SERUM LEVEL OF LEAD, ZINC, CADMIUM, COPPER AND CHROMIUM AMONG OCCUPATIONALLY EXPOSED AUTOMOTIVE WORKERS IN BENIN CITY

Adejumo Babatunde Ishola[1],Isu Michael Okechukwu[1] Uchuno Gregory Ashimedua,[2] Dimkpa Uchechukwu,[3] Emmanuel Alaba Michael,[4] Oke Ojo Moses, [5] Ikenazor Herbert Okwudili,[6] Hamidu Musa Vaima,[7] Abdulkadir Usman Itakure[8] and Omosor Kingsley Ifeanyichukwu[9]

1. Medical Laboratory Science Department, University of Benin, Benin City, Nigeria.
2. External Quality Assurance Department, Medical Laboratory Science Council of Nigeria, Abuja, Nigeria.
3. Physiology Department, Nnewi Campus, Nnamdi Azikiwe University, Awka, Nigeria
4. Medical Laboratory Science Department, College of Health Sciences and Technology, Idah, Kogi State, Nigeria.
5. Department of Medical Laboratory Science, College of Health Sciences and Technology, Akure, Ondo State, Nigeria.
6. Department of Medical Laboratory Science, Madonna University, Elele, River state.
7. Department of Medical Laboratory Science, College of Health Sciences and Technology, Maiduguri.
8. Department of Medical Laboratory Science, College of Health Sciences and Technology, Markafi, Kaduna State, Nigeria.
9. Shalom Diagnostic Medical Laboratory, Warri, Delta State, Nigeria

Correspondence: Adejumo B.I., Medical Laboratory Sciences Department, University of Benin, Benin City, Nigeria. +2348181561300

ABSTRACT: *Aim: This study is aimed at assessing the level of exposure to lead, cadmium, chromium, zinc and copper among occupationally exposed automobile repair workers and create awareness for proper safety measures.Methodology: A total of 94 auto repair workers comprising battery recyclers (n = 14), motor mechanics (n =59) and spray painters (n = 21), selected from various auto repair workshops in Benin City and 50 unexposed controls participated in the study. Blood samples were collected and analysis for blood levels of lead, chromium, cadmium, copper and zinc were done using flame atomic absorption spectrophotometer. Results: Data indicated significantly ($p < 0.001$) greater levels of lead, cadmium, chromium, zinc and copper in auto mechanics, spray painters and battery recyclers compared with the non-exposed controls. In contrast, the blood levels of these metals did not differ when compared among the auto repair workers. Conclusion: The significantly greater levels of lead, cadmium, chromium, zinc and copper in auto workers clearly demonstrates that auto repair workers are more likely to be exposed to toxicity of metals due to their occupational activities than the general population. This calls for adequate maintenance of safety measures and hygiene by auto repair workers to protect themselves from harmful effects of automobile workshop environment.*

KEYWORDS: serum, metals, exposed workers, Benin City

INTRODUCTION

A typical automobile repair workshop in Nigeria is made up of skilled workers such as auto mechanics, spray painters, panel beaters, welders, battery recyclers, radiator and air conditioner repairers who are routinely engaged in auto activities. These workshops have been identified as major sources of environmental pollution due to the unregulated activities of these workers. It has been reported that automobile workers are regularly exposed to lead toxicity [1, 2]. Automobile spray painters have also been reported to be at risk of exposure to heavy metals such as lead, cadmium and chromium are major toxic metals in their automobile paints workshops [3]. This is because; lead, cadmium and chromium are major toxic metals which are found in automobile paints. Welding results in excessive exposure to lead and cadmium and simultaneous release of zinc fumes [4].Other studies [5, 6] have also shown that automobile workers are at risk of chromium, lead and zinc, since these metals are components of spare parts used in the vehicle construction industry. Similarly, the fumes of metals such as chromium, lead, zinc, copper, manganese and nickel may be inhaled during melting, ingested or absorbed (through the skin) when panel beaters constantly use them for auto repairs [5].

Degeneration of the central nervous system, anemia and renal failure are some of the long term effects of exposure to lead [7]. In addition, lead has been shown to immunotoxicant, depressing humoral immunity [8. 9]. Chronic exposure tocadmium cancause lung cancer, and may have toxic effects on many body systems, including the immune, nervous, respiratory, endocrine, renal, musculoskeletal, and cardiovascular systems [10. 11, 12]. It has also been reported that long term exposure to cadmium via waterand food can lead to renal tubular dysfunction, disturbance of calcium metabolism, osteoporosis and osteomalacia [10]. Although copper and zinc have been shown to be important co-factors in the antioxidative activities of superoxide dismutase [13], they may be harmful at high concentrations. For instance, at toxic levels copper and zinc interact with superoxide radical to produce highly reactive and damaging hydroxylated free radicals which lowers the antioxidant status of an individual [14].

