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High Levels of Heavy Metals in Blood of the Urban Population in Nigeria

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Abstract: Two hundred and forty blood samples were collected from children, women and men in urban area of Enugu State. The samples were analyzed for nickel, manganese and chromium by atomic absorption spectrophotometer after wet digestion using 1:3 concentrated perchloric and nitric acid. The results of the analysis in ppm show the range and % detectable values as Ni(0.007-0.850)57.08%, Mn(0.006-0.861) 84.60% and Cr(0.006-0.829) 47.00%. The concentrations of the heavy metals were very high as most exceeded the World Health Organization permissible limit. The sample population was classified as pregnant women/nursing mothers and other women, according to age groups ($\leq$12, 13-25 and >25 years), sex, occupationally and non occupationally exposed and also as those exposed/or not exposed to some probably risk factors to be associated with the heavy metals. This was done to find out if there is a trend with the different categories which will help in identifying toxicity risk groups of the heavy metals in the country using complete randomized design (ANOVA) and t-test. Children ($\leq$12 years) had the highest mean concentrations of nickel and chromium. Males also had higher mean concentrations for nickel and chromium, while pregnant women/nursing mothers had lower mean concentrations than the other women for the heavy metals. There were significant differences between the responses for some of the factors. However, no risk factor could be pinpointed since, this study was not based on any pollution point source rather, on various diffuse (non-point) sources.

Key words: Nickel, manganese, chromium, blood, wet digestion, environmental pollution

INTRODUCTION

As developing countries of West Africa become industrialized and urbanized, heavy metal pollution is likely to reach disturbing levels. Industrialization and technological advancement/development processes have led to the introduction of hazardous chemicals into the environment. These chemicals include the following: agrochemicals, herbicides, pesticides, halogenated polycyclic hydrocarbons and food additives. In Nigeria, the growing rate of industrialization is gradually leading to contamination and deterioration of the environment. The critical issues however, are that preparations are not being made towards

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the protection of the environment (Olaifa and Ayodele, 2004). Some reported works established the fact that there is heavy metals pollution in Nigeria. For example, Onianwa *et al*. (2000) determined the nickel content of 78 different Nigerian foods of various classes, it was found to be higher than the levels observed in similar foods in some developed countries, Okoye (2001) in the determination of heavy metals in fruits and vegetables, obtained high levels of manganese for banana which if taken overtime can be detrimental to the health of the consumer. Ayodele and Gaya (2003) also reported high level of nickel in street dust in Nigeria, which has also been found to be higher than the concentrations found in other countries. In a study carried out in Taylor creek, Southern Nigeria on the inter-metal correlations in the three environmental segments: water column, sediments and cat-fish, the mean levels of Mn (0.035 mg mL^{-1}) and Cr (0.0024 mg mL^{-1}) in the dissolved phase and Mn (0.09 mg g^{-1} dry wt.) and Cr (0.0062 mg g^{-1} dry wt.) in the particulate phase were obtained. This was reported by Okaform and Opuene (2006) to be higher than the interim standards for aquatic life and domestic use. High concentrations of chromium exceeding WHO (1996) standard were also observed in several studies of some selected rivers in Nigeria by Obahiagbon and Okeimen (2007).

The heavy metals have been known to cause various diseases. The most common harmful health effect of nickel in humans is an allergic reaction others are chronic bronchitis, cancer of the lung and nasal sinus, moderate pulmonary fibrosis etc. (Berge and Skyberg, 2003). Manganese exposure has been associated with sudden death and psychomotor excitement (Koplan, 2000a). Manganism, also associated with manganese exposure is a progressive condition that usually begins with relatively mild symptoms but evolves to include dull affect, altered gait, fine tremor and sometimes psychiatric disturbances. At excessive levels causes decreased learning ability in school aged children and increased propensity for violence in adults (Fineley, 2004). Large amounts of chromium exposure have caused stomach upsets and ulcers, convulsions, kidney and liver damage and even death (Koplan, 2000b). Nickel, manganese and chromium are associated with automobile related pollution and released during combustion and spillage (Lytle *et al*., 1994). In comparison to other groups within the general population, persons living close to high density traffic areas, automotive workers and taxi drivers may be exposed to higher concentrations of the heavy metals (Koplan, 2000a). The levels of the heavy metals in blood can be taken as representative of dose/exposure (Baldwin and Marshall, 1999). There have so far been no reference values of the heavy metals in population of Enugu State, Nigeria. Therefore, the aim of this investigation was to determine the concentrations of nickel, manganese and chromium in human whole blood samples obtained from men, pregnant women, nursing mothers other women and children in Enugu State and also to identify possible risk factors of these heavy metals toxicity among the Nigerian population.

