Advances in Biomedical Sciences
2018; 3(5): 110-116
http://www.openscienceonline.com/journal/abs

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Blood Levels of Some Toxic and Essential Metals Among Rural and Urban Dwellers of Different Blood Groups in Edo State, Nigeria

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To cite this article

Mathias Abiodun Emokpae, Lawrence Victory Ogana, Dan Ugbomoiko. Blood Levels of Some Toxic and Essential Metals Among Rural and Urban Dwellers of Different Blood Groups in Edo State, Nigeria. *Advances in Biomedical Sciences.* Vol. 3, No. 6, 2018, pp. 110-116.

Received: November 11, 2018; **Accepted**: December 11, 2018; **Published**: January 18, 2019

Abstract

Introduction: Toxic metals pollutions in the environment as a result of human activities have resulted to some health challenges in the general population. The near absence of record keeping in our setting has made identification of candidate metal difficult and symptomatic management a challenge to health care providers. Objective: This study seeks to know whether the rural and urban dwellers are disproportionately exposure and whether the metal levels vary according to ABO blood group types. Materials and methods: Blood levels of mercury, cadmium, nickel, lead, chromium, arsenic, copper manganese and iron as well as ABO blood grouping were determined in 100 rural and 103 urban dwellers using Atomic Absorption Spectrophotometer (Bulk scientific model 210VGP) and serological technique respectively. Results: Rural dwellers had significantly higher serum levels of copper ($p<0.001$), manganese ($p=0.008$) and arsenic ($p<0.001$) than urban dwellers while urban dwellers had significantly higher levels of serum iron ($p=0.003$) and chromium ($p<0.001$). The differences in the levels of lead, cadmium and nickel were not significant. Serum copper, iron, nickel and lead were significantly lower ($p<0.001$) in individuals with blood group O but higher ($p<0.001$) in blood group A, AB and B respectively. Conversely, serum cadmium and mercury were significantly higher ($p<0.001$) in blood group O than non-O blood groups while Arsenic was higher ($p<0.001$) in blood group B than the other blood group types. Conclusion: Both rural and urban dwellers were equally exposed to environmental pollutants. The distributions of metals are different according to blood group types. The control of environmental pollution is essential in both rural and urban areas in order to avoid the associated adverse effects.

Keywords

Environmental Exposure, Toxic and Essential Metals, ABO Blood Group Types

1. Introduction

It has been reported lately that low-level of toxic metals exposure may be contributing much more towards the causation of chronic diseases than previously thought. The blood levels of toxic metals depend on the bio-accessibility rate and may be regarded as an index of biologically active metals in the body [1-2]. It is an indication of environmental exposure of a population which may provide useful information to the general public and policy makers to evolve strategies to minimize environmental pollution. The near absence of record keeping in our setting has made identification of candidate metal difficult and effective management of subjects by health care providers a huge challenge [3].

Toxic metals occur as natural constituents of the earth crust and are persistent environmental contaminants owing to the fact that they cannot be readily degraded or destroyed in nature, they are ubiquitous in the environment as a result of both natural and anthropogenic activities and humans are exposed to them through various pathways [4]. There has been an increasing ecological and global public health concerns associated with environmental contamination by

metals. Also, human exposure to metals has risen considerably as a result of an exponential increase of the use of metals in several industrial, agricultural, domestic and technological applications [5].

Occurrences of toxic metals-enriched ecosystem components, firstly, arise from rapid industrial growth, advances in agricultural modernization, or the urban activities of human beings, which have led to metal dispersion in the environment and, consequently impaired health of the population by the ingestion of harmful metals [6]. Some toxic metals at molecular level are capable of activating cells and trigger signaling pathways, arising by targeting a number of cellular regulatory proteins or signaling proteins participating in cell growth, cell cycle regulation, DNA repair mechanism, apoptosis and cellular differentiation [7]. The general effects of this action due to metals are the loss of growth regulatory mechanisms in cells, initiating uncontrollable cell multiplication and autonomous cell growth, which is the hallmark of carcinogenesis [8].

