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Markers of Neurotoxicity: Relating the Serum Levels of Mercury, Lead and Arsenic to Quality of Life of Panel Beaters in Enugu, Nigeria

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Abstract**—** *Nigeria's life expectancy, 54.33 years, is one of the lowest globally. This is made worse by occupational hazards, especially exposure to markers of neurotoxicity, which are most common heavy metals that can be harmful to the body, including aluminum, cadmium, arsenic, lead, and mercury contained in large amount in panel beating facilities, predisposing the artisans to heavy metal toxicity. The short communication reports on the work in progress which aimed to relate serum levels to quality of life of panel beaters who are more prone to the exposure to mercury, lead and arsenic in Enugu, Nigeria. Subsequent report on the field work will carry results, discussion, implications for development, conclusion and recommendations.*

Keywords**— Heavy metal neurotoxicity, Environmental health, Occupational hazards.**

I. INTRODUCTION

At 54.33 years, Nigeria has a low figure for life expectancy among the comity of nations. Concern for heavy metals contamination is on the increase because exposure to heavy metals has risen dramatically, leading to early deaths. Each day, humans are exposed to some kind of toxins through the air, water or food and occupational hazards. Markers of neurotoxicity include most common heavy metals that can be harmful to the body are aluminum, cadmium, arsenic, lead, and mercury which are in large amount, with the last three contributing to the most cases of heavy metal toxicity (*www.SixWise.com*, 2009). Heavy metals such as metalloid, e.g arsenic, lead, copper, and others, are widely utilized to sustain the living standards of the modern world and they are able to induce toxicity at low level of exposure (Duffus, 2002; Arif et al, 2015).

Most of the environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds (Goye, 2001; He et al, 2005). Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metallic ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and ground water (Niragu, 1989). Natural phenomena, such as weathering and volcanic eruptions, have also been reported to significantly contribute to heavy metal pollution (He et al, 2005). Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high-tension lines, plastics, textiles, micro-electronics, wood preservation and paper processing plants (Pacyna, 1996).

Anthropogenic activities often introduce antigenes, contaminants and pollutants into organism in home and work environments. Certain occupations are at higher risk for heavy metal exposure. These include dental professionals, laboratory workers, hairdressers, painters, printers, welders, metalworkers, cosmetic workers, battery makers, engravers, photographers, visual artists and potters. Heavy metals can accumulate in the body over time, causing symptoms that might not be associated with heavy metals symptoms. Often, it can be misdiagnosed for chronic conditions, such as autism, chronic fatigue syndrome, depression and multiple sclerosis. Specifically, symptoms of metal toxicity poisoning are chronic pain throughout the muscles and tendons or any soft tissues of the body, chronic malaise, brain fog, chronic infections such as candida, gastrointestinal complaints such as diarrhoea, constipation, bloating, gas, heartburn, and indigestion, food allergies, dizziness, migraines and/or headaches, visual disturbances, mood swings, depression, and/or anxiety, nervous system malfunctions; burning extremities, numbness, tingling, paralysis, and/or an electrifying feeling throughout the body (*www.SixWise.com*, 2009).

Contamination of dietary substances by chemicals and non-essentials elements such as heavy metal is known to have series of adverse effects in the body of humans and animals (D'Souza & Peretiatko, 2002). Their entry into the human systems poses a great treat to the human populations. Metals can escape control mechanisms such as homeostasis, transport, compartmentalization, and binding to specified cell constituents. Thus, they can have toxic and even lethal effects in the body. Heavy metals can cause malfunctioning of the cellular processes via displacement of essential metals from their respective sites. Also, oxidative deterioration of biological macromolecules has been found to be primarily due to binding of metals to DNA and nuclear proteins (Flora et al, 2008).

