Evaluation of Heavy Metals in AutoMechanics in Aba Metropolis, South East, Nigeria Who Were Exposed to Petrol and Petroleum Products

ABSTRACT

Background: Every day, humans come into contact with heavy metals in the environment. These metals are widespread throughout the world and are known to affect and create specific biological changes that may be detrimental to the body.Auto mechanics are known to come in contact with these hazardous substances during vehicle maintenance and repair activities, which may lead to the release of heavy metals into the body as well as the environment.

Aim: To evaluate the levels of heavy metals that auto mechanics are exposed to from petroleum and petroleum products in mechanic workshops in Aba Metropolis.

Study Design: A cross sectional study with a total of 204 participants, 123 of whom were auto mechanics and 81 of whom were non auto mechanics (controls), had blood samples taken from them

Place and Duration of Study. The blood samples were taken from auto mechanic working in mechanic workshop spread around four locations of Aba Metropolis during the period of may 2022 to November,2022.Samples were analyzed at Abia State University Teaching Hospital, Aba, Abia State and Laboratory Department, JAROS Inspection Services Limited, Port Harcourt, Rivers State,

Methods:. The levels of heavy metals (Pb, Hg, Cd, Cr, and As) in blood were measured using atomic absorption spectrophotometry.The Statistical Analysis System (SAS), STAT 15.1 was used to analyse the data from the study.

Results:The serum concentration of heavy metals in reducing order, were Cr > Pb > As > Hg > Cd in the exposed individuals while in the control subjects, the order from the highest concentration was; Cr > Pb >As > Cd > Hg. The blood of auto mechanics had a significantly higher level of Pb and Hg than that of non-automechanics ($p<0.05$).Duration of exposure of the auto mechanics to petrol and its product showed an adverse effect from the results gotten in this study.

Conclusion: Heavy metal contamination still poses a threat to health and well-being of the automechanics in Aba Metropolis.

Keywords*:Heavy Metals,Petrol and Petroleum products,Auto Mechanics, Aba Metropolis*

1. INTRODUCTION

The automotive repair industry is a significant source of heavy metal pollution due to the handling and use of petrol and petroleum products, which contains various heavy metal constituents. The auto mechanics are exposed to these substances during their daily work activities and stay in the mechanic garage or workshop which potentially leads to adverse health effects and environmental contamination [1]. Statistics shows that non-communicable diseases (NCD), is the cause of over 40.9 million deaths, representing approximately 70% of annual global death [2].Petrol or gasoline is a fractional distillate of crude oil which contains high concentration of mono and polycyclic hydrocarbons and heavy metals. It contains highly volatile substances including, monocyclic aromatic hydrocarbons, such as benzene, xylene, toluene with their derivatives and over 250 polycyclic aromatic hydrocarbons (PAH). It also contains heavy metals such as lead (Pb) and Iron (Fe). Studies have described petrol as an ‘environmental pollutant’ with cumulative toxic effect; however it is inevitably and widely used for domestic and outdoor applications. Globally it is used as fuel for automobile engine, various industrial machines and equipment. Contamination with these chemicals and the danger to health of the populace has been reported in many countries [3, 4, and 5, 6). The nature and the level of pollutants may defer from one geographical area to another but the ability to overcome or tolerate toxic effect depends on mainly nutritional status immunity, exercise, genetic factors, gender differences and lifestyle [7, 8]. .Heavy metal poisoning is an ancient event in the history of many nations of the world [9, 10, 11, and 12]. Much emphasis was on the removal of lead from petrol, paints and insecticides [13]. In addition to lead, removal of other heavy metals (including cadmium and mercury) and toxic chemicals such as, sulphur compounds and monocyclic aromatic hydrocarbons such as benzene and benzene derivatives from petrol were also prescribed [14] .Routes of exposure to petrol and petroleum products include inhalation of fumes or particulate matter, ingestion and contact with skin. Harmful effects of exposure have been described both at the local and at the systemic levels [15, 16, and 17).The presence of heavy metals have been described and reported variously in the human blood, urine, hair [18, 19) and in nails [20]. Exposure to petrol has been reported variously as predisposing factor to a catalogue of disease conditions such as dyslipidaemia, cardiovascular diseases, liver pathology and nephropathy with reduced life expectancy in many cases [17]. Due to this underlying health effects, the need to assess heavy metal levels in auto mechanics is of paramount importance.

