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ABSTRACT

The accumulation of Lead (Pb), Cadmium (Cd) and Chromium (Cr) in artisan electronic repair technicians, auto-mechanics and painters from Kaduna and Bauchi Metropolis Nigeria, was investigated. Hair and Nail samples of the artisans were tested for the selected metals using AAS. All artisans had Pb, Cd and Cr levels in both hair and nail samples within a range of 31.61 – 228.00, 0.09 -270.00 and 7.95-317.00 µg/g respectively. All three categories of artisans had the metal levels greater than that of the control subjects. The results indicate the bioaccumulation of Pb, Cd and Cr in the three categories of artisans. Electronic repair technicians (0.09 – 50.39 µg/g) had the lowest bioaccumulation levels of the metals than auto-mechanics and painters indicating a greater exposure to Pb, Cd and Cr by auto-mechanics and painters (0.00 – 317.00 µg/g) probably due to increased tendency of exposure via both ingestion and inhalation.

Keywords: Lead, Cadmium, Chromium, Auto-mechanics, Artisans

1.0 INTRODUCTION

Occupation comes only second to food as an important route of exposure of adults to harmful substances (Landrigan, 1982). Hazards in various occupations could range from physical, chemical, radioactive to psychological hazards. The kinds of hazards faced by workers around the world in their work places are pretty similar despite differences in physical, economic, social and political environments. However, most workers in developing countries disproportionately share in the global burden of occupational injuries. Several classical diseases such as silicosis, lead poisoning that have been greatly faced out of developed societies still remain persistent and widely reported in developing countries (Rosenstock *et al.*, 2006). A large

percentage of workers in developing countries are artisans usually with little or no formal education. This usually translates into low awareness about the hazards in their various occupations and hence laxity with the use of safety devices and implementation of safe practices. Lack of governmental interest in occupational health, poor data and data collection systems, and weak enforcement of health and safety regulations has greatly contributed to this problem in developing countries (Asuzu, 1996, Joubert, 2002, Ahasan, 1999 and Yingratanasuk *et al.*, 1998). Inability by any country or organization to provide occupational health and safety services to all categories of workers is in contravention to the

International Labour Organization (ILO) convention 161 and recommendation 171 of 1985, which requires that occupational health and safety (OHS) services should be developed for workers in all branches of economic activities and all undertakings. The availability of occupational health and services will protect workers from the effects of occupational hazards prevalent in almost all occupations. Arguably, the first step towards remedying this problem in developing countries is acquiring realistic data and a clear picture of the situation on ground, and that drive prompted this research.

Nigerian artisanal fisheries have been reported to have one of the highest occupational fatality rate; estimated to be between 999 and 3,329 per 100,000 fishermen (Udolis *et al.*, 2013). Arc eye injuries, back/waist pain, metal fume fever and cuts have been reported to be common among welder in Benin City, Edo-Nigeria largely due to lack of use of protective devices (Isah and Okojie, 2006). Low awareness, poor safety measures and the perceived influence of health education among factory workers and sawmill workers (Bankole and Ibrahim, 2012 and Osagbemi *et al.*, 2010), nurses (Amosu *et al.*, 2011) and welders in Kaduna State (Sabit *et al.*, 2009) have also been reported.

The aim of the current work was to assess the accumulation of Pb, Cd and Cr (chemical hazard) in electronic repair technicians, auto-mechanics and painters in Kaduna and Bauchi Nigeria.

2.0 MATERIALS AND METHODS

A total of nineteen volunteer artisan workers and two control subjects participated in the pilot study; nine electronic repair technicians from Kaduna Metropolis, five auto-mechanics and painters each from Bauchi metropolis and one control each from both towns. Subjects 1 to 9 are electronic repair technicians while subject

10 is the control subject for the repair technicians. Subjects 11-15 are auto-mechanics and 16-20 are painters while 21 is the control for both auto-mechanics and painters. The control subjects were carefully selected to match the volunteer artisans but differ only in terms of occupation. Sampling was carried out according to standard procedure as reported by Memon, A-R *et al.*, (2007) and Olmedo *et al.*, (2010). Hair samples, as close as possible to the scalp were collected using a stainless scissors and stored in clean polythene bags with identity numbers for further treatment. Nail samples were cut using a sterilised stainless scissors and sealed in plastic bags with identity numbers prior to analysis. The personal, medical history and general information of the subjects were obtained through a questionnaire filled by the subjects. The questionnaire is a modified version of the WHO health assessment questionnaire (WHO and UNEP, 2008); modified to suite the problem at hand.