Although the toxic effects of metals depend on the forms and routes of exposure, interruptions of intracellular homeostasis include damage to lipids, proteins, enzymes and DNA via the production of free radicals. Following exposure to heavy metals, their metabolism and subsequent excretion from the body depends on the presence of antioxidants (glutathione, tocopherol, ascorbate, etc.) associated with the quenching of free radicals by suspending the activity of enzymes (catalase, peroxidase, and superoxide dismutase) (Agency for Toxic Substances and Disease Registry, 2000).

Arsenic (As) is a ubiquitous element that is detected at low concentrations in virtually all environmental matrices. The major inorganic forms of arsenic include the trivalent arsenite and the pentavalent arsenate. The organic forms are the methylated metabolites; monomethylarsenic acid (MMA), dimethylarsenic acid (DMA) and trimethylarsenic oxide (Agency for Toxic Substances and Disease Registry, 2000).

Abnormal blood arsenic concentrations (>12 µg/mL) indicates significant exposure. Absorbed arsenic is rapidly distributed into tissue storage sites with a blood half-life of less than 6 hours, unless a blood specimen is drawn within 2 days of exposure (Mayo Foundation for Medical Education, 2018; Chappell et al, 1997).

Reports on epidemiological studies show a strong association between arsenic exposure and increased risks of both carcinogenic and systemic health effects. Arsenic exposure affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobilliary, renal, gastro-intestinal, and respiratory systems. Research has also pointed to significantly higher standardized mortality rates for cancers of the bladder, kidney, skin, and liver in many areas of arsenic pollution. The severity of adverse health effects is related to the chemical form of arsenic and is also time- and dose-dependent (Tchounwou et al, 2003; Yedjou et al, 2006). Arsenic-based additive is used in chicken feed to promote growth, kill parasites and improve pigmentation of chicken meat. Eating commercial, non-organic chicken predisposes one to arsenic poisoning. Some other sources of arsenic poisoning include paints, rat poison, fungicides, and wood preservatives. Arsenic targets specific organs such as the blood, kidneys, central nervous system and skin systems (Agency for Toxic Substances and Disease Registry, 1992).

Mercury (Hg) is a heavy metal belonging to the transition elements. It is found in nature in elemental, inorganic, and organic forms, each exhibiting its own profile of toxicity (Sarkar, 2005). The normal whole blood mercury is usually less than 10 µg/mL. Significant exposure is indicated when the whole blood mercury level exceeds 50 µg/mL, if exposure is due to alkyl Hg, or above 200 µg/mL, if exposure is due to Hg^{2+} (Bjorkman et al., 2007). Mercury is a pollutant ubiquitous in the environment. Each year, perhaps 300,000 U.S. children are born who were exposed *in utero* to blood levels of methylmercury that are above levels thought to be safe (Clarkson et al, 2003; Mahaffey et al, 2004).

Studies on Korean adults report that mercury levels are associated with various combinations of higher fasting glucose levels, obesity, body mass index (BMI), waist circumference, higher blood pressure, insulin resistance, or higher total cholesterol or triglyceride levels. In sum,

mercury was associated with metabolic syndrome (Bjorkman et al, 2006; You et al, 2011; Eom et al, 2014; Seo et al, 2014; Chung et al, 2015; Kim et al, 2015; Bae et al, 2016; Park et al, 2016a; Park and Seo, 2016; Lee, 2017).

Lead is a naturally occurring bluish-gray metal present in small amounts in the earth's crust. Although lead occurs naturally in the environment, anthropogenic activities such as fossil fuels burning, mining, and manufacturing contribute to the release of high concentrations. Lead has many different industrial, agricultural and domestic application (Gabby, 2006). Lead poisoning refers to the health effects associated with an abnormally high level of lead in the blood stream. Exposure to lead occurs mainly via inhalation of lead-contaminated dust particles or aerosols and ingestion of lead-contaminated food, water, and paints (Agency for Toxic Substances and Disease Registry, 1992; Flora et al, 2006).

