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Biomarkers of lead in occupationally exposed persons in Gurara and Suleja areas, Niger State, Nigeria

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Abstract

Human exposure to lead could pose serious health challenges, especially among occupationally-exposed workers. Though several toxicological studies have been carried out on toxic lead exposure in humans regarding their levels, reactions and disease conditions; dearth data exists in terms of correlation of lead levels with their exposure markers and subsequent manifested disease conditions. This study therefore aims to investigate the association between lead exposure and specific biomarkers used in monitoring lead levels in some occupationally exposed individuals and comparing the values with non-exposed individuals. A total of 116 subjects (72 occupationally exposed and 44 non-exposed subjects) within the age range of 17– 50 years were studied in a cross-sectional study conducted between August 2021 and November 2021 in Gurara and Suleja areas, in Niger state, Nigeria. Blood lead levels, hepato-renal indices and hematological parameters were analyzed using atomic absorption spectrophotometer (AAS) and abacus 380 analyzer, respectively. The mean blood levels of lead were 26.8±5.4 µg/dL in occupationally-exposed subjects, while in non-exposed subject's 3.7±2.1 µg/dL. The results showed that occupational exposure increases the blood level of lead, implicating hematological variables and elevating specific hepato-renal indices which consequently increase the health risk of occupationally exposed individuals. Therefore, taking note of other body burdens, the synergistic adoption of these indicative biomarker tests could be used to give an implicative assessment on lead exposure and toxicity.

Keywords: Biomarkers; Lead exposure; Hepatorenal; Occupationally exposed; Hematological parameters

1. Introduction

Lead is a ubiquitous environmental pollutant that has been detected in almost all phases of biological systems [1][2]. Even trace amounts of lead are harmful to humans and other organisms as they induce a broad range of physiological, biochemical and behavioral dysfunctions in many parts of the body, including the central and peripheral nervous systems, hematopoietic system, cardiovascular system, kidneys, liver and reproductive systems [2][3][27]. As a result, a safe level of lead exposure has not yet been defined [3]. Occupations mostly associated with disturbing levels of lead exposure include battery manufacturing and recycling, lead smelting and foundries, radiator manufacturing and repair,, petrol/gasoline dispensation in filling stations, scrap metal handling, spray painting etc. [16]. Lead can be absorbed into the human body through inhalation of lead dust or through ingestion from tobacco and contaminated food or drinks [17]. It has been proposed that the main mechanism involved in lead toxicity is the induction of oxidative stress. It is believed that lead is able to generate reactive oxygen species and alter the function of antioxidant defense system components, including antioxidant enzymes. Occupational lead poisoning has been a main source of lead toxicity, characterized by symptomatic features including anemia, colic, neuropathy, nephropathy, sterility and coma [18][27]. The environment is continuously fluxed with foreign chemical substances, released by anthropogenic events such as:

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industrial wastes, agricultural activities, mining operations, petrol attendants, automobile mechanics, welding, spray painting, battery charging and recycling etc. continue to make lead an issue to public health [6]. The Centre for Disease Control (CDC) currently considers lead poisoning the foremost environmental health threat to children in the United States [1][7].

Biomarkers are indicator-signaling events in biological systems or samples (body fluids, cells or tissues) [12]. They could be used to evaluate exposure and predict the toxicity of foreign components in the biological setup [4]. The usefulness of biomarkers in identifying a postulated adverse health effect is intrinsically related to their role within the mode of action of the toxicant [8].

Aim

The aim of this study was to investigate the association between lead exposure and specific biomarkers used in monitoring lead levels in some occupationally exposed individuals (such as fuel attendants, auto mechanics, generator mechanics, artisanal miners, battery chargers and spray painters) and comparing the values with unexposed individuals in Gurara and Suleja areas in Niger state, Nigeria.

