kinshasa: Mother and Child Health Risks

Christophe T. Masiala[1], Samy W. Masamba[2], M. Mbodo[1], Benjamin Longo-Mbenza[3], Simon F. Mbungu[4], Dieudonné N. Vangu[4]

[1]*Laboratoire de Bramatologie, Faculté des Sciences Pharmaceutiques, Université de Kinshasa; R.D. Congo.* [2]*Department of Chemistry and Chemical Technology, Walter Sisulu University, Mthatha, South Africa.* [3]*Research Champion, Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa.* [4]*Laboratoire d'Epidémiologie Clinique, Lomo Medical, Kinshasa - Limete, R.D. Congo.*

Corresponding Author: Christophe T. Masiala, Ph.D; (c): +243-732822843; E-mail: Chrismasiala@yahoo.fr

***J. Innov. Res. Health Sc. Biotech.* 2015; 1(1): 49 – 55.** **doi: 10.18644/jiresh-biotech.0000009**

ABSTRACT

Background: This study was aimed at assessing the influence of residence on mercury and lead contamination of breast milk and to analyse the correlations between the infants' anthropometry at birth, perinatal deaths, mothers' blood pressure, and the metals contamination in breast milk. **Methods:** A cross-sectional study was performed in urban and rural maternity hospitals, in Kinshasa. Twelve mothers with pre-eclampsia, eclampsia, gestational diabetes, and chronic diseases were excluded, while 30 healthy mothers were evaluated. **Results:** The average values of lead (19.6µg/L) and mercury (2082.9µg/L) in breast milk were out of the WHO range. Infants with low birth weight (222.3µg/L for lead and 2119.3µg/L for mercury), microcrania (1213.9µg/L for lead and 2142.5µg/L for mercury), and small size (179.4µg/L for lead and 2847.2µg/L for mercury) were born to mothers with higher lead and mercury in breast milk, respectively ($P<0.0001$). The breast milk of urban mothers (222.1µg/L for lead and 3153.2µg/L for mercury) had higher lead ($P<0.0001$) and mercury ($P<0.01$) contents than that of the rural mothers (remained in normal ranges). Systolic (Y=0.0763x±91.2; $P<0.01$) and diastolic (Y=0.0377x±52.3; $P<0.01$) blood pressures of the mothers were positively correlated with their respective lead and mercury contents. The content of mercury in breast milk was positively correlated with maternal age (Rho=0.324; $P<0.05$). The two deceased infants were born to mothers with mercury levels in breast milk higher than the average of those of surviving infants. **Conclusion:** These data demonstrate the need for regulation of the environment and further studies on the impact of pollution on the environmental impact in the city of Kinshasa are warranted.

Keywords: *Breast milk, lead, mercury, urban pollution, epidemiology, environment, health, blood pressure.*

RÉSUMÉ

Contexte : Cette étude vise à évaluer l'influence de la résidence par rapport à la contamination par le mercure et le plomb du lait maternel, et analyser la corrélation entre l'anthropométrie infantile à la naissance, aux décès périnataux, à la pression sanguine des mères et à la contamination de ces métaux dans le lait maternel. **Méthodologie :** Une étude transversale a été menée dans des hôpitaux de maternité ruraux et urbains de la ville de Kinshasa. Douze mères atteintes de pré-éclampsie, d'éclampsie, de diabète gestationnel et de maladies chroniques ont été exclues, alors que 30 mères apparemment en bonne santé ont été évaluées. **Résultats :** Les valeurs moyennes du plomb (19.6µg/L) et du mercure (2082.9µg/L) dans le lait maternel étaient en dehors de la plage des valeurs de l'OMS. Les enfants ayant un faible poids à la naissance (222.3µg/L pour le plomb et 2119.3µg/L pour le mercure), atteints de microcranie (1213.9µg/L pour le plomb et 2142.5µg/L pour le mercure) et ayant une petite taille (179.4µg/L pour le plomb et 2847.2µg/L pour le mercure) sont nés de mères ayant plus de plomb et de mercure dans leur lait maternel, respectivement ($P<0.0001$). Le lait maternel des mères urbaines (222.1µg/L pour le plomb et 3153.2µg/L pour le mercure) avait un contenu plus élevé en plomb ($P<0.0001$) et en mercure ($P<0.01$) que les mères rurales (avec de valeurs dans une plage normale). Les pressions sanguines systoliques (Y=0.0763x±91.2; $P<0.01$) et diastoliques (Y=0.0377x±52.3; $P<0.01$) des mères étaient positivement liées avec le contenu respectif en plomb et mercure. Le contenu en mercure dans le lait maternel était positivement lié à l'âge maternel (Rho=0.324; $P<0.05$). Les deux enfants décédés étaient nés de mères ayant un niveau de mercure plus élevé dans leur lait maternel que la moyenne de celles avec des enfants ayant survécu. **Conclusion :** Ces données démontrent la nécessité d'un règlement pour l'environnement et d'études d'impact environnemental pour la ville de Kinshasa sont recommandées.