2. MATERIAL AND METHODS.

2.1 Area of Study and Description of Study Site

The area of study is Aba and its metropolis including, Aba North, Aba South, Obioma Ngwa, Ugwunagbo and Osisoma local government area (LGA). The City of Aba is in the South Eastern zone of Nigeria. It lies on the geographical coordinates of $5^0$07 N, $7^0$22^0 E/S, 117^0 N and 7.36^0 E. Aba South LGA, located longitudinally at 5.1135^0 N and at the latitude 7.3761^0 E. It constitutes the heart of the city with many automehanic workshops. Aba North LGA which is separated from Aba North by Railway line is where the big market popularly called “Ariaria market” is located. Obingwa LGA, is located in longitudinally at 5^0 06’ 23.69’ N and at the Latitude$7^0$22’ 0. 01^{0}E. Ugwunagbo LGA is located in the geographical coordinates 5.0354’3’ N and 7^0.33 08.92. Popularly known as ‘Alaoji” it has the largest number of auto mechanics workshops in Aba metropolis in Aba metropolis.

2.2 Sample Size

This was calculated using the sample size for comparison of two groups [21].
Sample size N = $2Z^2$ P (1-P) /D^2 where,
Z = the standard normal deviation usually 1.96 (At 95% confidence level).
P =prevailence of conditions 4.9% Pleural plaque in automobile mechanics [22].
D = margin of unacceptable error or measure of precision = 0.05.
The test is two sided test.
N = $2(1.96)^2$ x 0.049 (1 – 0.049) /0.05^2
= 2 (7.6832 x 0.04699) /0.025
=0.3580/0.0025
= 143.2
A total of 204 individuals were recruited for this study.

2.3 Inclusion Criteria

Auto mechanics that are apparently healthy within the age range of 16 to 65years, resident in Aba Metropolis and have worked as auto mechanics in Aba for not less than two years were the exposed group. The individuals who were not auto mechanics served as the control group. They gave their informed consent to participate in the study.

2.4 Exclusion Criteria

Subjects who had any known acute or chronic disease condition or undergoing medication whether herbal or orthodox. Those who were not willing to give their consent were excluded.

2.5 Ethical Clearance

Ethical and legal standards were according to Helsinki considerations [23].

2.6 Collection of Samples and Separation.

About 5 ml of venous blood sample was collected from each subject using sterile hypodermic syringes and needles and was dispensed into plain bottles; the sample was spun, and the serum was separated and used for the analysis of heavy metals.

2.7 Determination of Heavy Metals

This was done using the Atomic Absorption Spectrophotometry (AAS) by the Method of Olimedo*et al*[24].

Principle

Essentially, this method relies on the fact that atoms of each metal have a strong ability to absorb and emit light at specific wavelengths. When a metal –containing sample is introduced into the flame as aerosols, it vaporizes and forms atom. A hollow cathode bulb, which contains the metal to be analyzed along with argon and other inert gases, is connected to an electric source. The metals are heated, causing their atoms to move towards the cathode. These atoms collide with the inert gases and absorb light at specific wavelengths, which is quickly released due to the unstable nature of the excited atoms. As the atoms lose energy, they emit light at specific wavelengths. The amount of light absorbed provides the measurement of the metal concentration in the sample. The emitted light is then directed to a monochromator and read by the in-built photomultiplier. The concentration of the metal in the sample is calculated by comparing the absorbance of the sample with that of the standard control sample.

2.8 Statistical Analysis

The statistical software used for the analysis and graphics presentation is the Statistical Analysis System (SAS), STAT 15.1, developed by SAS Institute, North Carolina State University, USA. Data are presented as Mean ±SEM, comparison of means of groups that are more than two was done using analysis of variance (ANOVA), and the Tukey test of multiple comparisons were used to test for variance within and across groups. Variation between two groups was done using the Student t-test analysis. Pearson ranked correlation was used to evaluate relationships between values in two groups, ternary plot, box plot, bivariate regression analysis, Overlay plots and variability chart were used to present adequate interpretation of some results obtained for some parameters. The probability (p) value less than 0.05 ($P<0.05$) was used and considered statistically significant.