Contamination of soils by toxic metals is the most serious environmental challenge and has serious implications for human health [9]. The health effects of toxic metals ranges from dermatitis to other damages involving various parts of the body and functions such as neurological and behavioral disorders, haematological defects, liver and kidney damage, cardiovascular defects, skeletal tissue damage, reproductive defects, genetic defects, induction of oxidative stress, cell component damage and induction of different types of cancer [10]. Human activities have led to the production and introduction of toxic metals in to the environment. These include gasoline, burning of garbage (both domestic and industrial refuses, plastics, paper products, wood and vegetation), use of fossil fuel for cooking and agrochemicals. It is obvious that both urban and rural dwellers are affected. Most studies of environmental toxic metal levels in blood were conducted among subjects in urban communities [3, 11-13]. In addition, the metabolism of toxic and essential metals may vary according to individual's blood group system. It has been previously reported that beyond blood transfusion, ABO blood group system may be risk factor for the development of chronic diseases [15, 16]. This study therefore seeks to know (i) whether occupationally unexposed rural and urban dwellers are disproportionately exposure to mercury, cadmium, nickel, lead, chromium, arsenic, copper manganese and iron. (ii) whether the distributions of measured metal vary according to ABO blood group type.

2. Method

2.1. Study Area

This study was conducted at Olumoye, a rural community in Ovia North East Local government area and Benin City, an urban and headquarter of Edo State, Southern Nigeria. The rural and urban populations were considered based on population threshold and basic social amenities/infrastructure available in the environment [17, 18].

2.1.1. Study Population

The study population includes apparently healthy adult male and female subjects who were primarily rural and urban dwellers in Olumoye village and Benin City for at least 20 years. A total number of 203 subjects (92 males, age range 20-55years and 111 females, age range 20- 56 years) were enrolled in the study. This is a cross sectional study of the levels of some toxic metals and essential metals among rural and urban dwellers in Edo State.

2.1.2. Rural Dwellers

The study participants were carefully selected using information provided by the subjects as rural dwellers who were resident in a farming community for a minimum of 20 years. No mining activity is carried out in the environment. The resident of the rural area are majorly occupational farmers. The selection of subjects was based on permanent place of resident for at least 20 years, occupation, age and health status.

2.1.3. Urban Dwellers

These were apparently healthy male and female subjects who were resident in Benin City, Edo State. By occupation, the urban dwellers were mostly civil servants and university students and are not occupationally exposed to toxic metals or mining activity.

2.2. Ethical Consideration

The study protocol was reviewed and approved by Edo State Ministry of Health, ethical code HM1208/161 dated 18th January, 2017. Informed consent was sought and obtained from the participants before blood specimen was collected.

Structured questionnaire was used to collect demographic data from the participants. The information obtained include; age, gender, weight, marital status, location or residence and duration, occupation, social life style (smoking/drinking) and staple food.

2.3. Inclusion and Exclusion Criteria

Only apparently healthy adult subjects who had resided permanently in the communities where the study was conducted for at least 20years, non-smokers and gave informed consent were enrolled. Those below 20 years, had dual-residences with chronic diseases and smokers were excluded.

2.4. Sample Size

The sample size of this study was calculated using sample determination formula for health studies [19].

2.5. Sample Collection

Four milliliters of whole blood was collected aseptically by venipuncture from each of the subjects using a sterile disposable needle and syringe, this was transferred into a

clean plain specimen container while avoiding haemolysis serum was promptly separated from whole blood after centrifuging and stored frozen at -20^{o}C until analysis was done. The red blood cell was used for the determination of blood group.

2.6. Laboratory Analyses

2.6.1. Blood Group Determination

Tile method was used to determine the blood group types using antisera supplied by Biotec (England) and the reversed serum grouping done using patient's serum and known washed red blood cells as previously described [20].

2.6.2. Determination of Metals

The concentrations of mercury, iron, cadmium, copper, nickel, lead, chromium, and manganese were determined using Atomic Absorption Spectrophotometer (Bulk scientific model 210VGP). Standard solutions of Pb, Mn, As, Cr, Cd, Cu, Ni, Fe, Hg were used for calibration. De-ionized water was used throughout for cleaning apparatus, preparing standard solutions and other laboratory material to avoid cross contamination. Perchloric acid 72% and nitric acid 70% was used for the digestion of the serum samples. Stock solution of each element (1,000ppm) was used to prepare diluted standard solutions of various concentrations. All solutions were prepared with de-ionized water.