Unfortunately, these auto workers are neither aware of the amount of these toxic metals they are exposed to nor thedeleterious effects they have on their health,thus they pay little attention to protecting themselves from the possible inhalation or ingestion of such toxic substances.Most disturbing is the lack of workplace regulations for environmental pollutant exposure in Nigeria and the utter disregard for workshop ethics and environmental protection laws by the auto workers. Similarly, these workers pay little attention to precautionary measures such as maintenance of hygiene and use of face masks to minimize possible ingestion and inhalation of such toxic substances. Furthermore, the wearing of recommended workshop garments and hand gloves and use of barrier creams to protect against direct contact with the toxic metals, are utterly disregarded. The present study istherefore aimed at assessing the level ofexposure to lead, cadmium, chromium, zinc and copper among automobile workers who have been occupationally exposed for a long time and developing awareness for proper safety measures in this regard.

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METHODOLOGY

This study was conducted at the Department of Medical Laboratory Science, University of Benin, Benin City. A total of 144 males (50 control; 94 auto repair workers) within the ages of 18-60 years participated in this study.The auto repair workers included battery recyclers (n = 14), motor mechanics (n =59) and spray painters (n = 21) selected from various auto repair workshops in Benin City. The control group (n = 50) comprises healthy young men who have never been exposed to metal contaminated areas. Workers on part-time duties and those who spent less than one year on the job were excluded from this study. The Ethics committee of Ministry of Health, Edo State approved this study. The personal consent of patients was sought after explaining the purpose of the research. A structured questionnaire was administered to every participant of this study. The questionnaire consisted of questions designed to elicit details about their personal data and health, residence, surrounding environment, length of time in occupation and daily hour of exposure.

Blood Collection and Analysis

Five millilitres of blood was collected and dispensed into a plain container. The non anticoagulated blood was spun at 1500rpm for 10minutes and the supernatant serum was separated into a separate sterile tubes. The serum was stored at -20^{0}C for up to 2 weeks prior to analysis. Analysis for lead, chromium, cadmium, copper and zinc were done using flame atomic absorption spectrophotometer (FAAS).

Data Analysis

Data was expressed as mean and standard deviation. Comparative analysis was done using independent sample t-test and analysis of variance (ANOVA). Statistical significance was set at $p < 0.05$. All statistics were done using IBM/SPSS software (version 20.0).

RESULTS

Table 1 shows mean levels of metals in mechanics compared to the controls. Data indicated significantly greater ($p < 0.001$) serum levels of lead, cadmium, zinc, copper and chromium in mechanics compared to controls.
Table 2 shows mean levels of metals in battery chargers compared to the controls. Data indicated significantly greater ($p < 0.001$) serum levels of lead, cadmium, zinc, copper and chromium in battery chargers compared to controls.
Table 3 shows mean levels of metals in spray painters compared to the controls. Data indicated significantly greater ($p < 0.001$) serum levels of lead, cadmium, zinc, copper and chromium in spray painters compared to controls.
Table 4 shows comparative analysis of mean serum levels of metals among the three automobile professional groups. One-way Analysis of Variance (ANOVA) indicated lack of significant differences in serum levels of lead, cadmium, zinc, copper and chromium amongst the three groups.

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DISCUSSION

The present study indicated significantly greater levels of lead, cadmium, chromium, zinc and copper in auto mechanics, spray painters and battery recyclers compared with the non-exposed controls. Interestingly, the blood levels of these metals did not differ among the auto repair workers.

Lead is recognized as an environmental and occupational pollutant [15, 16] and automobile repair works involving battery lead-acid recycling, automobile radiator repair, auto mechanic repair and welding have been identified as common sources of lead exposure [17]. In this study, greater blood lead level was observed in auto mechanics, vehicle spray painters and battery recyclers compared to the control. This clearly demonstrates that auto repair workers are more likely to be exposed to lead due to their occupational or professional activities than the general population. The present finding agrees with previous studies which have reported greater blood lead levels (BLL) in occupationally exposed auto workers [2, 3,18].It is noteworthy that, of the three groups of auto repair workers studied, only the battery recyclers indicated blood lead level (6.2 µg/L) above the normal reference value of 5µg/L; however, this value still remained below the permissible exposure limit of 40 µg/L. According to the National Institute for Occupational Safety and Health (NIOSH), an elevated blood lead level is defined as ≥5 µg/dL [19]. The U.S. Occupational Safety and Health Administration (OSHA) Lead Standards require workers to be removed from lead exposure when BLLs are equal or greater than 60 µg/dL (general industry) and allow workers to return to work when the BLL is below 40 µg/dL [19].Lead poisoning is known to have adverse effects on the nervous system, heme biosynthesis, kidneys, reproductive system, hepatic, hearing, endocrinal, gastrointestinal, blood pressure and cardiovascular system amongst occupationally exposed persons [20, 21]. Exposure to lead at workplaces such as automobile repair workshops has been shown to be mainly through inhalation of lead laden particles, poor personal hygiene, water and food also contribute to the exposure [22]. These facts call for adequate maintenance of safety measures and hygiene by auto repair workers to protect themselves from harmful effects of automobile workshop environment.