MATERIALS AND METHODS

The study was carried out from January 2008 to May 2009. To get the approval to work on human part, an Ethical Clearance Certificate was obtained from the University of Nigeria Teaching Hospital Health Research Ethics Committee, Ituku Ozalla, in Enugu State, Nigeria after undergoing an interview and submitting a detailed proposal of the research work. Informed consent was obtained from the sample population. All were made to complete a questionnaire concerning their environmental exposure as a means of obtaining information on likely environmental impact on the blood heavy metals levels.

Collection of Samples

Three milliliter of blood were collected directly from the select population made up of children, women (pregnant, nursing mothers, others) and men from Bishop Shanahan Hospital, Good Shepherd Hospital, St Raphael's Clinics, University Teaching Hospital (UNTH) Ituku Ozalla, Uzommiri study centre, Lantana catering school and Ezindu professional centre all in Enugu State Nigeria. This was done by vein puncture by a qualified nurse under contamination controlled conditions using pyrogen free sterile disposable syringes. The blood samples were put into 5 mL capacity EDTA plastic bottles containing K_3EDTA as anticoagulant. The samples were mixed carefully by shaking. All the samples were stored in the refrigerator to prevent deterioration before the analysis (Rahman *et al*., 2006).

Quality Assurance Procedures

Validation of the digestion method of analysis used and certification of the instrument as good enough for the analysis was done by carrying out recovery experiment and precision analysis, respectively. These were carried out in the University of Nigeria Nsukka, Enugu State.

Recovery Experiment

Three samples of blood were used. Each sample was taken in two portions of 2 mL into two conical flasks. One milliliter of mixed standard solution containing 20 ppm nickel, 10 ppm manganese and 20 ppm chromium was added to spike one set of portions (i.e., three conical flasks) of the blood samples. The other set was left unspiked. Perchloric acid and nitric acid were added into all the conical flasks in the ratio 1:3 as follows: 2 mL perchloric acid (70% v/v) and 6 mL nitric acid (72% v/v). The conical flasks were covered with evaporating dishes and the mixtures digested at low temperature using a thermostated Bitinett hot plate until clear solutions were obtained. At the end of the digestion, they were all made up to 20 mL and the concentrations of heavy metals determined using atomic absorption spectrophotometer. The recovery of each of the heavy metals was then calculated as follows:

$$\%\text{Recovery} = \frac{x - y}{z} x100$$

Where:
x = Concentration (ppm) of heavy metal determined in the spiked samples
y = The concentration (ppm) of heavy metal determined in the unspiked samples
z = The concentration (ppm) of heavy metal added to the spiked samples

Precision Analysis

One milliliter of the mixed standard solution was pipetted into a 20 mL standard flask and made up to mark, to give 0.5 ppm manganese and 1 ppm nickel and chromium.

This was analyzed 5 times for the heavy metals. The results obtained were subjected to statistical analysis using the formula below:

$$\frac{S}{X} x \frac{100}{1}$$

Where:
S = Standard deviation

Sample Preparation

Each sample (3 mL) was transferred into 100 mL conical flasks. The EDTA bottle was rinsed with little nitric acid and transferred into the 100 mL conical flask. Perchloric acid and nitric acid were added in the ratio 1:3 as follows: 2 mL perchloric acid (70% v/v) and 6 mL nitric acid (72% v/v). The conical flask was covered with an evaporating dish and the mixture digested at low temperature using a thermostated Bitinett hot plate until a clear solution was obtained. The digest was made up to 20 mL with deionized water in a 20 mL standard flask (Rahman *et al*., 2006).