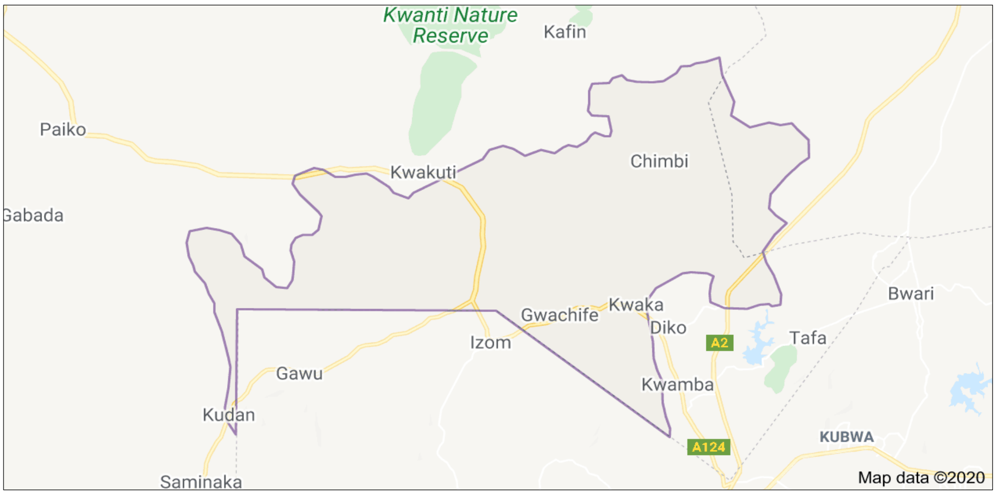
Objectives

- Determining the blood lead levels in occupationally exposed and unexposed individuals in the study area.
- Analysis of the hematological indices in the blood samples of occupationally exposed and unexposed individuals in the study area.
- Assessment of some biochemical parameters in occupationally exposed and unexposed individuals in the study area.
- Making relevant recommendations going forward.

2. Materials and methods

2.1. Study area

The study was carried out in Gurara and Suleja in Niger state.



(Source: Google/Web/Flickr)

Figure 1 Map of Gurara LGA

Gurara Local Government Area in Niger State, Nigeria, with a geographical coordinate at 9°21′N 7°05′E. Major inhabitants are the Gwari people engaging in farming and artisanal mining. It has an area of 954 km^2 and a population of 127,700 [16].

Suleja is a city in Niger state, Nigeria, with an area of 114.6 km^2 and a population of 260,240 [16]. Situated just north of Abuja, with a geographical coordinate at longitude 7°10'45.80"E and latitude 9°10'50.12"N. The chief occupation of the inhabitants is farming, with most engaging in local trade such as gbari pottery, cotton weaving and dyeing, with locally grown indigo and mat making as traditional activities.

(Source: Google/Web/Flickr)

Figure 2 Map of Suleja LGA

2.2. Study design and sample

This study employed a cross-sectional approach. The study sample consisted of 116 total subjects; 72 occupationally exposed and 44 unexposed individuals (control). The occupationally exposed subjects, consisting of automobile mechanics, generator mechanics, petrol dispensing attendants in filling stations, artisanal gold-miners, battery chargers and spray painters, volunteered to participate in this study. These occupations are among those likely to expose individuals to lead toxicity [2][5]. Workers on part-time duties and those who spent less than six months on the job were excluded from this study. The 44 unexposed (and mostly non-smoking) subjects were residents and students randomly selected from satellite towns and campuses around the study area. The age range of the subjects was between 17 to 50 years. A self-developed, semi-structured questionnaire, consisting of 20 questions for the exposed and 15 for the non-exposed were administered during a personal interview with the subjects. The additional five questions for the exposed were to determine their occupational exposure to lead. Participants were assured of the anonymity of their identity and responses. Before administering the questionnaire, respondents were interviewed to assess the validity, clarity and relevance of the test.

2.3. Blood collection and storage

A total of 10 mL venous blood sample was collected from each participant. 5 mL were collected via venipuncture into labeled potassium ethylene diamine tetra-acetic acid (K-EDTA) tubes certified for determination of metals in blood and hematological procedures [4]; 5 mL was dispensed into sealed plain tubes with no anticoagulant; suitable for serum electrolytes analysis and lithium heparin containers was used for collection of samples for serum urea, creatinine and uric acid investigations [4][5].

