Hair and Nails as Bioindicators of Occupational Hazard Exposure to Toxic Metals in Auto Repairers of Vehicle Workshops

Abdulazeez Mobolaji Hammed[1*], Ayodele Akinterinwa[1], Kabir Adebayo Sanusi[2], and Shuaibu Abdullahi[1]

[1]Department of Chemistry, Modibbo Adama University, Yola, Nigeria
[2]Department of Chemistry, Federal University of Kashere, Kashere, Nigeria

*Corresponding Author: bolajiabdulazeez@gmail.com

ABSTRACT

This study quantitatively determined the concentration of toxic trace metals in hair and fingernails as bioindicators of occupational exposure among auto repairers of vehicles in workshops within Yola, Nigeria. Exposure was evaluated from the concentrations of toxic metals in the hair and fingernail samples using an atomic absorption spectrophotometer. This was carried out with regard to the years of practice and smoking habits of the occupationally exposed individuals examined. The concentration of metals in the hair samples of auto repairers who had practiced for ≤5, ≤10, ≤15, and 15–20 years followed the order cadmium (Cd) > lead (Pb) > chromium (Cr) > nickel (Ni) > arsenic (As), while the fingernail samples followed the order Pb > Cd > Cr > Ni > As. Mean concentrations of toxic metals in the hair samples of smokers were Cd = 0.55 ± 0.25 μg/g, Ni = 0.30 ± 0.06 μg/g, Pb = 0.69 ± 0.18 μg/g, As = 0.34 ± 0.11 μg/g, and Cr = 0.42 ± 0.17 μg/g, while the mean concentrations in nails were Cd = 0.49 ± 0.21 μg/g, Ni = 0.28 ± 0.20 μg/g, Pb = 0.48 ± 0.11 μg/g, As = 0.25 ± 0.13 μg/g, and Cr = 0.36 ± 0.02 μg/g. The mean metal concentrations obtained fall within the acceptable limits of regulatory guideline values. This study proved that hair and nails are viable bioindicators to monitor the heavy metal toxicity in the human body.

Keywords: toxic metals, bioindicator, auto repairer, occupational hazards, atomic absorption spectrophotometer

INTRODUCTION

The movement of people, commodities, and services has grown due to the industrial revolution, economic expansion, and population growth (Ikese et al., 2021; Mehra & Juneja, 2005). As a result, Nigeria is a major importer of used vehicles, being a low-income economic nation. This category of vehicles typically requires frequent maintenance and repair to stay in functional conditions. Due to the rising demand for automobile maintenance and servicing, the nation now has a greater number of auto repairers and vehicle workshops. Automotive repair workshops are major sources of lead (Pb), cadmium (Cd), and other metals exposure to auto repairers. The older vehicles typically leave higher levels of heavy metal tailings on their different parts due to wear and tear, oil/grease and other fluid residues, and residues from gaseous deposits (Al-Easawi et al., 2017; Ikese et al., 2021). Furthermore, older vehicles are also known to pose more environmental pollution due to emissions and leaks compared to the newer vehicles with more advanced technologies (Orisakwe, 2009). All these in addition to poor protection and safety practices among the mechanics culminate into hazardous exposure to these toxic substances. Humans absorb extraneous substances such as heavy metals via skin contact, inhalation, and/or ingestion through food chain or water (Amartey et al., 2011). Therefore, it is highly possible to be occupationally exposed to many hazardous metals through regular and everyday industrial tasks including vehicle maintenance, welding, painting, battery manufacturing, electronic equipment repair, metal recycling, etc., and these routine activities can lead to a variety of health risks.

Auto repairers are susceptible to occupational hazards due to heightened metal toxicity, because of their exposure to toxic materials owing to the variety of job tasks executed on a regular and continuous basis (Al-Easawi et al., 2017). Toxic metals like arsenic (As), chromium (Cr), Cd, Pb, nickel (Ni), and mercury (Hg) have been identified as priority metals for health issues for a number of years (Dangi et al., 2022). When toxic metals corrupt or exceed the biochemically required concentrations, they frequently build up in human bones and tissues. Low intake of important mineral nutrients in our meals increases the risk of these harmful metals on human health since they compete with necessary elements for absorption (Amartey et al., 2011). Many of these metals have the ability to bioaccumulate over an extended period of time in bodily tissues and be hazardous at extremely low concentrations.