Mots clés : *Lait maternel, plomb, mercure, pollution urbaine, épidémiologie, environnement, santé, pression sanguine.*

Submitted 12/01/2015, accepted 21/09/2015 http://jiresh-biotech.edmgr.com

INTRODUCTION

The benefits of breast milk for infants are well known. Indeed, the high quality of its composition, its nutritional value and its peculiar properties such as its immunological power, ready-availability and also its low cost, makes it an excellent food for the infants (1).

The World Health Organisation (WHO) advocates for feeding the child with breast milk for at least the first six months of the child's life, especially in developing countries (2).

However, food safety and quality of breast milk can be affected by many environmental pollutants (3). Thus, any products that are absorbed by the mother; can be released into the milk and adversely affect its quality.

Chemical pollutants in our environment such as breast milk lead and mercury concentrations received our particular attention not only because of their short and long term high toxicity (4), but also and mainly because of their increasingly high concentration in our environment. This pollution may raise the risk of disease in the population. In fact, lead is found in the combustion gases from vehicles, in drinking water pipes and in many vegetables consumed in Kinshasa with very high lead levels (5, 6). Mercury is found in many cosmetic products such as antiseptic soaps widely used by Congolese black women to lighten their skin, as well as in marine fish (Jack mackerels or Trachurus) highly popular in the diet of people living Kinshasa (4).

Yet, it is a well-known fact that methyl mercury and lead readily cross the "placenta barrier" and find their way in the unborn child, and can contaminate the baby through breast milk. The fragile nature of infants and the young children's digestive tract, favours an easy absorption of these heavy metals as compared to older persons (7). Lead and mercury toxic effects can thus be expected in infants, a very vulnerable group.

A collective survey simultaneously conducted in Sweden, the Philippines, Hungary, Poland, and Zaire (now the Democratic Republic of the Congo) in 1989, revealed the presence, namely of lead and mercury in breast milk, in concentrations at times higher than the WHO standards (8). In Northern Sweden (9) and later in Kosovo (10), pregnant women exposed to lead from industry and the environment had a higher risk of spontaneous abortion and giving birth to children with low birth weight. Lead has also been incriminated in the genesis of hypertension in pregnancy (11).

In view of the absence of health policy in the detection and reduction of lead and other environmental toxins, the lead and mercury pollution in Kinshasa continues to grow. The overall objective of this study was to assess not only the levels of contamination of breast milk by lead and mercury, according to the residence of mothers, but also their toxic impact on the anthropometry and deaths of infants and the blood pressures of their mothers.

MATERIALS AND METHODS

Study Design and Sampling Strategy:

The present cross-sectional study was done on October 2003, in few maternities of Kinshasa, the capital city of the Democratic Republic of the Congo (10 Million inhabitants). The arbitrary choice of six maternities lies on a convenience sampling due to budget constraints (mobility, cost of reagents and dosage of pollutants), and residence representatives (three maternities for urban areas and three maternities for rural areas of Kinshasa province). Seven mothers and their single new babies were randomly selected at each maternity. These maternities were OMECO/Yolo (Kalamu Municipality), University Clinic (Lemba Municipality), Kindele Sisters Maternity (Mount Ngafula Municipality), Child-Mother Maternity (Ngaliema Municipality) and Kitokimosi Maternity (Selembao Municipality). Twelve mothers with histories of pre-eclampsia, eclampsia, gestational diabetes and chronic diseases were excluded along with their infants.