3. RESULTS

3.1 Demographic Characteristics of the Study Population

A total of 204 male subjects participated in this study. There were 124 automechanics (the exposed group) and the 81 non automechanics (serving as control group). The mean ± SD of the age of all participants was 33.7±12 years. A higher mean of 37.1±2.9 years was observed for the exposed group compared to28±9.4 years recorded for the control group. A graphical representation of the age of participants is illustrated with Mosaic plot as shown in Figure 1.

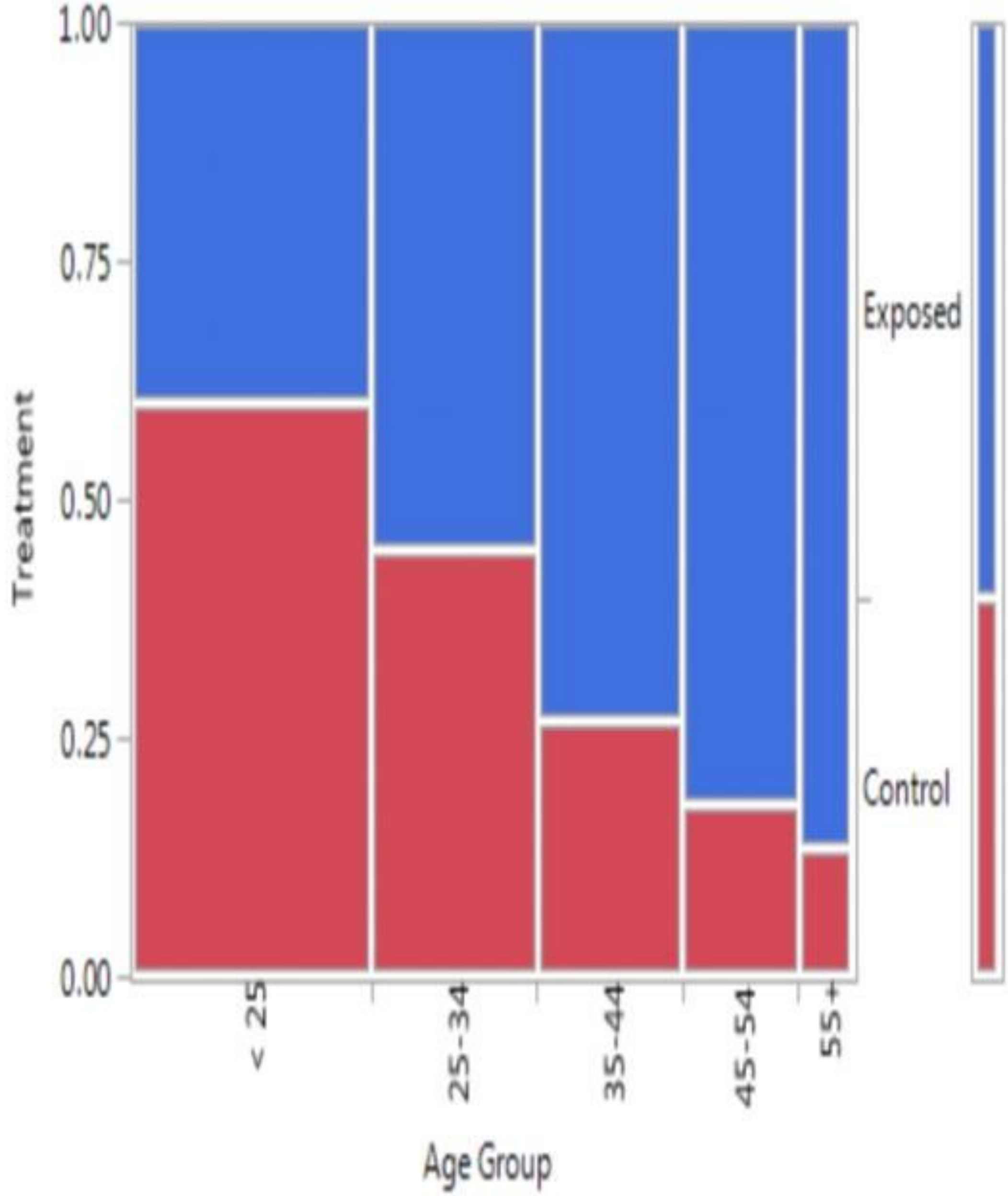

Figure 1: Demographic distribution of the Subjects indicating the Age ranges

3.2 Years of Exposure of Automechanics

The number of years the automechanic has worked, or being exposed to petroleum products was taken into consideration for all parameters determined in this study. The exposed groups were arranged according to the years of exposure, into 4 groups in the following order ≤5 years (25.2%), 6-10 years (11.4 f%), 11-20 years (27.6%) and 21 years (35.8%). Result shows that those who had been working as automechanics for 21 years and above represented the highest number of participants, 44 (35.8%) and the lowest group 6-10 years of exposure had 14 participants compared with other groups of exposure. The mean of duration was 16.5± 11.4 years. Graphical representation with normal quartile plot showing the distribution, of the duration of exposure to petroleum products for all participants is shown in Figure 2.