The significantly higher blood cadmium levels observed in the occupationally exposed auto repair workers compared with the non-exposed controls indicate that these automobile workers are at greater risk of the health hazards associated with cadmium toxicity.The present finding concurs with previous studies which have reported greater blood cadmium levels in auto mechanics [1, 23], spray painters [3, 23], and battery recyclers [23]. The present study also indicated that the mean blood cadmium level for all the occupationally exposed auto repair workers (mechanics, 1.17 ± 0.52; spray painters, 1.16 ± 0.67; battery recyclers, 0.97 ± 0.33) were higher than the WHO's permissible range of 0.03–0.12 µg/dl of Cd [24].Cadmium is a common component of welding fume, spray paint pigment (cadmium yellow), cadmium containing batteries, and cigarettes [25, 26] and may explain the elevated blood levels of the auto repair workers in this study. The main routes of exposure to cadmium are via inhalation, butadditional routes may be through cigarette smoking and eating contaminated food at work due to poor personal hygiene at the place of work. The health risks associated with cadmium toxicity include obstructive lung disease and lung cancer

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through chronic inhalation of airborne cadmium and renal tubular dysfunction, disturbance of calcium metabolism, osteoporosis and osteomalacia through water and food [10].

Chromium levels were higher in auto repair workers compared with the controls. The present finding is in agreement with previous study by [27] who reported significantly higher blood chromium levels in auto workers compared with control subjects. Another study [3] also showed greater blood levels of chromium in spray painters who wore aerosol removing respirators and those who did not compared with controls. Furthermore, the present findings which showed values higher than serum level of ≤1.4 µg/mL [28] in mechanics (5.21 ± 2.88), spray painters (4.86 ± 2.23) and battery recyclers (4.23 ± 2.07) are indicative of possible chromium toxicity in these auto workers.These auto workers are constantly exposed to chromium contained in fumes given off by metal coated welding electrodes used by welders who share the garage environments with them.Similarly, theuse of chromium-pigmented corrosion protective spray paints by spray painters; the use oflubricants and oils containing complex organometallic compounds by the mechanics, and the use of steel containing varying amounts of chromium by auto repair workers are additional sources of chromium. These facts may explain the high serum levels of chromium recorded in autoworkers in this study. The principal route of human exposure to chromium is through inhalation, and the lung is the primary target organ, significant human exposure to chromium has also been reported to take place through the skin [29, 30].Chromium released into the environment from anthropogenic activity occurs mainly in the hexavalent form [Cr(VI)] and occupational and environmental exposure to Cr(VI)-containing compounds is known to cause multiorgan toxicity such as renal damage, allergy and asthma, and cancer of the respiratory tract in humans [31]. Chromium (IV) may also find its way into the body by ingestion of contaminated food and this may cause irritation and ulcers in the stomach and small intestine, anemia, sperm damage and male reproductive system damage [32].

Zinc and copper are very essential trace elements that are very vital for the proper functioning of the human body. Zinc is needed for proper functioning of the body's immune system. It also plays a role in cell division, cell growth, wound healing, hormone production, and facilitates digestion [33]. Zinc benefits also include its ability to act as an anti-inflammatory agent, therefore zinc may have significant therapeutic benefits for several common, chronic diseases like fighting cancer or reversing heart disease [34]. Connective tissue formation, nerve conduction, ATP synthesis, iron metabolism, brain health via neurotransmitter synthesis, gene transcription, synthesis of the antioxidant superoxide dismutase, skin pigmentation, nerve tissue: myelin sheath formation, and blood vessel formation [35]. Despite these great benefits, excessive intake of zinc and copper can be harmful, and cause zinc and copper toxicity.

In the present study significantly higher blood zinc and copper levels were observed in the auto workers compared with the control. While the mean copper levelsof the respective automobile worker groups werebelow the normal average permissible limit of 150 µg/dL, their zinc levels exceeded the permissible limit of 130µg/dL. Exposure to zinc may be through oral intake of contaminated food and by inhalation. Welding fume is a major source of freshly formed zinc oxide during the welding of galvanized materials in the auto repair workshops and which is inhaled by the auto workers.Inhalation of Zn fumes during welding of galvanized metals is analogous to Zn supplementation above the recommended daily allowance. Exposure to copper fumes when welding copper and copper alloys as well as the inhalation of fine dust particles consisting of copper oxide or copper acetate and oral ingestion of copper metal in contaminated food or beverages are principal routes of exposure [36]. These facts may explain the higher values in the auto workers compared with the non-exposed control.