The procedure used consisted of collecting samples and data in 30 apparently healthy mothers and their single infants:

a) Samples of breast milk were collected from mothers aged between 14 to 39 years;

b) Use of cosmetics to lighten the skin, residence of the mother and arterial systolic pressure were noted. Arterial diastolic pressure was measured in lie-down position after ten minutes of rest;

c) Anthropometry at birth of new born babies from these selected mothers, including weight, length and skull perimeter was performed.

d) Vital outcome (death or discharge) after sixty days of life of these new-born babies was noted;

e) Lead and mercury concentration of the maternal milk was measured.

After a thorough explanation and verbal consent, the mothers accepted to participate in this study, according to Helsinki II Declaration and ethical authorisation of the Faculty of Pharmacy, Kinshasa University. A rigorous and validated technical standard for sampling and preparation of the maternal milk was applied.

The breast was first disinfected with denatured alcohol, then left to dry for fifteen minutes. The milk was manually collected until the breast became empty between (from 07 to 12 October 2003) and was kept in a 25 ml clean plastic

Citation: Masiala CT, Masamba SW, Mbodo M, Longo-Mbenza B, Mbungu SF, and Vangu DN (2015) Lead and Mercury Pollution in Breast Milk in Kinshasa: Mother and Child Health Risks. *J Innov. Res. Health Sc. Biotech.* 1(1): 49-55. **doi: 10.18644/jiresh-biotech.0000009**

container. Milk samples were homogenised and stored in the deep freezer at -18^{o}C.

After mineralisation with a mixture of nitric and sulphuric acid, Pb^{2+} ions formed under basic conditions a pink or red complex with dithizon. This complex was extracted in chloroform and its concentration determined at 515 nm. The procedure described by HACH using Dithiver reagent (the stable form of powder dithizon) was followed for its evaluation using a Hach DR/2000 spectrophotometer (12).

Mercury concentration was determined at the Kinshasa Regional Nuclear Centre, by neutron activation. The principle relies on the determination of the mass of a particular element in a sample subjected to neutron bombardment. This treatment was followed by measuring the induced radioactivity. A Triga Mark II reactor provided with a chain of gamma spectrometry, a HPGE detector (type Enertec – Schlumblerger Oscilloscope) and a Digital Venturis 466 computer were used according to IAAE standard (Technical Reports Series n^{o}197, 1980).

Operational Definitions:

Central Kinshasa (Kalamu, Lemba and Makala municipalities) emerged as high risk zones for lead and mercury emissions: urban environment next to many mechanical workshops and other former battery manufacturing factories, old water drainage systems and road networks as a source of car combustion gases containing lead, decomposition of lead containing paints, house dust (residual contaminants), consumption of vegetables grown along the main roads (5) and fish (Jack mackerels or Trachurus, rich in mercury) (6), and the use of hydroquinone and mercury based soap and creams (6). Kinshasa rural areas (Mount Ngafula, Selembao and Ngaliema municipalities), far away from these industrial sites, main roads and with a non-westernised lifestyle, were defined as an environment, not high in metal pollution risk (within the WHO ranges).

Low birth weight was <2500 g. New-born babies with a length of <50 cm (sample median value) were considered as small size. Microcrania was defined by a skull perimeter of <31 cm (sample median value).

Statistical Analysis:

The data were shown in the tables as proportions (%) for qualitative variables and means ± standard error of the mean (SEM), medians and ranges for quantitative variables. Lead and mercury variables were converted into their corresponding log values in some calculations.

Wilcoxon non parametric test on paired series was used to compare lead and mercury mean values between groups.

Correlation coefficients Rho of Spearman rows were calculated to assess an eventual association between quantitative variables. The regression lines of these associations were then computed.