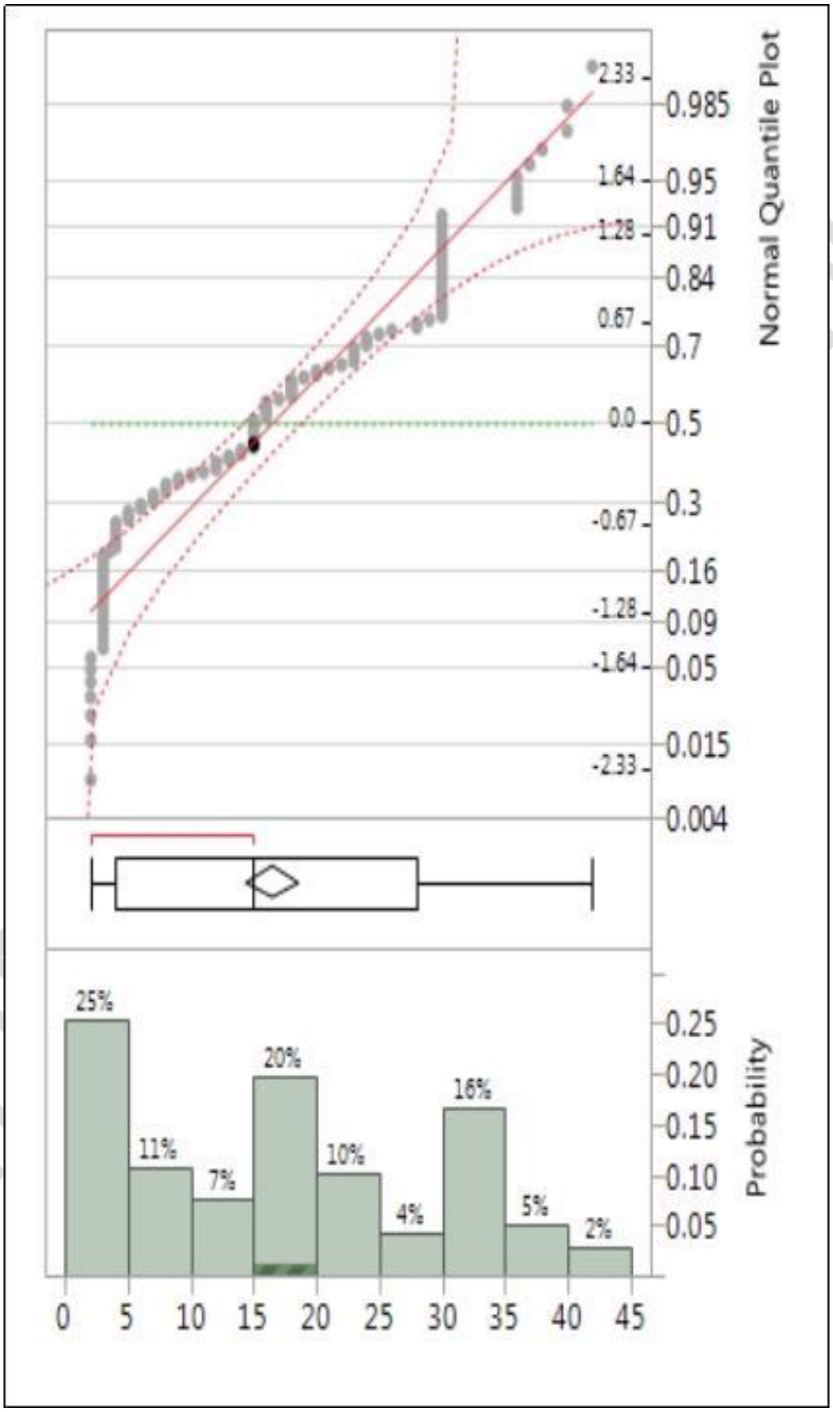

Figure 2: Normal Quantile Plot Showing the Distribution of Participants by Years of Exposure of Auto Mechanics to Petroleum products.

3.3 Determination of Heavy Metal inthe Test Group and Control Group

The mean of the exposed and control group are shown in the Table 1 below.

Table 1: Mean values of Heavy Metals (As, Pb, Hg, Cr, Cd) in exposed and control groups

Characteristic	**N**	**As (mg/L)** Mean ± SEM	**Pb (mg/L)** Mean ± SEM	**Hg (mg/L)** Mean ± SEM	**Cr (mg/L)** Mean ± SEM	**Cd (mg/L)** Mean ± SEM
Treatment group						
Auto mechanic (exposed)	123	0.324±0.056	0.414±0.044 [a]	0.203±0.044 [a]	0.492±0.083	0.134±0.073
Non-auto mechanic (control)	81	0.146±0.085	0.233±0.042 [b]	0.031±0.012 [b]	0.699±0.291	0.048±0.011
P-value		0.0682 [ns]	0.0055**	0.0024**	0.4203 [ns]	0.3455 [ns]

Abbreviations: SEM: Standard error of mean, As: Arsenic, Pb: Lead, Hg: Mercury, Cr: Chromium, Cd: Cadmium.Within each Characteristic, means ± SEM with different superscripts are significantly different at p<0.05. Significance Level: **=p<0.05

3.4 Heavy metals, Arsenic (As), Lead (Pb), Mercury (Hg), Chromium (Cr) and Cadmium (Cd) in the Groups according to Age Classification.

The concentration of heavy metals, As, Pb, Hg, Cr and Cd in the various groups according to the age classification is shown in Table 2. There was no significant difference in the mean ± SEM of As(p = 0.2409) between the exposed and the control subjects.. No significant difference was observed in the mean of Pb (p = 0.6205) between the groups, however slight increases were observed in the exposed subjects compared with the control group as age increased. The mean of Hg showed no significant difference (p =0.1021) between the exposed and the control groups in all age groups. Similarly the mean of Cr showed no significant difference (p = 0.3530) in the age between the exposed and the control groups. The mean of Cd was not significantly different (p=0.8065) in the group based on age classification between the exposed and control groups,

Table 2: Heavy Metals including Arsenic (As), Lead (Pb), Mercury (Hg),Chromium(Cr) and Cadmium (Cd) Treatment Group by Age Classification.