The toxicity of heavy metals has been linked to a wide range of detrimental health issues resulting from both occupational and non-occupational exposure. For instance, abnormalities of the brain and reproductive systems, kidney malfunction, cardiovascular issues, endocrine problems, and gastrointestinal disorders are among the health challenges linked to Pb toxicity (Adejumo et al., 2017; Mahurpawar, 2015). Analogous to Pb, prolonged exposure to Cd has been linked to various health hazards, including the possibility of lung cancer and detrimental impacts on the neurological, immunological, cardiovascular, renal, endocrine, and musculoskeletal systems (Adejumo et al., 2017; Mitra et al., 2022). Depending on the specific exposure circumstances, Cd exposure at the workplace or in the environment may have immunosuppressive consequences (Mitra et al., 2022). The human body needs Ni, among other essential micronutrients, for biochemical and physiological processes (Hammed et al., 2023; Tchounwou et al., 2012). However, an excess of Ni in the body has been linked to adverse health effects, such as diabetes (Lotah et al., 2021), allergic reactions, lung and nasal cancer, kidney disease, and cardiovascular disease (Lotah et al., 2021; Lu et al., 2005; Mitra et al., 2022). Similarly, Cr, which is used in many applications such as fabrication of stainless-steel alloys and metal plating for the construction of automotive parts, has been considered a carcinogen and toxicant when present at a higher degree of toxicity in the human body (Martin & Griswold, 2009). Numerous health-related problems have been linked to prolonged Cr exposure, including damage to the liver, kidneys, circulatory system, and nerve tissue (Martin & Griswold, 2009) and respiratory cancer, ulcers, and nasal septal perforations (Mahurpawar, 2015); chronic exposure can also induce immunotoxicity (Mahurpawar, 2015; Martin & Griswold, 2009; Mitra et al., 2022). Furthermore, exposure to As has been connected to heart attacks, high blood pressure, and other circulatory disorders. According to reports (Mahurpawar, 2015; Martin & Griswold, 2009), prolonged occupational exposure to As may result in neurological disorders; lung, kidney, skin, and other associated cancers; and As poisoning (Szynkowska et al., 2009). Inhalation and dermal absorption have been the major routes of occupational exposure to As (Mahurpawar, 2015; Mitra et al., 2022).

Evaluation of the extent to which environmental factors, social activity, and occupational exposure primarily affect the health of individuals and population groups is the driving force behind the analysis of harmful and toxic substances such as metals and organic pollutants in human media (Szynkowska et al., 2009). Despite the grave public health concerns, researchers have hitherto paid little attention to the assessment of occupational hazards from toxic metal exposure particularly in auto repairers of automobile workshops using noninvasive human body samples. Hair and nails are noninvasive samples that serve as vital bioindicators, used to examine occupational hazards exposure to toxic metals body burden. Fingernails and scalp hair tissues are abundant in keratin, which are metabolically dead materials in the epidermis (Mehra & Juneja, 2005). Metals present in blood can reach nail and hair follicles by binding with keratin and get trapped or adsorbed in hair shaft and nail tissues (Lotah et al., 2021). However, their roots are highly influenced by the health status of the cell and can provide a good indicator of essential element status and environmental and occupational exposure to toxic metals. These, therefore, constitute a simpler technique for monitoring pollutant exposure (such as heavy metal bioaccumulation in humans (Liu et al., 2015). Compared to other human tissues and bodily fluids, these matrices also have advantages, such as the ability to provide reliable and stable information regarding the long-term history of individual exposure (weeks or months), easy and inexpensive sample collection, and constituent stability over a wide range of time before analysis, while providing useful information about the health status of the substances. These are not easily achieved using other matrices such as human milk, urine, blood, and serum analyses (Han et al., 2021; Liu et al., 2015; Szynkowska et al., 2009). These demonstrate that hair and nails are good bioindicators that can be used to assess environmental and occupational exposure to heavy metals.