Lead is the most systemic toxicant that affects several organs in the body including the kidneys, liver, central nervous system, hematopoietic system, endocrine system, and reproductive system (Agency for Toxic Substances and Disease Registry, 1992). Lead exposure usually results from lead in deteriorating household paints, lead in the work place, lead in crystals and ceramic containers that leaches into water and food, lead use in hobbies, and lead use in some traditional medicines and cosmetics (Apostoli et al, 1998; Centers for Disease Control, 1991).

About 5µg/dL is the blood lead level of concern. Lead kills red blood cells through oxygen deprivation. It also reduces the ability to generate new red blood cells, resulting in anemia. It can cause high blood pressure which increases the risk of heart attack, stroke, and kidney disease (Farfel et al, 1991; Weatherization Assistance Program Standardized Curriculum, 2012).

According to Picciotto (2000), the main adverse effects of lead in adult population with high lead exposure include reproductive effects, such as decreased sperm count in men and spontaneous abortions in women. Chronic exposure may cause adverse effects on the blood, central nervous system, blood pressure, kidneys, and vitamin D metabolism (United States Environmental Protection Agency, 2002). The levels of malondialdehyde (MDA) in blood strongly correlate with lead concentration in the blood of exposed workers (Jiun & Hseien, 1994).

Therefore, there is the need to assess the serum levels of selected heavy metals among panel beaters in Enugu metropolis in relation to their quality of life (QOL) reflected by various symptoms of toxicity poisoning by the metals. There is paucity of academic reports relating serum levels to quality of life of panel beaters exposed to mercury, lead and arsenic materials in Africa, especially Nigeria. This study is an assessment of the relationship between serum levels and quality of life of panel beaters who are more prone to the exposure to mercury, lead and arsenic in Enugu metropolis, Enugu State, Southeast of Nigeria.

The specific objectives of the study are to ascertain the serum level of mercury, lead and arsenic among panel beaters in Enugu metropolis; quality of life (QOL) reflected in prevalence of pain among panel beaters in Enugu metropolis; and relationship between exposure to the selected metals and the QOL. The findings of this study will enlighten some artisans and the public on the health effects of markers of neurotoxicity on artisans. They will also expose the need for health professionals to engage studies on holistic health assessments of artisans in relation to occupational hazards, in order to minimize early death in a country with life expectancy at birth of 54.33 years in 2018.

II. MATERIALS AND METHODS

The study adopted the cross-sectional survey design. Convenience sampling technique was adopted based on the number of subjects available at the time of survey, met participation criteria and were willing to participate. Study population consisted of all panel beaters working and residing in Enugu metropolis, Enugu State, South-east, Nigeria. Power analysis was done using NCCS PASS 15 to determine the minimum sample size. The study was set at power (β) of 0.9, α of 0.150. Sample size obtained at second degree of freedom (df) of 2 was 60, 20, in each group. A sample size of 50 was obtained, but was increased to 100 to allow for generalization of results.

An ethical approval was obtained from the Health Research and Ethical Review Committee of a University Teaching Hospital (tertiary health institution and referral centre) that covers the area or research. The purpose and procedure of the study were explained to prospective the participant and the informed consents for both participation in the study and publishing the results with anonymity were obtained.

Selection criteria consisted of inclusion criteria and exclusion criteria. Only panel beaters in Enugu metropolis from 18 years upwards, who had worked for at least six months, were included in the study. Subjects excluded were those suffering from trauma, fracture, arthritis, neurological conditions, hypertension, cardiac problems and respiratory diseases, such as asthma.

Questionnaire used consisted of World Health Organization Quality of Life and Nordic questionnaire for

pain. The procedure for the study was explained to the subjects from whom informed consent was also sought. Two (2) questionnaires, WHO quality of life and Nordic questionnaire for pain, were given to the participants to complete. WHO questionnaire for quality of life was either self-administered by subjects who had the ability or desire to do so or administered by the researcher. It consisted of 26 questions which were explained to subjects for clarity. Nordic questionnaire for pain consisted of demographic part and other sections like pain intensity rating scale, anthropometric part, and the part for treatment intervention for pain. After completion of the questionnaire, the instrument was retrieved immediately.