The sample solutions were then analyzed for the heavy metals in Anal Concepts limited, Port Harcourt Nigeria using a GBC atomic absorption spectrophotometer, model no A6600 AVANTA PM.

RESULTS

Results of the recovery analysis for the heavy metals were: Ni 87.43-99.14%, Mn 90.77-103.34 and Cr 89.04-92.53% signifying high accuracy. The % precisions were 2.367-5.097%, all below 10%. Statistical analyses were carried out using the Complete Randomized Design (CRD) or one-way Analysis of Variance (ANOVA). Table 1 shows the mean concentrations (ppm) of the heavy metals in blood of different age groups. The concentration of Nickel was highest in ≤12 years age group with a concentration range of 0.01-0.85 ppm and mean of 0.411 ppm. Manganese was highest in >25 age groups with a concentration range of 0.01-0.04 ppm and mean of 0. 111 ppm while chromium was highest in ≤12 years age group with a concentration range of 0.01-0.68 ppm and mean of 0.267 ppm. Table 2 shows the mean concentrations (ppm) of the heavy metals in males and females. The males had higher levels of nickel and chromium while the females had higher levels of

Table 1: Mean concentrations (ppm) of heavy metals in blood of different age groups

Age group	Nickel	Manganese	Chromium
≤12 year			
N	46	35	24
Mean±SD	0.411±0.241	0.091±0.147	0.267±0.228
Range	0.01-0.85	0.01-0.86	0.01-0.68
13-25 year			
N	34	68	34
Mean±SD	0.079±0.061	0.108±0.062	0.221±0.148
Range	0.01-0.29	0.01-0.31	0.01-0.58
>25 year			
N	57	100	55
Mean±SD	0.124±0.072	0.111±0.063	0.245±0.205
Range	0.01-0.33	0.01-0.40	0.01-0.83
Sig. ANOVA	0.000	0.468	0.670

N = No. of detectable concentrations

Table 2: Mean concentrations (ppm) of heavy metals in blood of male and female donors

Sex	Nickel	Manganese	Chromium
Male			
N	70	83	41
Mean±SD	0.250±0.227	0.105±0.073	0.308±0.231
Range	0.01-0.85	0.01-0.40	0.01-0.83
Female			
N	67	120	72
Mean±SD	0.166±0.178	0.108±0.090	0.204±0.159
Range	0.01-0.68	0.01-0.86	0.01-0.67
Sig. 2-Tailed	0.017	0.815	0.013

N = No. of detectable concentrations

Table 3: Mean concentrations (ppm) of heavy metals in blood of pregnant women/nursing mothers and other women

Group	Nickel	Manganese	Chromium
Pregnant women/nursing mothers			
N	31	52	35
Mean±SD	0.096±0.061	0.088±0.040	0.201±0.150
Range	0.01 0.21	0.01-0.21	0.01-0.57
Women			
N	20	53	28
Mean±SD	0.096±0.067	0.121±0.059	0.214±0.167
Range	0.01-0.25	0.02-0.31	0.01-0.67
Sig. 2- Tailed	0.981	0.001	0.766

N = No. of detectable concentrations

Table 4: Mean concentrations (ppm) of heavy metals in blood of occupationally and Non-occupationally exposed

Occupationally exposed	Nickel	Manganese	Chromium
No.			
N	83	104	55
Mean±SD	0.274±0.239	0.108±0.094	0.236±0.185
Range	0.01-0.85	0.01-0.86	0.01-0.68
Yes			
N	54	99	58
Mean±SD	0.109±0.074	0.105±0.070	0.248±0.202
Range	0.01-0.33	0.01-0.40	0.01-0.83
Sig. 2- Tailed	0.000	0.816	0.748