Nevertheless, numerous studies have been conducted to assess the toxic trace metal levels in auto repairer blood serum (Adejumo et al., 2017), work clothes (Sani et al., 2019), and workshop soil (Durumin-Iya et al., 2023; Isah et al., 2023; Ogunkolu et al., 2019; Pam et al., 2013a, 2013b). Recently, studies have reported on the use of hair or nail samples for human exposure to toxic metals as a consequence of occupational exposure among auto repairers (Al-Easawi et al., 2017; Ikese et al., 2021) and welders (Al-Easawi et al., 2017; Lotah et al., 2021), as well as other environmental exposures from other studied populations (Dessie et al., 2020; Mehra & Thakur, 2023; Nakaona et al., 2019; Szynkowska et al., 2009; Were et al., 2008). In general, these studies have reported various levels of heavy metals in hair and nails specific to particular occupations and studied populations. However, there is currently no literature on biomonitoring studies looking into the presence of toxic metals in human hair and nail samples from auto repairers of vehicle repair workshops in Yola metropolis as a measure of exposure to occupational hazards. The objectives of the study focused on (i) the suitability of using hair and nails as bioindicators of occupational exposure to toxic metals, (ii) the levels of toxic metals in hair and nails of vehicle repairers based on the years of practice, and (iii) the evaluation of the contribution of smoking habits of exposed individuals to heavy metal concentration in the body. This was achieved through the paired samples of human hair and fingernails taken from 40 individuals who had been occupationally exposed for different duration of time and 20 non-exposed individuals as well as the factors of smoking habits. The results from this study are expected to provide the level of these auto workers' exposure to toxic metals and how this was influenced by the years of practice and smoking habits. Results from this study will provide necessary health and occupational guide to the target population and provide guides and information towards better practices and wellness.

MATERIALS AND METHODS

Chemical Reagents

All chemical reagents used for the purpose of this analysis are of Analar grade. Concentrated nitric acid (Conc. HNO_3, 69%), concentrated hydrochloric acid (Conc. HCl, 36%), and perchloric acid ($HClO_4$, 70%) were obtained from Merck Incorporation.

Study Population

The population of this study is predominantly auto repairers at vehicle workshops from five different vehicle workshops in Yola metropolis, Nigeria. The study population comprises forty (40) vehicle auto repairers categorized as the exposed group and twenty (20) individuals categorized as the non-exposed (control) group. The control group samples were drawn among the students of Modibbo Adama University (MAU), Yola, as shown in Figure 1. In this study, the sampled population was categorized on the basis of duration of practice and smoking habits. Hair and nail samples were collected from the workers categorized by the years of practice as follows: seven (7) workers with ≤5 years of practice, eighteen (18) workers with 6–10 years, nine (9) workers with 11–15 years, and six (6) workers with 16–20 years. Meanwhile, seventeen (17) and twenty-three (23) hair and nail samples of smokers and nonsmokers, respectively, were selected among the exposed auto repairers in the vehicle workshops. This was done to examine the effects of prolonged duration of practice of mechanic and smoking lifestyle on the bioaccumulation of metals in their body. Also, hair and fingernail samples of 20 nonexposed individuals were collected among the students of Modibbo Adama University as control samples.

Sample Collection and Pretreatment

Hair and fingernail samples of 40 vehicle auto repairers (exposed) were collected from five selected workshops in Yola, Adamawa State. The exposed workers and nonexposed persons were washed (with medicated soap and distilled water) and dried their hands and heads before the sample collection to efficiently remove dirt and any external contaminants. Fingernails were collected from the 10 fingers of sampled subjects using sterilized