The labeled tubes containing the blood samples were immediately placed in ice pack at the site of blood collection and transferred into a refrigerator at 4 °C [8]. To avoid external contamination of the blood sample, the skin at the site of the venipuncture was thoroughly swabbed with methylated spirit and cleaned with dry cotton wool to remove any external traces of lead that may have been present on the subject's skin.

2.4. Ethical clearance

Informed consent was obtained from all participants in this study and ethical approval was obtained from the Ethical Committee of General Hospital Suleja, Niger State.

2.5. Analysis of blood samples for lead

Blood lead levels were determined using atomic absorption spectrometry (AAS) as described by the method [18]. One mL of 5% triton x-100 was added to 5 mL well mixed EDTA blood to lyse the erythrocytes and release lead [4]. Mixing the content of the tube in a vortex mixer enhanced rapid haemolysis. One mL of 2% ammonium pyrrolidine dithiocarbamate solution was added to chelate the lead. The solution was then extracted with 5 mL methyl-isobutyl ketone and the organic supernatant separated into screw-capped specimen containers and analysed in a Perkin-Elmer 703 Atomic Absorption Spectrophotometer at a wavelength of 283.3 nm.

2.6. Determination of Electrolytes, Urea and Creatinine

Serum levels of sodium and potassium were determined using the M508/UV-VIS spectrophotometer, at 630 nm and 578 nm respectively, adopting the methods [19].

Chloride and bicarbonate were determined by at 492 nm and 340 nm wavelengths respectively, adopting titrimetric method [19].

Urea and creatinine levels in blood were spectrophotometerically determined by measuring their absorbances at 340 nm and 492 nm wavelengths respectively, following the methods [17] and [18] respectively.

Uric acid was determined by the method of Fujihara et al. (1987) [19]. This method is similar to the method proposed by [18] at 546 nm using an RA-50 spectrophotometer (Ames/Technicon, France).

For Bilirubin, methods [19] as adopted. Where mixtures were incubated accordingly at room temperature in the absence of light and absorbances read at 546 nm using a RA-50 spectrophotometer (Ames/Technicon, France).

Alkaline phosphatase activity was determined by the method of Bessey, Lowry and Brook (1946) [18]. Absorbance was read at 405 nm using a RA-50 spectrophotometer (Ames/Technicon, France).

The activities of ALT and AST were determined by the method of Reitman and Frankel (1957) [19]. Read at 505 nm using a RA-50 spectrophotometer (Ames/Technicon, France).

Hematologic parameters of complete blood count (CBC) were analyzed by DIATRON Abacus 380 Hematology Analyzer (Diatron-A380, Hungary). Mean corpuscular volume (MCV), Hemoglobin (Hb), red cell distribution width (RDW) and reticulocyte counts with basophilic stippling were determined by the method [19].

3. Results

Table 1 Demographic characteristics of study subjects

Characteristics	Exposed individuals	Unexposed individuals (control)
Sex		
Male	64	30
Female	8	14
Total	72	44
Age		
17–24	12	13
25–35	19	11
36–50	41	20
Occupation		
Automobile mechanics	34	-
Petrol attendants	12	-
Artisanal miners	17	-
Battery chargers	10	-
Spray painters	9	-

Table 2 Mean blood lead (BPb) levels in subjects occupationally exposed and unexposed subjects

Group	Blood Pb (µg/dL)
Exposed subjects	26.8±5.4*
Unexposed subjects	3.7±2.1*

All values are means ± SDs, *= statistically significant at $p < 0.05$.

Table 3 Mean serum urea, electrolytes, creatinine, and uric acid levels in subjects occupationally exposed to lead and in unexposed subjects

Group	Urea (mmol/L)	Sodium (mEq/L)	Potassium (mmol/L)	Chloride (mmol/L)	Creatinine (mg/dL)	Uric acid (mg/dL)
Exposed subjects	8.1±1.6*	163±32*	6.1±1.3*	106.4±18	0.9±0.3	9.6±1.3*
Unexposed subjects	4.6±0.6*	138±17*	4.5±0.9*	110.5±21	1.1±0.6	3.2±0.9*

*Statistically significant P-value.