Ingestion of large amounts of zinc over a short period of time can result in digestive system symptoms such as abdominal cramps, nausea, vomiting, diarrhea and stomach irritation [37]. Other possible symptoms include headache, irritability, fatigue and dizziness. Acute symptoms of copper poisoning by ingestion include vomiting, hematemesis (vomiting of blood), hypotension (low blood pressure), melena (black "tarry" feces), coma, jaundice (yellowish pigmentation of the skin), and gastrointestinal distress [38].Chronic (long-term) effects of copper exposure can damage the liver and kidneys [39].

CONCLUSION AND RECOMMENDATIONS

The present findings revealed significantly higher blood levels of lead, cadmium, chromium, zinc and copper in auto repair garage workers compared with the unexposed control subjects. In addition, the observed blood levels of lead, cadmium, chromium and zinc in occupationallyexposed auto workers were above the permissible range and could be a potentialhealth hazard.The study also demonstrates that the higher blood levels of these metals in automobile workers are influenced by their occupational practices, lack of protection against workplace environment pollutants, thus placing them at risk of exposure to toxicity.

We therefore recommend the use of protective masks to avoid the inhalation of toxic metal fumes and the maintenance of clean workplace environment and personal hygiene. Occupationally exposed workersshould ensure they wash their hands and face before eating at the workplace. Comprehensive environmental policies and occupational safety and health actsshould be mandated by the government to meet the needs of these auto repair garage owners and strict enforcement of such policies should be ensured.

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Table 1. Mean levels of metals in mechanics compared to the controls

Variables	Controls (n =50)	Mechanics (n = 59)	t-stat	p-value
Lead (µg/dL)	0.74 ± 0.20	4.74 ± 2.35	-12.00	0.000
Cadmium (µg/L)	0.41 ± 0.09	1.17 ± 0.52	-10.10	0.000
Zinc (µg/dL)	83.22 ± 14.87	153.56 ± 38.28	-12.22	0.000
Copper (µg/dL)	85.42 ± 17.32	113.74 ± 31.98	-5.60	0.000
Chromium (µg/mL)	0.98 ± 0.44	5.21 ± 2.88	-10.27	0.000

Table 2. Mean levels of metals in battery chargers compared to the controls

Variables	Controls (n =50)	Battery Chargers (n = 14)	t-stat	p-value
Lead (µg/dL)	0.74 ± 0.20	6.20 ± 2.12	-18.25	0.000
Cadmium (µg/L)	0.41 ± 0.09	0.97 ± 0.33	-10.76	0.000
Zinc (µg/dL)	83.22 ± 14.87	168.0 ± 37.11	-13.02	0.000
Copper (µg/dL)	85.42 ± 17.32	113.36 ± 28.15	-4.60	0.000
Chromium (µg/mL)	0.98 ± 0.44	4.23 ± 2.07	-10.51	0.000

Table 3. Mean levels of metals in spray painters compared to the controls

Variables	Controls (n =50)	Spray Painters (n = 21)	t-stat	p-value
Lead (µg/dL)	0.74 ± 0.20	4.72 ± 1.92	-14.56	0.000
Cadmium (µg/L)	0.41 ± 0.09	1.16 ± 0.67	-7.74	0.000
Zinc (µg/dL)	83.22 ± 14.87	172.38 ± 40.81	-13.55	0.000
Copper (µg/dL)	85.42 ± 17.32	108.57 ± 27.65	-4.27	0.000
Chromium (µg/mL)	0.98 ± 0.44	4.86 ± 2.23	-11.87	0.000

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Table 4. Mean levels of metals compared among the three automobile professional groups

Variables	Mechanics (n =59)	Battery Chargers (n = 14)	Spray Painters (n = 21)	t-stat	p-value
Lead (µg/dL)	4.74 ± 2.35	6.20 ± 2.12	4.72 ± 1.92	2.55	0.083
Cadmium (µg/L)	1.17 ± 0.52	0.97 ± 0.33	1.16 ± 0.67	0.81	0.446
Zinc (µg/dL)	153.56 ± 38.28	168.0 ± 37.11	172.38 ± 40.81	2.19	0.118
Copper (µg/dL)	113.74 ± 31.98	113.36 ± 28.15	108.57 ± 27.65	0.23	0.796
Chromium (µg/mL)	5.21 ± 2.88	4.23 ± 2.07	4.86 ± 2.23	0.80	0.452

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