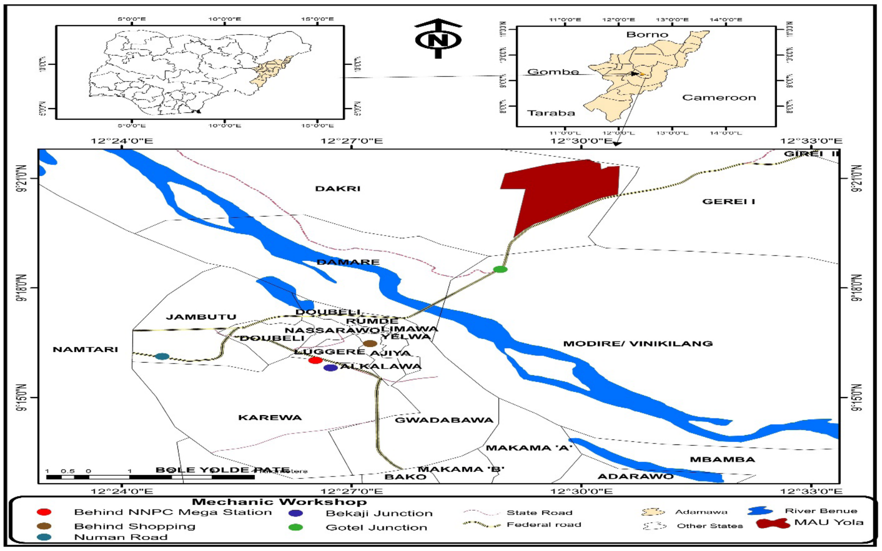

Figure 1. **Map of the study area.**

nail clippers, and hair was collected using a sterilized electric clipper and categorized based on duration of practice (≤5 years, ≤10 years, ≤15 years, and 15–20 years) and smoking and nonsmoking habits. The samples were preserved in pretreated plastic polythene bags and labelled. The samples were washed and dried again in the laboratory prior to further preparations and analysis.

Sample Preparation

The hair and nail samples were digested using the procedure adopted by Al-Easawi et al. (2017). Hair and nail samples were separately ground with a mortar and pestle, and 0.5 g of the grounded samples was weighed in a Kjeldahl digestion flask. A mixture of concentrated nitric acid and perchloric acid (6:1) was prepared, and 10.0 ml was added to the sample in the flask and kept at room temperature overnight to prevent excessive foaming. The flask was then placed in a digestion block inside a fume hood and heated subsequently at temperature ranging between 160 and 180°C until the mixture become a clear solution. After cooling, each sample was quantitatively diluted up to 50.0 ml using diluted nitric acid.

Instrumental Analysis of Heavy Metals

The determination of As, Cd, Cr, Pb, and Ni concentrations in the hair and fingernail sample solutions was carried out using an atomic absorption spectrophotometer (Buck Scientific 205 AAS). A series of trace metal standards was prepared by serial dilution of stock solutions containing 1,000 mg/L to obtain a calibration curve. Blank reagent and blind samples were prepared and analyzed for quality control. Triplicate analysis of the metals of the sample solutions was carried out to examine the reproducibility of the study. The average concentrations of blank samples were 0.0012 for As, not detected (ND) for Cd, ND for Cr, 0.001 for Pb, and below detection limit (BDL) for Ni, and the correction formula was used to evaluate concentrations of metals in the samples detected in the blank samples, while the blind sample concentration was found in the percentage range of 98.9%–100%.

Statistical Analysis

Results obtained are presented as mean ± standard deviation (SD). Statistical analyses were done using IBM SPSS version 20. The mean values of the data were subjected to a Student's *t*-test and one-way analysis of variance (ANOVA) with a 5% ($p < 0.05$) level of significance.

RESULTS AND DISCUSSION

The results of the concentrations of metals (As, Cd, Cr, Pb, and Ni) in nails and hair samples from the auto repairers as categorized in this study are presented and discussed in this section. The results are reported as the mean ± SD for each heavy metal analyzed. Table 1 presents the concentration of heavy metals in the nails of the auto repairers according to the duration of practice of the repairing work in their respective workshop. In general, the concentration of the heavy metals in the fingernails of auto repairers is in the order of Pb > Cd > Cr > Ni > As. Pb and As have the highest and lowest concentrations, respectively. As was not detected in fingernails of the ≤5-years auto repairers and nonexposed (control) group. From Table 2, Cd has the highest concentrations, while As is present at lower concentrations in the hair of auto mechanics with ≤5 years of practice.