A value of $P<0.05$ was considered to be a threshold of statistical significance. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) for Windows Version 16.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Mean values and extremes of age, weight and blood pressure at the time of the breast milk collection were summarised in Table 1. Of all the mothers, 15 (50%) came from urban areas – high risk zones of metal pollution. The duration of breast milk development post-delivery was appropriate: 29.9±24.9 hours (extremes of 1 hour and 72 hours).

Lead and Mercury contamination of breast milk taken after childbirth was shown in Table 2. The average values demonstrated a very important lead (Pb) and mercury (Hg) contamination (Table 2). Of the 30 mothers, 29 (96.6%) used skin lightening products.

Of these 30 new born babies examined, 7 (23.3%) were characterised by a low birth weight, 15 (50%) by a small size, 13 (43.3%) by microcrania and 2 (6.7%) cases of post-natal death (n=2 children in the second month following birth) (Table 3).

Low birth weight (Table 4), microcrania (Table 5), and small size at birth (Table 6), were significantly associated with higher lead ($P<0.01$) and mercury ($P<0.001$) values in the mother's milk.

When compared to the 28 children who survived, the children who died from unknown cause were born of mothers with significantly higher mercury content (14232.3±7752 µg/L versus 116.2±1472.6 µg/L; $P<0.01$), but of mothers with identical lead content (111.8±143.9 µg/L versus 202.6±125.2 µg/L; $P>0.05$).

Systolic ($Y=0.0763x±91.2$; $P<0.01$) and diastolic ($Y=0.0377x±52.3$; $P<0.01$) blood pressures of the mothers were positively correlated with their respective lead contents. On the other hand, the Log Hg content of mother's milk was positively and significantly ($P<0.05$) correlated with the mothers' age (Rho = 0.624), whereas the Log Pb content was negatively but not significantly correlated with the mothers' age (Rho = -0.241; $P = 0.503$).

The breast milk of urban mothers (222.1µg/L for lead and 3153.2µg/L for mercury) had higher lead ($P<0.0001$) and mercury ($P<0.01$) contents than that of the rural mothers (remained in normal ranges) (Table 7).

Table 1. Characteristics of mothers at the time of milk collection

Variables	Average ± SEM	Range
Age (years)	24.9 ± 1.4	14 to 39
Weight (Kg)	55.7 ± 1.5	42 to 72
SBP (mmHg)	106 ± 2	80 to 130
DBP (mmHg)	61 ± 1.3	40 to 70

Table 2. Metal contamination of breast milk taken after childbirth

Heavy Metals		Values in µg/L
Lead		
	Average	196.6 ± 23
	Minimum	7.3
	Median	197.5
	Maximum	422.3
Mercury		
	Average	2082.9 ± 379.6
	Minimum	0.02
	Median	858.1
	Maximum	8750.8

Table 3. Anthropometric measures of the 30 new born children

Variables	Average ± SEM	Range
Birth Weight (g)	3130 ± 136.2	1700 to 4500
Birth Lenght (cm)	48.4 ± 0.62	43 to 55
Birth Head circumference (cm)	31 ± 0.35	27 to 35

Citation: Masiala CT, Masamba SW, Mbodo M, Longo-Mbenza B, Mbungu SF, and Vangu DN (2015) Lead and Mercury Pollution in Breast Milk in Kinshasa: Mother and Child Health Risks. *J Innov. Res. Health Sc. Biotech.* 1(1): 49-55. **doi: 10.18644/jiresh-biotech.0000009**

Table 4. Metal contamination of breast milk versus the birth weight of the newborns

Heavy metals in breast milk	Newborns with low birth weight	Newborns with birth weight >2500 g	*P*
Lead (µg/L)	222.3 ± 26.8	188.8 ± 23.8	<0.0001
Mercury (µg/L)	2119.3 ± 427.7	1967.8 ± 232.1	<0.01

Table 5. Metal contamination of breast milk versus head circumference (HC) of the newborns

Heavy metals in breast milk	Microcrania	HC ≥ 31 cm	*P*
Lead (µg/L)	213.9 ± 26.9	183.3 ± 16.7	<0.0001
Mercury (µg/L)	2142.5 ± 465.9	2007.3 ± 271.1	<0.0001