N = No. of detectable concentrations

Table 5: Levels of Ni, Mn and Cr in blood of those who eat balanced diet and others

Dieters	Nickel	Manganese	Chromium
Balanced dieters			
N	135	201	113
Mean±SD	0.210±0.209	0.107±0.083	0.242±0.194
Range	0.01-0.85	0.01-0.86	0.01-0.83
Others			
N	2	2	
Mean±SD	0.158±0.013	0.065±0.032	-
Range	0.15-0.17	0.04-0.09	
Sig. 2 Tailed	0.017	0.294	-

N = No. of detectable concentrations

Table 6: Levels of Ni, Mn and Cr in blood of those who eat lots of fish and others

Eat lots of fish	Nickel	Manganese	Chromium
No			
N	124	184	107
Mean±SD	0.208±0.205	0.106±0.085	0.246±0.197
Range	0.01-0.85	0.01-0.86	0.01-0.83
Yes			
N	13	19	6
Mean±SD	0.219±0.241	0.112±0.055	0.163±0.092
Range	0.01-0.77	0.01-0.20	0.05-0.26
Sig. 2 Tailed	0.875	0.645	0.084

N = No. of detectable concentrations

manganese. As shown in Table 3, other women had higher levels of the heavy metals than the pregnant women/nursing mothers except nickel for which they had the same mean value but a higher range (0.01-0.25). Results of those occupationally and non occupationally exposed are shown in Table 4. Those considered to be nonoccupationally exposed had higher values of the heavy metals except for chromium. The results for the different factors i.e., eating balanced diet, eating lots of fish, taking herbal medicine, cigarette smoking, using bleaching cream, handled pesticides, lived in house under renovation, handle broken fluorescent bulbs and living with occupationally exposed individuals are shown in Table 5-13, respectively.

Table 7: Levels of Ni, Mn and Cr in blood of users and non-users of herbal medicine

Herbal medicine	Nickel	Manganese	Chromium
Non-users			
N	113	169	96
Mean±SD	0.217±0.215	0.111±0.088	0.232±0.182
Range	0.01-0.85	0.01-0.86	0.01-0.76
Users			
N	24	34	17
Mean±SD	0.174±0.168	0.086±0.043	0.298±0.250
Range	0.02-0.68	0.01-0.18	0.01-0.83
Sig. 2 Tailed	0.288	0.017	0.315

N = No. of detectable concentrations

Table 8: Levels of Ni, Mn and Cr in blood of smokers and non-smokers

Smoking	Nickel	Manganese	Chromium
Non-smokers			
N	130	193	110
Mean±SD	0.214±0.212	0.108±0.084	0.240±0.194
Range	0.01-0.85	0.01-0.86	0.01-0.83
Smokers			
N	7	10	3
Mean±SD	0.109±0.055	0.088±0.058	0.313±0.220
Range	0.05-0.18	0.01-0.19	0.09-0.53
Sig. 2 Tailed	0.001	0.329	0.624

N = No. of detectable concentrations

Table 9: Levels of Ni, Mn and Cr in blood of users and non-users of bleaching cream

Bleaching	Nickel	Manganese	Chromium
Non-users			
N	131	194	104
Mean±SD	0.208±0.203	0.107±0.084	0.244±0.1917
Range	0.01-0.85	0.01-0.86	0.01-0.83
Users			
N	6	9	9
Mean±SD	0.232±0.314	0.089±0.041	0.221±0.228
Range	0.01-0.85	0.02-0.17	0.01-0.67
Sig. 2 Tailed	0.860	0.241	0.778

N = No. of detectable concentrations

Table 10: Levels of Ni, Mn and Cr in blood of those who handle pesticides and others