The height of the participant was obtained using stadiometer (calibrated in centimeter) placed on flat surface and the bare-footed subject standing in the platform in an upright position with the heel in contact with the vertical bar of the instrument for a reading recorded immediately. Bathroom weighing scale (Hana Model) calibrated in kilogramme was used for weight measurement. The bare-footed participant stepped on the weighing scale, standing straight and looking straight at an eye level, for a reading taken immediately. For cardiovascular parameters, an automatic sphygmomanometer was used to obtain the systolic and diastolic blood pressure as well as the pulse rate. The subject was asked to stay quiet, calm and rest for five (5) minutes before the blood pressure measurement was taken. The cuff was fitted comfortably and strongly around the left bare arm 1-2 cm above the elbow joint of the seated subject with the palm supinated in front on a flat surface (desk) (WHO, 2000). A Teaching Hospital (tertiary health institution) supplied the fresh and sterile needles, syringes, blood sample bottles, cotton wool and methylated spirit imported from recognized pharmaceutical manufacturing companies in Asia, which were considered trace elements-free and used by a phlebotomists (staff of the Teaching Hospital) to collect the blood samples, who also gave a sample bottle to each subject to supply early morning urine, with an instruction to store the sample in the fridge between collection and delivery to the laboratory. The samples were analyzed by a Medical Laboratory Scientist working in the Medical Diagnostic Laboratory Unit of the Teaching Hospital for serum levels of mercury (Hg), lead (Pb) and arsenic (As) (independent variables) and the quality of life as determined by some symptoms (dependent variables) of the target artisans.

The data were subjected to descriptive statistics and analyzed using paired and unpaired sample t-test. Pearson correlation was used to determine the relationship between the variables. A probability value of 0.05 was considered statistically significant. Analysis was performed using Statistical Package for Social Sciences (SPSS) Version 20.0 for windows evaluation.

2.1 Quantitative determination of mercury (Hg)

Absorption spectrometry (dithizone colorimetry), neutron activation analysis or cold vapor atomic absorption spectrometry of the Environmental Protection Agency (EPA) of the United States of America (USA) Method – 200_13 – Trace element determination via Atomic Absorption Graphite Furnace Spectrometer using Buck Scientific Atomic Absorption Spectrophotometer (GFAAS, made in USA) was used to determine the total mercury (Bakırdere *et al*, 2013).

2.2 Quantitative determination of arsenic (As) and lead (Pb)

Arsenic and lead were determined by Environmental Protection Agency (EPA) of the United States of America (USA) Method – 200_13 – Trace element determination via Atomic Absorption Graphite Furnace Spectrometer using Buck Scientific Atomic Absorption Spectrophotometer (GFAAS, made in USA). Pd-Mg mixture was served as the matrix modifier for As, while Ni was used as matrix modifier for Pb and Cd (Bakırdere *et al*, 2013).

III. RESULTS, DISCUSSION, IMPLICATIONS FOR DEVELOPMENT, CONCLUSION AND RECOMMENDATIONS

This report is the short communication on the work in progress. The results, discussion, implications for development, conclusion and recommendations of the study will be presented in the full report to be published shortly.

ETHICAL APPROVAL

The Health Research and Ethical Review Committee of a tertiary health institution approved the study.

CONSENT TO PARTICIPATE AND FOR PUBLISHING

All subjects gave informed consent to participate in the study and for academic publishing of the results of the study with anonymity.

AVAILABILITY OF MATERIAL AND DATA

Materials and data embedded in this work are transparently available.

CODE AVAILABILITY

Materials and data are in Microsoft Word with custom code.

AUTHORS' CONTRIBUTIONS

Formal analysis and write-up – O.C. Eneh. Methodology and data curation – C.I. Ezema. Laboratory investigation – E.C. Ogbaronya. Project supervision and administration – C.K. Nwafulume.

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