Table 6. Average values of lead and mercury concentration in breast milk versus infants size at birth

Heavy metals In breast milk	Lenght at birth < 50 cm	Lenght at birth ≥ 50 cm	*P*
Lead (µg/L)	213.7 ± 19.1	179.4 ± 23.4	<0.0001
Mercury (µg/L)	2847.2 ± 508.4	1320.7 ± 217.5	<0.0001

Table 7. Metal contamination of breast milk versus residence location in Kinshasa

Heavy metals in breast milk	Central Urban area	Surrounding Rural area	*P*
Lead (µg/L)	222.1 ± 16.1	171.1 ± 23.3	<0.0001
Mercury (µg/L)	3153.2 ± 510.4	1014.6 ± 158.8	<0.01

DISCUSSION

This study has shown that the exposition of the mothers and their babies to lead and mercury can trigger adverse health effects (3, 4, 9-11, 13, 14). Breast milk and residency in high risk atmospheric pollution zones are the sources of contamination by these two heavy metals. The other sources of contamination for Kinshasa inhabitants are: car exhaust gases, drinking water and vegetables (5) as reported in some European (4, 9, 10) and other developing countries (15). Mercury intoxication in Kinshasa comes often from the use of skin lightening cosmetic products and from imported fish (Jack mackerels) (6).

The study did not consider other possible contamination sources and variations of this metal contamination such as incineration (16), traditional cooking using smoke wood and traditional pottery and ceramic kitchen ware (17), sex, tobacco from cigarettes, alcohol consumption and other drinks, and time of implementation of accommodation infrastructure (18). Nevertheless, the present data suggest that in most cases, cumulative lead and mercury poisoning occurs according to the hypothesis of accumulation and the rate of dispersion (15, 19). This is especially true looking at the average lead (196.6±125.9 µg/L) and mercury (2082.9±3872.5 µg/L) content in breast milk which are well above WHO standards (8). This major public health problem can be explained by the absence of regulations aimed at reducing lead and mercury pollution in the Kinshasa environment. Indeed, in France, the compliance with the March 29th, 1977 guidelines led to a significant decrease in lead impregnation of the French urban population during the early eighties (18).

Despite of their high variability (averages influenced by their extremes and asymmetric distribution), lead and mercury concentrations in breast milk varied depending on the urban environment and the mother's age both in Kinshasa and elsewhere (18). Kinshasa central city is more exposed to atmospheric and industrial pollution, and is characterised by higher lead and mercury levels than the rural suburbs.

In addition, the mercury content in breast milk increased with the mother's age in Kinshasa city. This can partially explain the outbreak of chronic renal failure in adult Congolese and the corresponding medical mobilisation to combat this condition (20). This, however, is not the case with lead, which negatively correlated with the mother's age without statistical significance. The absence of any significant correlation between blood impregnation by lead and exposition time (time embedded in age) was also observed in Saudi Arabia (15).

Lead and mercury were cumulative poisons and induced growth disorders in children in Kinshasa as well as their brain development. Indeed, the rate of low birth weight, small size and microcrania at birth were higher in children born from mothers with high lead and mercury levels in breast milk, respectively. Exposure of foetuses to mother's lead and mercury contamination occur through the placenta. These effects of lead on the growth of children (9, 10), neurobehavioral development and grow related exposure to methyl mercury on neurological functions (21) are reported in the literature. Finally, breast milk poisoning by lead can explain the death of many infants aged less than two months.

This study reveals the important role of mothers' exposure to lead on their high systolic and diastolic blood pressures. This finding can explain the vulnerability towards pre-eclampsia of pregnant women living in the outskirts of the city of Kinshasa whose water supply is done with lead pipes (22). High school students from these outskirts suffer more from high blood pressure than their counterparts living in other environments of Kinshasa (23). Thus, this work confirms the role of lead in the genesis of hypertension (11). Lead exposure induces arterial hypertension by several pathophysiological mechanisms: focal tubulo-interstitial lesions, angiotensine II cellular expression and NF-Kappa B activation (24), damage of endothelium vasodilator function due to the increase in free radicals and in the decrease in the activity of the anti-oxidative barrier with the consequent hormonal and renal response (25).