From Table 1 and Figure 2, it was observed that the concentrations of heavy metals in the nails of the auto repairers increased based on a longer period of practice. It was also revealed from Table 1 that the concentration of metals in the ≤15- and ≤20-years groups is significantly higher ($p < 0.05$) than in the ≤5-years, ≤10-years, and nonexposed groups. The highest concentrations (As = 0.22, Ni = 0.26, Cr = 0.38, Cd = 0.42, and Pb = 0.47 **µg/g) were observed in the auto** repairers who have practiced for ≤20 years, while the lowest concentrations of the metals (As = ND, Ni = 0.09, Cr = 0.11, Cd = 0.15, and Pb = 0.19 **µg/g) were recorded for** those who have ≤5 years of practice. The level of metals in nails follow the order Pb > Cd > Cr > Ni > As. High Pb contents in these samples can be attributed to frequent contact with Pb-laden automobile parts (especially the combustion chamber and surfaces), as well as fluids and spent lubricants (Ikese et al., 2021). The concentration of metals in the nails of auto repairers is consistent with the previous studies by Ikese et al. (2021), although there are slight variations in the metals examined. However, the results deviate from those reported by Al-Easawi et al. (2017), where Ni and Cd were reported to have the highest and lowest concentrations in the nails of vehicle mechanics and other vehicle repair personnels.

***Table 1.* Concentration (µg/g) of Heavy Metals in Nails of Auto Repairers Based on Duration of Practice**

Heavy Metals	Duration of Practice				
	≤5 Years	**6–10 Years**	**11–15 Years**	**16–20 Years**	**Nonexposed**
As	ND	0.08 ± 0.06	0.14 ± 0.08*	0.22 ± 0.10*	ND
Cd	0.19 ± 0.03	0.22 ± 0.024	0.33 ± 0.11*	0.42 ± 0.20*	0.16 ± 0.10
Cr	0.11 ± 0.08	0.18 ± 0.10	0.26 ± 0.15*	0.38 ± 0.08*	0.09 ± 0.041
Pb	0.15 ± 0.02	0.21 ± 0.10	0.35 ± 0.12*	0.47 ± 0.25*	0.13 ± 0.023
Ni	0.09 ± 0.036	0.13 ± 0.08	0.22 ± 0.014*	0.26 ± 0.10*	0.06 ± 0.013

Note. As = arsenic; Cd = cadmium; Cr = chromium; Pb = lead; Ni = nickel; ND = not detected.

*Statistically significant at $p < 0.05$.

Table 2. **Concentration (µg/g) of Heavy Metals in Hair of Auto Repairers**
Based on Duration of Practice

Heavy Metals	Duration of Practice					
	≤5 Years	6–10 Years	11–15 Years	16–20 Years	Nonexposed	Biolab**
As	0.09 ± 0.078	0.12 ± 0.085	0.21 ± 0.12	0.32 ± 0.13*	0.10 ± 0.025	NA
Cd	0.21 ± 0.055	0.26 ± 0.12	0.40 ± 0.25*	0.51 ± 0.29*	0.18 ± 0.16	<0.10
Cr	0.10 ± 0.071	0.20 ± 0.16	0.33 ± 0.14*	0.41 ± 0.20*	0.12 ± 0.052	0.1–1.50
Pb	0.19 ± 0.081	0.23 ± 0.17	0.42 ± 0.20*	0.48 ± 0.28*	0.15 ± 0.081	<2.00
Ni	0.14 ± 0.088	0.16 ± 0.075	0.24 ± 0.19	0.3 ± 0.14*	0.11 ± 0.024	<1.40

Note. As = arsenic; Cd = cadmium; Cr = chromium; Pb = lead; Ni = nickel; NA = not available.

*Statistically significant at $p < 0.05$.

**Standard cited from Nakaona et al. (2019).

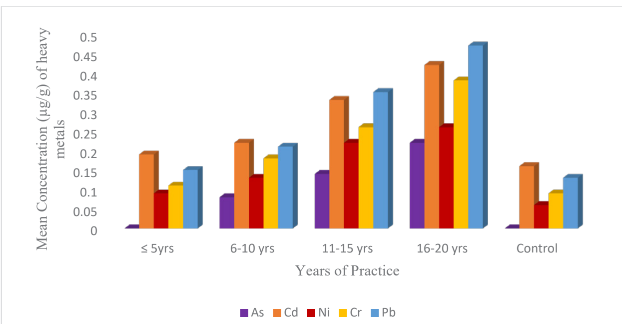

Figure 2. **Distribution of heavy metals concentration in nails of auto repairers based on years of practice.**