Handle pesticides	Nickel	Manganese	Chromium
No			
N	107	155	91
Mean±SD	0.219±0.205	0.107±0.090	0.246±0.201
Range	0.01-0.85	0.01-0.86	0.01-0.83
Yes			
N	30	48	22
Mean±SD	0.175±0.218	0.106±0.052	0.228±0.162
Range	0.03-0.85	0.02-0.24	0.03-0.67
Sig. 2 Tailed	0.334	0.938	0.664

N = No. of detectable concentrations

Table 11: Levels of Ni, Mn and Cr in blood of those who lived in house under renovation and others

Lived in house under renovation	Nickel	Manganese	Chromium
No			
N	116	168	94
Mean±SD	0.221±0.211	0.109±0.088	0.238±0.193
Range	0.01-0.85	0.01-0.86	0.01-0.83
Yes			
N	21	35	19
Mean±SD	0.144±0.177	0.097±0.047	0.263±0.201
Range	0.01-0.85	0.01-0.18	0.01-0.67
Sig. 2 Tailed	0.085	0.245	0.627

N = No. of detectable concentrations

Table 12: Levels of Ni, Mn and Cr in blood of those who handle broken fluorescent bulb and others

Handle broken fluorescent bulb	Nickel	Manganese	Chromium
No.			
N	115	166	93
Mean±SD	0.227±0.217	0.107±0.089	0.243±0.201
Range	0.01-0.85	0.01-0.86	0.01-0.83
Yes			
N	22	37	20
Mean±SD	0.118±0.118	0.106±0.046	0.239±0.162
Range	0.01-0.57	0.01-0.20	0.02-0.58
Sig. 2 Tailed	0.001	0.955	0.919

N = No. of detectable concentrations

Table 13: Levels of Ni, Mn and Cr in blood of people living with occupationally exposed individuals and others

Living with occupationally exposed individuals	Nickel	Manganese	Chromium
No			
N	117	175	98
Mean±SD	0.227±0.218	0.103±0.084	0.247±0.198
Range	0.01-0.85	0.01-0.86	0.01-0.83
Yes			
N	20	28	15
Mean±SD	0.107±0.074	0.128±0.077	0.211±0.168
Range	0.02-0.33	0.01-0.40	0.01-0.58
Sig. 2 Tailed	0.000	0.122	0.456

N = No. of detectable concentrations

DISCUSSION

The % precisions were all below 10% signifying high precision as stipulated by Taylor *et al*. (2000). Also, for most instrumental methods, coefficient of variation is in the order of 10% (Okoye, 2005). Comparing the concentrations obtained from this study with the W.H.O.(1996) standard for heavy metals in blood, all the samples had concentrations higher than the permissible levels stipulated for each of the three heavy metals (0.001-0.005 ppm for nickel, 0.008-0.012 ppm for manganese and <0.005 ppm for chromium) except for 5 that were within the range stipulated for manganese i.e., 0.008-0.012 ppm.

The high levels of the heavy metals can be due to the fact that environmental pollution seems to be prevalent in Nigeria as reported from various studies carried out on the environment. High concentrations of heavy metals have been determined in the analysis of water e.g., concentrations of nickel, manganese, chromium exceeding the WHO (1996) standard were observed in several studies of some selected rivers in Nigeria (Adekola and Saidu, 2005; Egbereonu and Ozuzu, 2005) etc. High concentrations of heavy metals have been determined in food e.g., a study which assessed and monitored the concentrations of manganese, chromium and nickel in the gills, offal, muscle and liver of a commercially important mudfish from Ogba River, Benin City, Nigeria showed that the concentrations of manganese and chromium in all the fish tissues and nickel in some of the fish tissues exceeded WHO (1996) limits of 0.5 0.6 and 0.15 ppm for manganese, nickel and chromium, respectively (Obasohan, 2007). Concentrations of heavy metals have also been determined in the analysis of soil e.g., Igwilo *et al*. (2006) reported the concentrations of nickel (0.36-5.64 ppm) in soil samples near Anam River in Otuocha, Anambra State, which he considered to be high. Several studies carried out inorder to compare the concentrations of some of the heavy metals in Nigeria with those of other countries, establishing higher concentrations of the heavy metals in Nigeria have been reported. For example, Biney *et al*. (1994) in the determination of heavy metals in inland water sediments reported higher concentrations from Nigeria as compared with some other countries e.g., South Africa, Kenya, Ghana and Egypt. However, even with the established higher concentrations in Nigeria than in other countries, little effort is being made in addressing heavy metals exposure in the domestic environment (Adebamowo *et al*., 2006). This shows that the Nigerian population is at risk of the adverse health effects that may result from heavy metals toxicity.