The situation in Kinshasa is peculiar since the abolition of lead in gasoline is not feasible. Soil and house dust, degradation of lead paint, the proximity of industrial sites and roads (combustion of leaded fuel), drinking water, food and air (19, 21), can be important routes of lead and mercury exposure. The regulation (maximum allowable concentrations) should target air, drinking water, food and the sale of skin lightening cosmetics. It was the regulation and population monitoring over time that allowed blood lead level diminution in adult persons of the United States of America (26) and France (18). But this diminution of blood lead remains associated with a higher risk of l renal hypertension among non-Hispanic blacks (26). To estimate the health impact of risk events identified in this study, we urgently need to assess the number of people concerned in Kinshasa and the other provinces of the DRC. Indeed, breast milk provides information on the level of exposure to the chemical environment of the mother and the child (27).

CONCLUSION

This work shows that the mothers and their infants of the city of Kinshasa are exposed to persistent environmental lead and mercury contamination that is above the WHO standards.

The breast milk exposed these new-borns into cumulative lead and mercury poisoning, and, therefore, correlated positively with lower birth weight, small size, microcrania, and neonatal deaths. Mothers' blood pressure increased with the increase of lead content in the breast milk. Therefore, there is a significant need for an urgent legislative action on environmental health.

Competing Interest:

Authors declare that they have no competing interest.

Acknowledgments:

We acknowledge and appreciate the LOMO Medical Clinic for providing the funding and also for their assistance. The Nuclear Centre of Kinshasa, the Faculty of Pharmaceutical Sciences of Kinshasa and the Department of Chemistry at Walter Sisulu University are gratefully acknowledged for performing the analytical tests. Finally, we express our special gratitude to the mothers for their full cooperation.

REFERENCES

1. Akre J. Infant feeding. The physiological basis. Bull World Health Organ. 1989; 67 Suppl:1-108. PubMed PMID: 2702124. Pubmed Central PMCID: 2491197.

2. WHO. Infant and young child nutrition. Resolution WHA542 of the fifty-fourth World Health Assembly. 2001.

3. OMS. Rapport sur une étude collective de l'OMS consacrée à l'allaitement au sein. Quantité et qualité du lait maternel. Organisation Mondiale de la Santé. 1987.

4. CSHPF. DGS. Plomb, cadmium et mercure dans l'alimentation : évaluation et gestion du risque. 1996.

5. Masiala TC. Toxiques alimentaires. In: Tandu-Umba NFB (ed). Nutrition : de la théorie à la pratique. Nutrition : de la théorie à la pratique PUK, Kinshasa. 2001:110-27.

6. Masiala TC, Moyogo M. Evaluation par activation neutronique des teneurs de mercure dans Trachurus trachurus et Heterotis niloticus, deux poissons couramment consommés à Kinshasa. Université de Kinshasa. 1995.

7. Dreisbach RH. Handbook of Poisoning. Lange Medical Publication. 1988;10:578.

8. OMS. Oligo-Éléments, éléments mineurs et éléments en traces dans le lait maternel. Rapport d'une étude collective OMS/AIEE. OMS. 1989.

9. Nordstrom S, Beckman L, Nordenson I. Occupational and environmental risks in and around a smelter in northern Sweden. V. Spontaneous abortion among female employees and decreased birth weight in their offspring. Hereditas. 1979;90(2):291-6. PubMed PMID: 437992.

10. Murphy MJ, Graziano JH, Popovac D, Kline JK, Mehmeti A, Factor-Litvak P, et al. Past pregnancy outcomes among women living in the vicinity of a lead smelter in Kosovo, Yugoslavia. Am J Public Health. 1990 Jan;80(1):33-5. PubMed PMID: 2293800. Pubmed Central PMCID: 1404542.

11. Vigeh M, Yokoyama K, Mazaheri M, Beheshti S, Ghazizadeh S, Sakai T, et al. Relationship between increased blood lead and pregnancy hypertension in women without occupational lead exposure in Tehran, Iran. Arch Environ Health. 2004 Feb;59(2):70-5. PubMed PMID: 16075900.