In a similar manner, Table 2 shows that there is a significant difference in the concentrations of heavy metals in the hair of auto mechanics based on the duration of practice as a result of longer exposure time. As shown in Figure 3, the mean values of metals in the nonexposed and exposed groups based on the classified duration of exposure of the auto repairers were found to be As = 0.09–0.32 **µg/g, Ni** = 0.14–0.33 **µg/g, Cr** = 0.10–0.41 **µg/g,** Pb = 0.15–0.48 **µg/g, and Cd** = 0.18–0.51 **µg/g, respectively. The levels of metals in the hair of auto** repairers were in the following order: Cd > Pb > Cr > Ni > As. However, the trend of this result deviates from the study reported by Lotah et al. (2021), which examined the concentrations of metals among welders working in vehicle workshops.

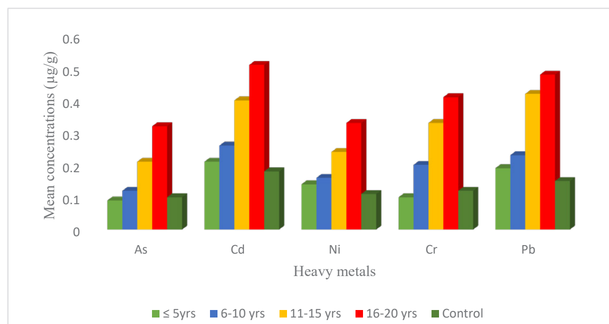

Figure 3. **Distribution of heavy metals concentration in hair of auto repairers based on years of practice.**

Analysis of the results revealed that the concentrations of these metals in the ≤15- and ≤20-years groups were significantly higher ($p < 0.05$) than the concentrations in the ≤5-years, ≤10-years, and nonexposed groups, as shown in Table 2, with the exception of As and Ni in the ≤15-year-duration group. In contrast, the toxic metal contents of fingernails are generally lower than the concentrations of toxic metals in hair samples, where Cd and Pb have higher accumulation. This can be attributed to frequent handwashing with detergents and sterilizers to temporarily attend to other activities during the daily jobs, which might have continuously reduced the absorption of the metals through the hands and fingernails. The high contents of these metals in hair may be associated with unavoidable head contact with the floor and parts of the vehicle while working under the vehicles and in other tight locations in the vehicle. Long contact (without thorough washing) in this case may enhance higher accumulation of heavy metals in hair scalp.

Table 3. **Mean Concentration (μg/g) of Heavy Metals in Nails Between Smoker and Nonsmoker Auto Repairers of Vehicle Workshops**

Heavy Metals	Smokers	Nonsmokers	p-Value
As	0.25 ± 0.13	0.20 ± 0.07	$p > 0.05$
Cd	0.49 ± 0.21	0.38 ± 0.14	$p < 0.05$*
Cr	0.36 ± 0.02	0.33 ± 0.04	$p > 0.05$
Pb	0.48 ± 0.11	0.41 ± 0.08	$p < 0.05$*
Ni	0.28 ± 0.20	0.25 ± 0.19	$p > 0.05$

Note. As = arsenic; Cd = cadmium; Cr = chromium; Pb = lead; Ni = nickel.

*Statically significant at $p < 0.05$.

Table 4. **Mean Concentration (μg/g) of Heavy Metals in Hair Between Smoker and Nonsmoker Auto Repairers of Workshops**

Heavy Metals	Smokers	Nonsmokers	p-Value
As	0.34 ± 0.11	0.31 ± 0.15	$p > 0.05$
Cd	0.55 ± 0.25	0.42 ± 0.29	$p < 0.05$*
Cr	0.42 ± 0.17	0.39 ± 0.20	$p > 0.05$
Pb	0.69 ± 0.18	0.50 ± 0.20	$p < 0.05$*
Ni	0.30 ± 0.06	0.28 ± 0.10	$p > 0.05$

Note. As = arsenic; Cd = cadmium; Cr = chromium; Pb = lead; Ni = nickel.