The sample population was classified into different categories: sex (male and female), age groups (≤12, 13-25 and >25 years), pregnant women/nursing mothers and other women (those who are not pregnant women or nursing mothers), occupationally and non occupationally exposed and also as those exposed to some possible risk factors to be associated with the heavy metals, according to individual responses in the questionnaires. This was done to find out if there is a trend with the different categories which will help in identifying the heavy metals toxicity risk factors in the country.

Nickel mean concentration was highest in children (≤12 years). This might be as a result of the children's habit of playing with just any object including metallic objects that might contain nickel, as such are among the major sources of exposure to nickel. Kirchgessner *et al*. (1981) stipulates that nickel absorption is enhanced by pregnancy and lactation and as has been suggested by Christensen (1995) physiological differences or other factors could affect the absorption of nickel leading to higher bioavailability of nickel in pregnant women/nursing mothers than in other women. In this study, both groups had the same average concentration, while the other women had a higher range with no significant difference ($p>0.05$). This can be due to the fact women lose significant amounts of iron during menstruation, which if not replenished with a healthy diet might lead to high level of heavy metals in their body as nickel absorption is enhanced by iron deficiency (Kirchgessner *et al*., 1981). In this study the males had a higher concentration of nickel than the females which can probably be attributed to a more conscious effort of the females in feeding well during those periods. The mean value of blood nickel obtained from this study was higher than those of other countries which is probably due to reported prevalent environmental pollution in Nigeria e.g., Llobet *et al*. (1998) reported blood nickel concentration range of adults in Spain was 0.0008-0.0881 ppm. The mean value from this study was comparable with 0.25 ppm that was obtained from men in Nkpor Nnewi in Anambra State by Orisakwe *et al*. (2007).

For manganese, the other women had a higher mean concentration than the pregnant women and nursing mothers. This can also be due to the fact women lose significant amounts of iron during menstruation, which if not replenished with a healthy diet might lead to high level of heavy metals in their body as individuals with iron deficiency have been known to show increased rates of manganese absorption (Mena *et al*., 1974). The females had a higher mean concentration of the heavy metal than the males even though there was no significant difference ($p>0.05$). The >25 years age group had the highest concentration of manganese among the different age groups with no significant difference ($p>0.05$). This might suggest that manganese absorption is more with age. The values obtained from this study are higher than those obtained from other countries possibly for the same reason of reported prevalent environmental pollution in Nigeria e.g., Gulson *et al*. (2006) reported that the manganese concentrations of children in Australia were between 0.0018 to 0.045 ppm. Llobet *et al*. (1998) reported that manganese levels in adults in Spain were between 0.0035-0.149 ppm. Meanwhile the mean values (0.119 and 0.121 ppm for adult men and women, respectively) obtained from this study are even lower than the mean of 0.63 ppm obtained in Ibadan by Arinola *et al*. (2008). This is possibly due to the difference in diet of the two groups studied.

In the absence of known exposure, whole blood chromium concentrations are in the range of 0.02 to 0.03 ppm (ATSDR, 2006). The range obtained from this study is therefore, exposing a source of significant chromium exposure in Nigeria. The other women had a higher mean concentration than the pregnant women and nursing mothers eve though there was no significant difference between the two ($p>0.05$). Generally, males showed higher concentrations than females. With respect to the age groups, children ≤ 12 years of age had the highest concentration of the heavy metal even though there was no significant difference between the age groups ($p>0.05$). This might suggest that chromium absorption in some cases is probably depressed by aging. People may be exposed to higher levels of chromium if they use tobacco products, since tobacco contains chromium (IARC, 1980). Clearly, the values obtained in this study are higher than those obtained from other countries e.g., blood chromium of adults in Spain was 0.0001-0.0011 ppm (Llobet *et al*., 1998).