200 mg of the hair samples was washed as described by Afridi *et al* (2010). The hair specimens were cut into 0.2 to 0.3cm pieces and washed four times with a 1:200 v/v dilution of triton X-100, then rinsed three times with distilled water and two times with acetone. The samples were then be dried in an oven at 75-85°C. The washed hair samples were digested as described by Memon *et al.* (2007).

Collected nail samples were washed using Gammelgaard's method (Gammelgaard *et al*, 1991); the nail samples were washed thoroughly stirring with different solvents in sequence: acetone, deionized water and 0.5% Triton X-100 solution. The nail samples were then dried in an oven at 110°C for about 30 minutes. The dried nail samples were digested with 10 cm³ of 6:1 mixture of concentrated nitric and perchloric acid and kept overnight at room temperature to prevent excessive foaming and subsequently

heated at 160-180°C until the mixture was clear and less than 1 cm³ of the solution was remain. Each sample solution was then diluted with 0.1 M nitric acid (Mehra and Juneja, 2005).

The concentrations of the metals were determined using Varian AA240FS Fast Sequential Atomic Absorption Spectrometer.

2.1 Quality Assurance Procedure

Validation of the digestion method of analysis used and certification of the instrument as good enough for the analysis was done by carrying out a recovery experiment. This was done by spiking the predigested nail and hair samples with 10cm³ of multi-element metal standard solution (MESS) (20 ppm of Pb, Cd and Cr).

3.0 RESULTS AND DISCUSSION

The percentage recoveries of the metals in the nail and hair samples were between 95.27 and 99.07 % (Table 1). Pb metal had the highest percent recovery in all samples, the trend of the percent recoveries of the metals in the nail samples was generally Pb>Cr>Cd while it was observed to be Pb>Cd>Cr in the hair sample. The percent recoveries are consistent with similar results reported for spiked samples as a means of quality assurance. A range of 93.6 to 107.8% was reported for Pb, Cd and Cr in hair sample (Olmedo et al., 2010), 97.5-99.7% (Afridi et al., 2012). Hence, the method of digestion and the instrument of analysis can be said to be suitable for the analysis.

3.1 Electronic Repair Technicians

Pb was highest in both nail and hair samples of the electronic repair technicians (Figure 1 & 2). The trend of the concentrations of the three metals can be generally represented as Pb>Cr>>Cd. The mean Pb concentration in the nail samples was 37.13 ± 4.08 µg/g, with the lowest observed value of 31.61 µg/g (subject 10) and maximum of 44.12 µg/g (subject 4). The mean Pb concentration in

the hair samples was 39.41 ± 5.63 µg/g, with the least and highest values in subjects 10 and 4 respectively (33.26 and 50.39 µg/g). The mean values of Pb (and indeed all values for the repair technicians) in both nail and hair were higher than that of the control (22.59 µg/g and 22.05 µg/g), an indication that the electronic technicians are occupationally exposed to Pb metal. The result is in agreement with the reported value of Pb by Abdulrahman *et al.*, (2012) in fingernails of welders of 0.78 to 30.44 µg/g. Nail-Pb is considered to reflect long-term exposure because this compartment remains isolated from other metabolic activities in the body (Takagi *et al.*, 1988).

The mean Cd concentrations in the electronic repair technicians were 1.00 ± 1.21 µg/g (nail) and 1.09 ± 1.14 µg/g (hair) while the mean Cr concentration was 18.49 ± 12.71 µg/g (nail) and 19.13 ± 11.61 µg/g (hair). Similarly, all Cd and Cr values were higher in the repair technicians than the control except subject 8 who had a lower Cd concentration in the hair sample. Similar values were reported for welders (Abdulrahman *et al.* 2012) and in occupationally exposed subjects in India (Mehra and Juneja, 2004).

The peak value of Pb in the nail samples observed in subject 4 where as peak values of Cd and Cr were observed in subject 3 could be attributed to the slightly longer duration in the job of subject 4 (22 years) over subject 3 (20 years), thereby implying a greater accumulation of Pb in subject 4. The peak values of Cd and Cr in subject 3 is likely due to the smoking habit of the subject as gathered from the questionnaire issued.

Correlation coefficients of the metal pairs in the nail and hair samples show a significant positive correlation between Pb/Cd ($r=0.7756$ & 0.9579), positive correlations were also observed for Pb/Cr pair ($r= 0.8510$ & 0.8974) and Cd/Cr ($r= 0.9540$ & 0.9238)

at $P < 0.01$ respectively. These high positive correlation values indicate the metals are

very likely also from the same pollution source.