2.6.3. Digestion of Samples

Sample digestion was to ensure optimum condition for analysis. A homogenized solution formed by the addition of 500µl serum sample to a mixture of analar grade nitric acid and perchloric acid were added in the ratio of 3:1 as follows: 6ml nitric acid (72% v/v) and 2ml perchloric acid (70% v/v) in a 50ml Kjeldahl digestion flask, was wet digested at 90℃ using a hot plate in a fume extractor for about 1 hour until a white fume is formed in the flask and the wall of the flask is cleared. The solution was then allowed to cool and filtered into a separate 5ml flask using Whatmann No 1 filter paper and a funnel. The filtered digested solution was then made up to 50ml with de-ionized water and transferred into previously washed and dry-cleaned tubes for AAS analysis.

2.7. Statistical Analysis

Data was analyzed using Statistical Package for Social Science (SPSS) version 20.0. The data were expressed as Mean ± Standard Error of Mean (Mean±SEM). Analysis of Variance (ANOVA) and unpaired Students t-test were used to compare means between the groups and P-value <0.05 was considered statistically significant.

3. Results

The results of the investigation are presented in tables 1 – 4. Table 1 shows serum metal levels in both rural and urban dwellers. Rural dwellers had significantly higher serum levels of copper ($p<0.001$), manganese ($p=0.008$) and arsenic ($p<0.001$) than urban dwellers. On the other hand, urban dwellers had significantly higher levels of serum iron ($p=0.003$) and chromium ($p<0.001$). The differences in the levels of lead, cadmium and nickel were not significant.

Table 2 shows the serum levels of metals based on gender distribution, cadmium ($p=0.04$) and nickel ($p=0.05$) levels were significantly higher in males than females irrespective of settlement. Table 3 shows the ABO and Rhesus blood group distribution among the study participants while table 4 shows the comparison of measured metal levels between individuals of different ABO blood group systems. Serum copper, iron, nickel and lead were significantly lower ($p<0.001$) in individuals with blood group O but higher ($p<0.001$) in blood group A, AB and B respectively. Conversely, serum cadmium and mercury were significantly higher ($p<0.001$) in blood group O than non-O blood groups while Arsenic was higher ($p<0.001$) in blood group B than the other blood group systems.

Table 1. *Serum levels of metals according to settlement of all study subjects (Mean± SEM).*

	Settlement of Subjects		
Metal	**Rural n = 100**	**Urban n = 103**	**P-value**
Mercury (mg/L)	0.0085±0.0011	0.0087±0.0010	0.893
Iron (mg/L)	0.7009±0.0477	0. 9665±0.0530	0.003
Copper (mg/L)	0.3118±0.0161	0.2245±0.0153	0.001
Cadmium (mg/L)	0.0166±0.0047	0.0132±0.0046	0.605
Nickel (mg/L)	0.1432±0.0059	0.1599±0.0074	0.079
Lead (mg/L)	0.1515±0.0128	0.1404±0.0136	0.553
Chromium (mg/L)	0.4646±0.0373	0.8220±0.0580	0.001
Manganese (mg/L)	0. 1235±0.0046	0.1069±0.0042	0.008
Arsenic (mg/L)	0.0815±0.0089	0.0517±0.0018	0.001

Table 2. *Serum levels of metals according to gender of study participants (Mean ± SEM).*

	Gender of Subjects		
Metal	**Female n=111**	**Male n=92**	**P-value**
Mercury (mg/L)	0.0084±0.0010	0.0088±0.0012	0.798
Iron (mg/L)	0.8433±0.0486	0.8264±0.0566	0.821
Copper (mg/L)	0.2677±0.0128	0.2673±0.0203	0.986
Cadmium (mg/L)	0.0086±0.0034	0.0223±0.0060	0.048
Nickel (mg/L)	0.1432±0.0058	0.1619±0.0077	0.054
Lead (mg/L)	0.1484±0.0133	0.1428±0.0130	0.763
Chromium (mg/L)	0.6163±0.0468	0.6817±0.0585	0.383
Manganese (mg/L)	0.1115±0.0043	0.1194±0.0047	0.216
Arsenic (mg/L)	0.0641±0.060	0.0691±0.0071	0.591

Table 3. *Blood group of subjects according to settlement of subjects.*

Blood group of Subjects	**Rural N**	**Urban N**	**Total N (%)**
Blood group A Rhesus D Negative	0	0	0
Blood group A Rhesus D Positive	18	25	43 (21)
Blood group B Rhesus D Negative	0	1	1 (0.5)
Blood group B Rhesus D Positive	16	18	36 (17.7)
Blood group AB Rhesus D Positive	4	2	6 (3.9)
Blood group O Rhesus D Positive	58	53	111 (54.7)
Blood group O Rhesus D Negative	4	2	6 (2.9)
Total	100	103	203