12. HACH. Methods for chemical Analysis. Handbook Hach Company, Loveland, Iowa, USA. 1991.

13. Annest JL, Pirkle JL, Makuc D, Neese JW, Bayse DD, Kovar MG. Chronological trend in blood lead levels between 1976 and 1980. The New England journal of medicine. 1983 Jun 9;308(23):1373-7. PubMed PMID: 6188954.

14. Mushak P. Defining lead as the premiere environmental health issue for children in America: criteria and their quantitative application. Environ Res. 1992 Dec;59(2):281-309. PubMed PMID: 1464283.

15. Sawas AH, Eldeib AR. Serum lead levels in civil servicemen and public transport drivers in Makkah City, Saudi Arabia. East Afr Med J. 2005 Sep;82(9):443-6. PubMed PMID: 16619716.

16. Incineration W. Waste Incineration. A Dying Technology. GAIA. 2003.

17. Hibbert R, Bai Z, Navia J, Kammen DM, Zhang J. High lead exposures resulting from pottery production in a village in Michoacan State, Mexico. J Expo Anal Environ Epidemiol. 1999 Jul-Aug;9(4):343-51. PubMed PMID: 10489159.

18. Huel G, Frery N, Takser L, Jouan M, Hellier G, Sahuquillo J, et al. Evolution of blood lead levels in urban French population (1979-1995). Rev Epidemiol Sante Publique. 2002 Jun;50(3):287-95. PubMed PMID: 12122345.

19. Hivert G, Coquet S, Glorennec P, Bard D. [Is compliance to current lead regulations safe enough for infants and toddlers?]. Rev Epidemiol Sante Publique. 2002 Jun;50(3):297-305. PubMed PMID: 12122346. Le respect de la reglementation actuelle permet-il une protection suffisante de la population infantile vis-a-vis du plomb?

20. Nseka Mangani N. Rein et Santé : les maladies des reins en Afrique noire. Presses de l'Université de Kinshasa. 2005:231.

21. Cordier S, Garel M, Mandereau L, Amiel - Tison C, Morcel H. Résumé de communications orales, Enquête sur les risques neurotoxiques chez l'enfant liés à l'exposition au méthylmercure en Guyane française. Rev Epidém et Santé Publique. 2000;2:86-7.

22. Longo-Mbenza B, Bayekula M, R N. Maternal and perinatal mortality in case of pregnancy-induced hypertension. Simon Kimbangu University Press, Kinshasa. 2003.

23. Longo-Mbenza B, Bayekula M, Ngiyulu R, Kintoki VE, Bikangi NF, Seghers KV. Survey of rheumatic heart disease in school children of Kinshasa town. . International journal of cardiology. 1998;63(3):287-97.

24. Rodriguez-Iturbe B, Sindhu RK, Quiroz Y, Vaziri ND. Chronic exposure to low doses of lead results in renal infiltration of immune cells, NF-kappaB activation, and overexpression of tubulointerstitial angiotensin II. Antioxidants & redox signaling. 2005 Sep-Oct;7(9-10):1269-74. PubMed PMID: 16115032.

25. Goch A, Goch JH. [Lead-induced pathomechanisms of hypertension]. Polski merkuriusz lekarski : organ Polskiego Towarzystwa Lekarskiego. 2005 Mar;18(105):351-3. PubMed PMID: 15997651. Rola olowiu w patogenezie nadcisnienia tetniczego.

26. Muntner P, Menke A, DeSalvo KB, Rabito FA, Batuman V. Continued decline in blood lead levels among adults in the United States: the National Health and Nutrition Examination Surveys. Archives of internal medicine. 2005 Oct 10;165(18):2155-61. PubMed PMID: 16217007.

27. LaKind JS, Brent RL, Dourson ML, Kacew S, Koren G, Sonawane B, et al. Human milk biomonitoring data: interpretation and risk assessment issues. Journal of toxicology and environmental health Part A. 2005 Oct 22;68(20):1713-69. PubMed PMID: 16176917.