Table 4 Mean blood hematological parameters in subjects occupationally exposed and unexposed subjects

Group	MCV (fL)	Hb (g/dL)	RDW (%)	Reticulocytes (%)
Exposed subjects	76.2 ± 5.4*	9.8±1.1*	17.8±1.2*	5.7±0.1*
Unexposed subjects	75.7±2.1*	13.0±1.9*	12.8±1.0*	2.3±0.2*

*Statistically significant P-value.

4. Discussion

Among the seventy-two occupationally exposed individuals with a minimum of one year experience on their current jobs and forty-four non-occupationally exposed individuals that were recruited for this research, this study established a significant difference in the mean blood lead level (BLL) between the occupationally exposed and non-exposed subjects in this study. Hematological indices and hepato-renal parameters in occupationally exposed group were also implicated and with a positive association with reports by [5][6][8][9][10].

The mean BLL in the occupationally exposed group (26.8±5.4 µg/dL) was significantly higher than the blood lead concentration in non-exposed individuals (3.7±2.1 µg/dL). This result is lower than 48.5±9.08 µg/dL recorded for occupationally exposed workers in Abeokuta, Nigeria [6], and 45.43±6.93µg/dL as reported in occupationally exposed persons in Gwagwalada, Abuja, Nigeria [22]. However, the finding is consistent with reports from other studies reporting higher mean BLL in occupationally exposed populations compared to controls of 50.4±24.6µg/dL vs 41.4±26.9 µg/dL [2], 46.0±0.2µg/dL vs 31.0±0.1 µg/dL [6], 48.1±9.1 µg/dL vs 33.7±10.1 µg/L [6]. It is however higher than the mean blood lead level of 12.3 µg/dL reported [21] for the male population in Ibadan, Nigeria. It is also higher than 18.1 µg/dL±6.4 and 10.2 µg/dL±2.7 reported by [21] for occupationally exposed traffic wardens in Lagos and Ife, Nigeria, respectively. Taking into consideration the fact that these occupations are continuously exposing the workers to lead, threatening blood lead levels were seen to show a strong association with one disease condition or the other as obtained with indicative biomarkers analyzed. For instance, leaded gasoline for vehicles in Nigeria [20][21] may contribute to the relatively high blood level of lead among automobile mechanics and fuel attendants when compared to other groups in this study. Unsafe techniques and work habits observed among the auto mechanics, involving sucking of petrol/gasoline with the mouth while working, could also contribute significantly to the level of lead observed in their blood. The high blood lead levels observed in the non-occupationally exposed in this study and in several other studies [12][13][20][22][23]are indicative of the extent of environmental lead pollution in Nigeria. This is of serious concern as it implies that many Nigerians are exposed to lead from the environment irrespective of their occupation [24]. The slightly elevated BLLs observed in the non-occupationally exposed in this study and in several other studies [12][20][22][26] are indicative of the extent of environmental lead pollution in Nigeria. This is of serious concern as it implies that many Nigerians are exposed to lead from the environment irrespective of their occupation [24]. The average lead value for the exposed subjects in this study was higher than the WHO permissible range of less than 10 μg/dL of lead in adults, and fall within the normal range in the non-exposed group. While no safe blood lead threshold has been identified for children [7][25]

Recommendations

- The regular use of protective face masks by workers while on duty to prevent inhalation of lead fumes.
- Routine hematological tests (CBC) should be advised for industrial workers associated with lead exposure, this may be helpful for screening subclinical lead exposure.
- Also, occupationally exposed workers should wash their hands and face before eating at the workplace, shower at work before going home and avoid wearing work clothes in their homes.

5. Conclusion

The study established a corroboration between the significantly high BLL, hepatorenal indices and a corresponding impaired hematological parameters among occupationally exposed workers. Taking other body burdens into cognizance, the synergistic profile of the biomarker tests could be used to give a precise and implicative assessment on lead exposure and toxicity.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interests regarding the study and findings of this research paper.

Statement of informed consent

Informed consent was read to, signed and obtained from all participants in this study and ethical approval was obtained from the Ethical Committee of General Hospital Suleja, Niger State.

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