Table 4. *The comparison of measured metal levels between individuals of different ABO blood group systems.*

Measured Variables	Blood Group A (n=43)	Blood Group B (n=37)	Blood Group AB (n=06)	Blood Group O (n=117)
Mercury (mg/L)	0.0067±0.0005[a]	0.0064±0.0005[a]	0.0057±0.004[a]	0.0091±0.002[b]
Iron (mg/L)	0.9403±0.09[a]	0.7600±0.10[a]	0.9159±0.22[a]	0.7247±0.015[b]
Copper (mg/L)	0.2776±0.004[a]	0.2593±0.003[b]	0.2709±0.06[a]	0.2365±0.004[b]
Cadmium (mg/L)	0.0062±0.001[a]	0.0096±0.001[b]	0.0064±0.002[a]	0.0141±0.001[b]
Nickel (mg/L)	0.1532±0.001[a]	0.1204±0.001[b]	0.1586±0.006[a]	0.1316±0.009[b]
Lead (mg/L)	0.1415±0.03[a]	0.1572±0.03[a]	0.1534±0.04[a]	0.1175±0.01[b]
Chromium (mg/L)	0.5798±0.06[b]	0.9479±0.07[a]	0.9569±0.05[a]	0.7655±0.08[b]
Manganese (mg/L)	0.1112±0.08[a]	0.1129±0.01[a]	0.1290±0.07[a]	0.1125±0.05[a]
Arsenic (mg/L)	0.0594±0.005[a]	0.0765±0.004[b]	0.0531±0.002[a]	0.0647±0.002[b]

a=p>0.05; b=p<0.001

4. Discussion

Toxic and essential metal levels in the blood of rural and urban dwellers may differ due to environment, occupation, nutrition and lifestyle habits. It was previously suggested by some authors that both urban and rural communities are affected by environmental toxic metal pollution because of apparently similar human activities [11]. This study compares the mean levels of some toxic and essential metals among rural and urban dwellers and to determine whether the levels of these metals are different according to the participants ABO blood group types.

Serum copper ($p<0.001$), manganese ($p<0.008$) and arsenic ($p<0.001$) were significantly higher in rural than urban dwellers while serum iron and chromium were significantly higher ($p<0.001$) in urban than rural dwellers (table 1). Blood cadmium and nickel levels were significantly higher in men than women but no gender differences were observed in the levels of other measured metals. Serum iron, copper, nickel and lead were lower ($p<0.001$) in individuals with blood group O than non-O blood groups while cadmium and mercury were significantly higher ($p<0.001$) in individuals with blood group O than non-O blood group types.

In this study we observed no statistically significant difference in the levels of cadmium, lead and nickel between rural and urban dwellers and the concentration of cadmium in males was higher than in females. This is not consistent with that reported among environmentally exposed residents of Stara Zagora, Bulgaria [22], the authors observed that cadmium levels were higher in rural dwellers than urban dwellers. The report of gender differences in the concentration of cadmium has not been consistent. Whereas Chia et al [23] reported higher levels of cadmium among non-smokers in Singaporean women than men, others observed higher levels among men than women in Sardinia, Italy and Morocco [24, 25]. Long-term exposure to cadmium with concentration above 2µg/L can cause renal tubular dysfunction which is manifested with 2-microglobulinuria [22]. The half-life of cadmium may extend to decades in kidney because it is not readily degraded [1]. It can readily be transferred across the placenta, find its way into breast milk and cause various health hazards in infants and foetus. Some authors have reported that environmental cadmium exposure correlated with an increasing risk of all cause, cancers and cardiovascular mortality in men but not in women [26]. The reason for the gender differences in the impact of environmental cadmium exposure is not clear. It was however reported that there was dose-response relationship between men and women in cadmium contaminated areas [1]. Chronic exposure of cadmium may reduce life expectancy and increase mortality in the general population especially among individuals with O blood group system who appear to accumulate cadmium than non O blood group systems from our study. Chronic environmental cadmium exposure may cause increased blood pressure and nephrotoxicity. It can adversely impact blood pressure via mechanism associated with oxidative stress [27], endothelial dysfunction, partial agonism of calcium channels, increase vasoconstriction and activation of the sympathetic nervous system [28]. Cadmium can also act via renal tubular injury, sodium retention and volume overload [29]. Some authors have suggested a cautious interpretation of invalidated biomarkers of cadmium exposure since little information is available to associate cadmium exposure to elevated blood pressure [30]. Urinary cadmium and protein levels have been reported in some patients with renal dysfunction induced by environmental cadmium exposure [31]. Unfortunately, renal tubular damage induced by environmental cadmium exposure has been reported to be irreversible [31, 32]. Deliberate proactive measures must be taken to control environmental cadmium in order to prevent the associated health consequences.