*Statistically significant at $p < 0.05$.

The mean concentrations of heavy metals in the nails and hair of auto repairers according to their smoking habits are summarized in Tables 3 and 4. When compared with a t-test, it was observed that there is no significant difference between the smoker and nonsmoker (control) groups (at $p < 0.05$) in the concentrations of As, Cr, and Ni in nail and hair samples. However, there is a significant difference in the concentrations of Pb and Cd in the nail and hair of the auto mechanics. The mean concentrations of Pb and Cd in hair and nails of smokers (0.48 ± 0.11 μg/g and 0.49 ± 0.21 μg/g) were significantly higher ($p < 0.05$) when compared with nonsmokers (0.41 ± 0.08 μg/g and 0.38 ± 0.14 μg/g). Moreso, the average Cd and Pb concentrations in hair follow a trend similar to that of nails, where their concentrations in smokers (0.55 ± 0.25 μg/g and 0.69 ± 0.18 μg/g) were higher than the nonsmokers (0.42 ± 0.29 μg/g and 0.50 ± 0.20 μg/g).

This study therefore revealed that there is a general increase in the heavy metal contents of smokers compared to the nonsmokers among automotive vehicle repairers in both hair and nail samples (Figures 4 and 5). According to the American Cancer Society, cigarettes contain trace quantities of toxic metals such as Pb, As, and Cd, and consequently, the high concentration of heavy metals in smoker auto repairers could be attributed to the contributing factor of the smoking of cigarettes. Ashraf (2012), Caruso et al. (2013), Benson et al. (2017), and Haleem et al. (2020) reported that several heavy metals (Ni, Cd, Pb, As, Cr) are found in tobacco smoke and are capable of accumulating in tissues and body fluids after smoking. The biomonitoring studies of these metals indicated that cigarettes are the major exposure pathway for Cd and Pb in smokers, and bioaccumulation has been observed in smokers chronically exposed to tobacco smoke as well as tobacco smoke pollution (referred to as secondhand smoke). Thus, the metals have long half-lives of 10–12 years within the human body system (Caruso et al., 2013; Haleem et al., 2020). Schamberger (2002) and Lotah et al. (2021) reported that the tobacco cigarette contains 1–2 μg of Cd per pack of cigarettes on absorption, and this will approximately increase the content in smokers. Other sources of toxic metals reported apart from tobacco include filters and wrapping paper. It is also noteworthy that another additional route of toxic metal intake is through food contaminated with these elements. In this study, it is crystal clear that the heavy metal contents in hair are higher than those in nails, and this can be established from the fact that hair proves to be a more reliable noninvasive biomarker sample in the monitoring of pollutants in the human body system.

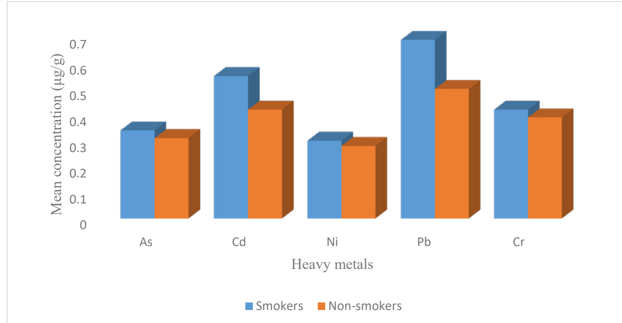

Figure 4. **Heavy metal concentrations in nails between smoker and nonsmoker auto repairers.**

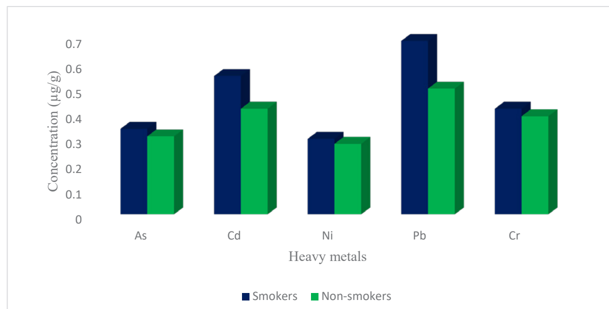

Figure 5. **Heavy metal concentrations in hair between smoker and nonsmoker auto repairers.**