Some donors may be occupationally exposed such as those working in filling stations (pump attendants, administrators and sales men), mechanics, painters (car) and roadside petty traders. This is due to the fact that all the heavy metals determined are associated with fossil fuels spillage or combustion. The filling stations are places of constant direct contact with high concentration of fossil fuels (Nriagu, 1996; DeRosa *et al*., 2003). The non-occupationally exposed are those considered to be minimally exposed to these heavy metals as a result of their occupational status. Several researchers have reported higher concentrations of heavy metals in the occupationally exposed than in non-occupationally exposed individuals e.g., Adeniyi and Anetor (1999), Ademuyiwa *et al*. (2005), Orisakwe *et al*. (2007) but some studies have also reported that non occupationally exposed have higher concentrations of some heavy metals than the occupationally exposed e.g., Ogunsola *et al*. (1994) and Mehdi *et al*. (2000). However, in this study as shown in Table 4, those considered to be non-occupationally exposed had higher mean concentration of nickel ($p<0.05$) than those believed to be occupationally exposed. There were no significant differences ($p>0.05$) between the two groups for chromium and manganese. The comparable values for chromium and manganese among the two groups could be due to the dietary status of those believed to be occupationally exposed. If they really take balanced diet as they indicated in their questionnaire, then that might have affected the concentrations of the heavy metals in their body.

Table 5 shows the comparison for the levels of the metals in those who eat balanced diets and those who do not. There were no values for chromium for those who do not feed on balanced diet. Nickel was higher ($p<0.05$) in those who claimed to feed on balanced diet while there was no significant difference in manganese levels in the two groups. Table 6 shows the comparison of values determined in donors who indicated to be heavy fish eaters and those who do not eat much fish. The analysis show no significant differences ($p>0.05$) in the concentration of the three metals in the two groups, indicating that fish are not likely important factors with respect to blood burdens of the donor subjects used in this study. As for the use of herbal medicine (Table 7), manganese was higher ($p<0.05$) in non-users than in users. Even though there was a report suggesting that regular use of herbal preparations could lead to heavy metal toxicity (Obi *et al*., 2006) the present study does not indicate that regular use of herbal medicines could be a strong risk factor. Moreover, the availability of these metals in plants depends much on the geochemistry. Table 8 shows higher concentrations ($p<0.05$) of nickel in non-smokers. However, very few indicated to be non-smokers. No significant differences ($p>0.05$) could be found between those who use bleaching cream and those who do not (Table 9) as well as between those who handle pesticides and those who do not (Table 10). The same similarities are found between those who have lived in a house under renovation and those who had not (Table 11).

Considering those who handle broken fluorescent bulb and those who do not (Table 12), higher nickel concentrations ($p<0.05$) were determined in those who do not regularly come in contact with broken fluorescent bulbs, while Table 13 also shows higher nickel content ($p<0.05$) in the blood of those who had not lived with occupationally exposed persons than in the few who indicated to the contrary.

CONCLUSION

It is clear that the blood of most Nigerians contain high levels of the nickel, manganese and chromium. The data obtained from this study, provide some information about the heavy metals burdens of the urban population of the Nigerians, living in the Southeast, especially in Enugu and Nsukka in Enugu State. The data obtained can be considered as reference showing the ranges of the studied heavy metals in the blood of the various age groups and in males and females in the area of study. With heavy metals content of air, water, soil, plants and food in Nigeria, it is clear from this study that the generally polluted environment has probably had significant impact on the heavy metal blood burdens of the Nigerian population. However, no risk factor could be pinpointed since, this study was not based on any pollution point source rather, on various diffuse (non-point) sources.

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