Higher mean levels of blood lead were reported among rural dwellers than urban dwellers with no history of occupational exposure in Mexico [33], China [34], Italy [35] and in Sardinia [36], but we observed no significant different in the concentration of lead among rural and urban dwellers. Adverse effects were reported even at low levels as lead toxicity may cause anaemia and gastrointestinal disturbances, elevated peripheral nerve dysfunction, increased coproporphyrin [1]. It was reported that the level of environmental and occupational exposure to lead in Port Harcourt, a crude oil exploration city in Nigeria is high and has been implicated in the increasing incidence of renal dysfunction [40]. The integration of an intervention measures into preventive programs for chronic kidney disease in Nigeria was advocated [1].

The observance of no significant different in the level of nickel between rural and urban dwellers is not consistent

with that reported in environmentally exposed rural dwellers in Stara Zagora in Bulgaria [22]. It was reported that concentrations above 1.0µg/L of nickel may indicate a chronically excessive intake [37]. The in significant different observed in the levels of cadmium, lead and nickel between rural and urban dwellers may be due to the consumption pattern of similar stable foods. It was previously reported that high levels of some toxic and essential metals were present in most staple foods including yam, amala, protato fish and other roots and tubers in Nigeria [38].

The measured toxic and essential metals were unevenly distributed among individuals of different ABO blood group systems. The clinical importance of ABO blood group system has been noted to extend beyond blood transfusion and some authors have reported that it could be a risk factor in the development of chronic diseases [16]. Even though controversy exists regarding the correlation between ABO blood group system and susceptibility to certain infectious and non-infectious diseases due to lack of probable mechanisms, some studies have shown ABO blood system may influence the risk of different diseases by different known and unknown mechanisms [39]. The finding in this study is in conformity with previous study [16]. We previously reported varied serum copper levels in apparently healthy participants according to their ABO blood group system that followed the order A>AB>B>O. Serum copper level was significantly higher and calcium lower in subjects with blood group A than other blood group types. The reason for this variation was attributed to differences in the clearance rate according to their blood group type [16].

This study revealed that rural dwellers were significantly more exposed to copper, manganese and arsenic than urban dwellers. The reason for this is not clear but may be associated with contamination from soil due farming activities, use of fossil fuel for energy production, dust from earth roads, contaminated air with smoke and ash from bush burning in rural environment. The finding of higher copper levels in rural dwellers than urban dwellers is consistent with previous study [40]. This may be due to the consumption of green leafy vegetables, cereals and nuts which are rich in copper. The levels observed in the rural dwellers were however within normal reference range.

This study showed that the mean concentration of iron was statistically higher in urban dwellers compared with rural dwellers ($p< 0.01$). Higher iron levels observed in urban subjects than rural could also be due to higher rate of consumption of beverages and food drink; also an indication of better consumption of nutrients rich in iron.

This study revealed that mean manganese concentrations was significantly higher ($p<0.01$) in rural dwellers compared to urban. The higher mean concentrations of manganese among rural dwellers may be due to lower iron levels observed among them. This is because iron deficiencies have been known to increase rate of manganese absorption [11].

5. Conclusion

Both rural and urban dwellers were equally exposed to environmental pollutants. The concentrations of the toxic metals were unevenly distributed in individuals of different ABO blood group types. Serum copper, iron, nickel and lead were significantly lower in individuals with blood group O but higher in blood group A, AB and B respectively. Conversely, serum cadmium and mercury were significantly higher in blood group O than non-O blood groups while Arsenic was higher in blood group B than the other blood group systems. The adverse effects of chronic low-level toxic metal accumulation in tissues could progress from a steady decline in energy, productivity and quality of life to progressive cardiovascular diseases and other health consequences. Effective control of environmental pollution is needed in both rural and urban areas in order to avoid the associated adverse effects.

Acknowledgements

We appreciate the contributions of all Medical Laboratory Scientists in the Department of Medical Laboratory Science towards the completion of this study.

Conflict of Interest

The authors declare that they have no competing interests.

Source of Funding

None.

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