Furthermore, Lotah et al. (2021) reported that the maximum allowable limit of Pb in hair and nails is <4.0 **μg/g, and a concentration greater than 10 μg/g signifies higher** Pb exposure, while the accepted limits of Cd and Ni in hair are <0.5 **μg/g and 1.0 μg/g,** respectively. However, the levels of Cd, Ni, Pb, and Cr in all the categories of hair examined were within the accepted guideline limits of <0.10 mg/kg, <1.40 mg/kg, <2.0 mg/kg, and 0.1–1.50 mg/kg, respectively, in the human hair of a healthy individual according to Biolab guideline values. In the current study, the concentrations of the metals examined in auto repairers of workshops were within the accepted permissible limit, although the concentrations increased greatly in smokers than in nonsmokers and were also based on duration of exposure and years of practice.

Although trace metals, including copper, zinc, and Ni, are bio-important and perform specific physiological functions in the body system, the bio-toxic effects and health challenges associated with many of the metals (Cd, Pb, As, Hg, Mn, Cr, etc.) in human biochemistry are of great concern. Moreover, several studies have linked some health problems with heavy metal concentrations and toxicities, such as Cd and hypertension, mental, neurological, and respiratory disorders (Lotah et al., 2021; Mitra et al., 2022); Pb and mental stress, central nervous system (CNS) disorder, peripheral neuropathy, and anemia (Mahurpawar, 2015; Mitra et al., 2022); Ni and cancer, diabetes, and allergies (Lotah et al., 2021; Mahurpawar, 2015; Mitra et al., 2022); and As/Cr and respiratory cancer, perforation of the nasal septum, ulcer, and lots more (Mahurpawar, 2015). Besides, Mitra et al. (2022) categorized metal toxicity as neurotoxic, nephrotoxic, carcinogenic, hepatotoxic, genotoxic, cardiovascular toxic, and immunological toxic agents based on their associated health effects in the various organs of the body.

The results obtained from nails and hair in this study demonstrate greater risk indicators of bioaccumulation of heavy metals in the nails and hair of auto repairers as a consequence of longer exposure to automobile repairing services. Although auto mechanics can only be exposed to small amounts of heavy metals during repair service, the accumulation and bioconcentration of these metals in the body over a long period of time could cause severe and chronic health problems. Furthermore, it implies that higher accumulation of the heavy metals could lead to greater toxicity and biomagnification in the entire body system of the auto repairer and, as such, pose a threat to their health. Although some of these metals are beneficial elements that are required for cellular growth and development, a higher overdose of the trace metals can lead to toxicity and potentially pose harmful effects to the body. In this study, there are high concentrations of Pb, Cd, Cr, and Ni in the fingernails and hair of auto repairers and non-automobile repairers, which pose a significant threat to their health.

CONCLUSION

This study presented the levels of heavy metals in the noninvasive samples, such as hair and fingernails, as biomarkers of occupational hazards in auto repairers of vehicle workshops in Yola metropolis, Nigeria. The results obtained showed that the concentration of heavy metals increases with time of exposure (years of practice) as well as with smoking habits in both hair and nails. In addition, the heavy metals examined in hair were within the acceptable limits for a healthy individual by Biolab and other regulatory standards. Therefore, the amounts of Cd, Pb, Ni, and Cr in the hair and nails of the auto repairers are indicators of occupational hazards and have shown possible metal toxicities from further exposure. From the findings, it is recommended that auto repairers and other allied workshop workers within the study area use personal protective equipment (PPE) to reduce the risk of metal toxicity. In light of the findings of this study, it is pertinent that vehicle auto repairers and other hands-on workshop workers stay informed of the risks associated with their occupations and, most importantly, present themselves for medical examination and regular checkups of their health situations.

ACKNOWLEDGEMENT

The authors acknowledge the vehicle repairers who have voluntarily given the samples used for this study and particularly the management of each of the vehicle workshops where the samples were drawn for the cooperation and assistance. We equally appreciate the students who gave the samples for the nonexposed group.

STATEMENT OF COMPETING INTEREST

The authors declared that there is no statement of competing interest.

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