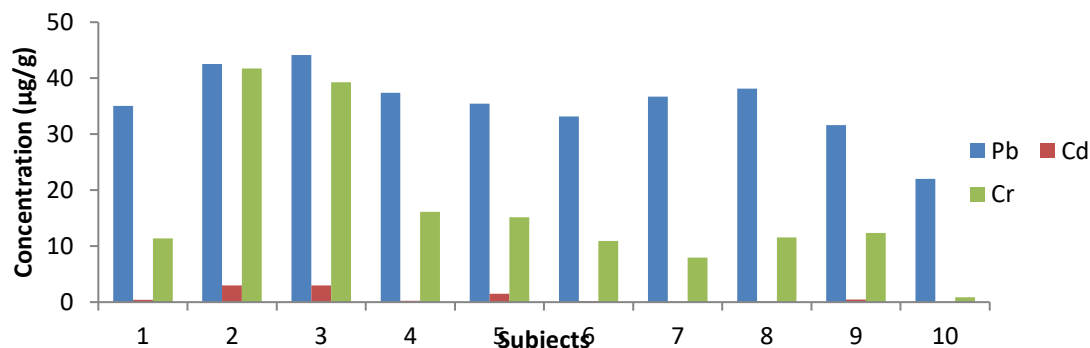


Figure 1: The Concentrations of Pb, Cd & Cr in Nail Samples of Electronic Repair Technicians

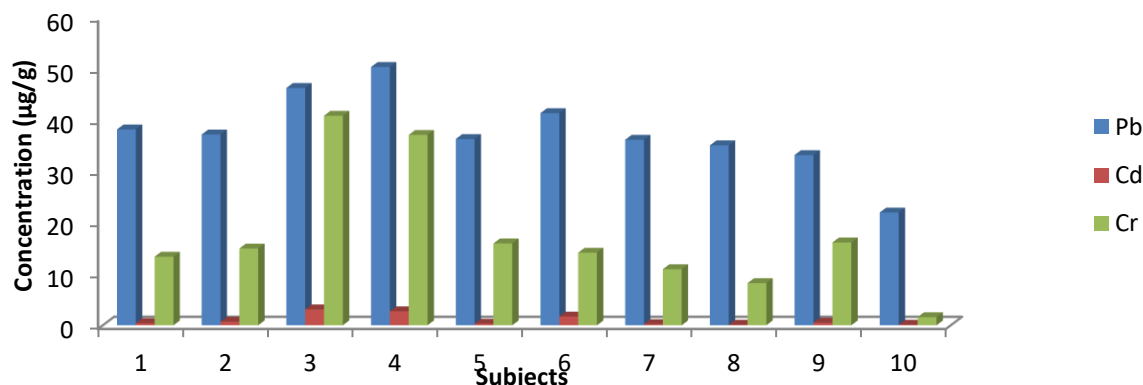


Figure 2: Concentrations of Pb, Cd & Cr in Hair Samples of Electronic Repair Technicians

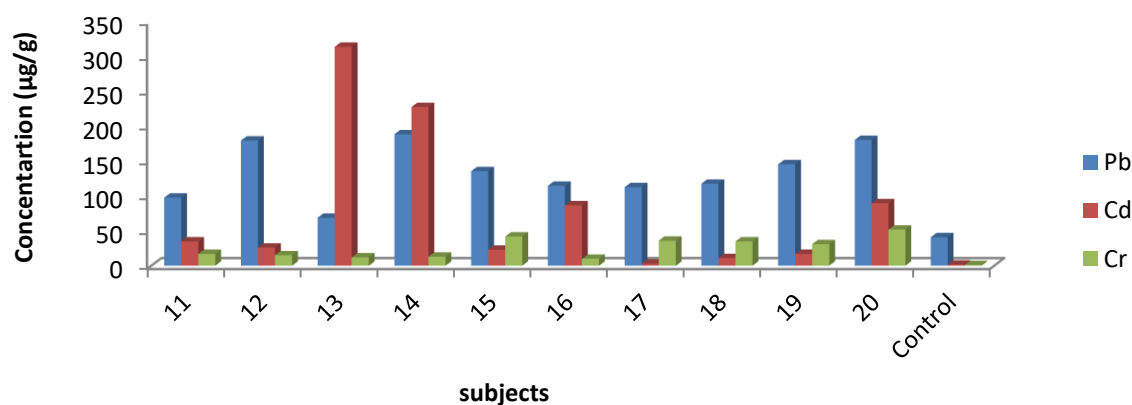


Figure 3: Concentrations of Pb, Cd & Cr in Hair Samples of Auto-mechanics and Painters

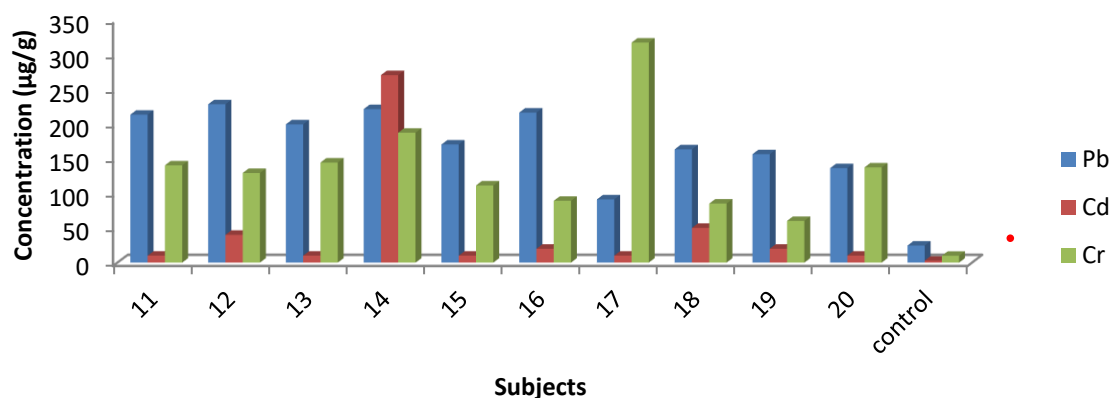


Figure 4: Concentrations of Pb, Cd & Cr in Nail Samples of Auto-mechanics and Painters

The mean concentration of Pb in the hair samples of auto mechanic and painters was found to be $134.5 \pm 39.55 \mu\text{g/g}$, with the maximum $189.0 \mu\text{g/g}$ (subject 14) and the minimum $69.0 \mu\text{g/g}$ (subject 13) both auto-mechanics (Figure 3). The mean concentration of Cd was found to be $83.4 \pm 105.17 \mu\text{g/g}$, while the mean Cr concentration, the highest concentration was observed in subject 20 to be $52.0 \mu\text{g/g}$ and the least concentration was observed in subject 13 to be $12.0 \mu\text{g/g}$. whereas the mean concentration was observed to be $28.11 \pm 14.43 \mu\text{g/g}$. All values observed for the metals in the hair samples were higher than that of the control (Pb= $41.00 \mu\text{g/g}$, Cd= $1.60 \mu\text{g/g}$ and Cr= $1.00 \mu\text{g/g}$) as can be seen in figure 3, an indication that the occupations contributed to the metal burden in the subjects. Generally, auto-mechanics showed higher accumulation of the metals than painters, this may be due to the wider variation of fluids, metallic parts auto-mechanics work with and the fact that most auto-mechanics join the trade from a much tender age and spend far more years in the job (as gathered from the questionnaire).

A similar pattern was also observed in the nail samples (Figure 4), the mean Pb concentration in the nails samples was found to be $179.3 \pm 44.16 \mu\text{g/g}$, which was higher than the mean Pb concentration in hair

samples of both artisans. The mean Cd and Cr concentrations were found to be $45.00 \pm 80.31 \mu\text{g/g}$ and $139.9 \pm 71.92 \mu\text{g/g}$ respectively. The mean Pb hair and nail concentrations are higher than reports for auto-mechanics in Abeokuta-Nigeria ($17.75 \pm 5.16 \mu\text{g/g}$, $5.92 \pm 3.30 \mu\text{g/g}$) by Babalola *et al.* (2005).

Correlation coefficients of the metal pairs in the hair and nail samples showed weak positive correlation to negative correlation; Pb/Cd ($r = -0.1540$ & 0.3692), positive correlations were also observed for Pb/Cr pair ($r = 0.1931$ & -0.4492) and Cd/Cr ($r = -0.5140$ & 0.1619) at $P < 0.01$ respectively.

4.0 CONCLUSION

An overview of the concentrations of the metals in the three categories of artisans compared to control subjects showed that the artisans face an occupational burden towards the metals, since the similarity in the geography of the control subjects and artisans would mean similar background levels of environmental exposure. However, the results further showed that auto-mechanics and painters are more occupationally exposed to Pb, Cd and Cr than electronic repair technicians probably due to increased tendency of exposure via ingestion and inhalation.

5.0 CONFLICT OF INTEREST

The authors declare no conflict of interest.

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