Age Group (Years)	Treatment Group	N	As (mg/L) Mean ± SEM	Pb (mg/L) Mean ± SEM	Hg (mg/L) Mean ± SEM	Cr (mg/L) Mean ± SEM	Cd (mg/L) Mean ± SEM
< 25	Auto mechanic (Exposed)	27	0.174±0.130	0.393±0.087	0.027±0.073	0.344±0.343	0.037±0.123
	Non-auto mechanic (Control)	41	0.214±0.105	0.178±0.071	0.026±0.059	0.221±0.279	0.037±0.100
25 – 34	Auto mechanic(Exposed)	26	0.087±0.132	0.320±0.089	0.064±0.075	0.505±0.3501	0.055±0.125
	Non-auto mechanic (Control)	21	0.122±0.147	0.286±0.099	0.069±0.083	.721±0.389	0.078±0.139
35 – 44	Auto mechanic (Exposed)	30	0.506±0.123	0.406±0.083	0.385±0.069	0.568±0.326	0.078±0.116
	Non-auto mechanic (Control)	11	0.038±0.204	0.382±0.137	0.003±0.115	0.472±0.538	0.051±0.192
45 -54	Auto mechanic (Exposed)	27	0.538±0.130	0.458±0.087	0.294±0.073	0.671±0343	0.401±0.123
	Non-auto mechanic (Control)	6	0.006±0.276	0.162±0.185	0.001±0.155	0.803±0.729	0.017±0.260
55+	Auto mechanic (Exposed)	13	0.247±0.187	0.577±0.126	0.234±0.105	0.223±0.495	0.067±0.177
	Non-auto mechanic (Control)	2	0.006±0.478	0.203±0321	0.002±0.269	0.733±1.262	0.039±0.451
P-Value			0.2409 ^{ns}	0.6205 ^{ns}	0.1021 ^{ns}	0.3530 ^{ns}	0.8060 ^{ns}

Abbreviations:SEM: Standard error of mean, As: Arsenic, Pb: Lead, Hg: Mercury, Cr: Chromium, Cd: Cadmium,.Within each parameter, means ± SEM with different superscripts are significantly different at p<0.05. ; ns=Non Significant (p>0.05).

3.5 Heavy metals, Arsenic (As), Lead (Pb), Mercury (Hg), Chromium (Cr) and Cadmium (Cd) of the Treatment Group and Duration of Exposure

The heavy metals, As, Pb, Hg, Cr and Cd of the treatment group and the concentration of heavy metals according to the duration of exposure are shown in Table 3. Comparison with ANOVA of the mean ± SEM of

As in groups according to the duration of exposure, showed no significant difference (p = 0.1715). Graphic representation with bivariate regression analysis of As against duration of exposure is shown in Figure 3 There was no significant variation in mean ± SEM of Pb (p= 0.7606) between the groups based on duration of exposure. Graphic representation with bivariate regression analysis of Pb against duration of exposure is shown in Figure 4. Group comparison with ANOVA based on duration of exposure showed no significant difference in the mean ± SEM of Hg (p= 0.1419). Graphic representation with bivariate regression analysis of Hg against duration of exposure is shown in Figure 5. Similarly there was no significant variation in the mean ± SEM of Cr (p=3412) between the groups according to duration of exposure. Graphic representation with bivariate regression analysis of Cr against duration of exposure is shown in Figure 6. The comparison of the mean ± SEM of Cd in the groups according to the duration of exposure showed no significant difference (p= 0.4893). Graphic representation with bivariate regression analysis of Cd against duration of exposure is shown in Figure 7.

Table 3: Heavy Metals (As, Pb, Hg, Cr, Cd) by Treatment Group and Duration of Exposure

Duration of Exposure (Years)$^{\beta}$	**N**	**As (mg/L)** Mean ± SEM	**Pb (mg/L)** Mean ± SEM	**Hg (mg/L)** Mean ± SEM	**Cr (mg/L)** Mean ± SEM	**Cd (mg/L)** Mean ± SEM
<=5	31	0.218±0.054	0.414±0.071	0.104±0.077	0.251±0.100	0.037±0.012
6-10	14	0.086±0.031	0.289±0.041	0.013±0.008	0.579±0.201	0.061±0.019
11-20	34	0.351±0.132	0.416±0.094	0.235±0.081	0.656±0.177	0.054±0.011
21^{+}	44	0.454±0.108	0.453±0.087	0.307±0.090	0.506±0.159	0.287±0.204
P-value		0.1715 ^{ns}	0.7607 ^{ns}	0.1419 ^{ns}	0.3412 ^{ns}	0.4893 ^{ns}

Abbreviations: SEM: Standard error of mean, As: Arsenic, Pb: Lead, Hg: Mercury, Cr: Chromium, Cd: Cadmium. **ns- Non Significant**

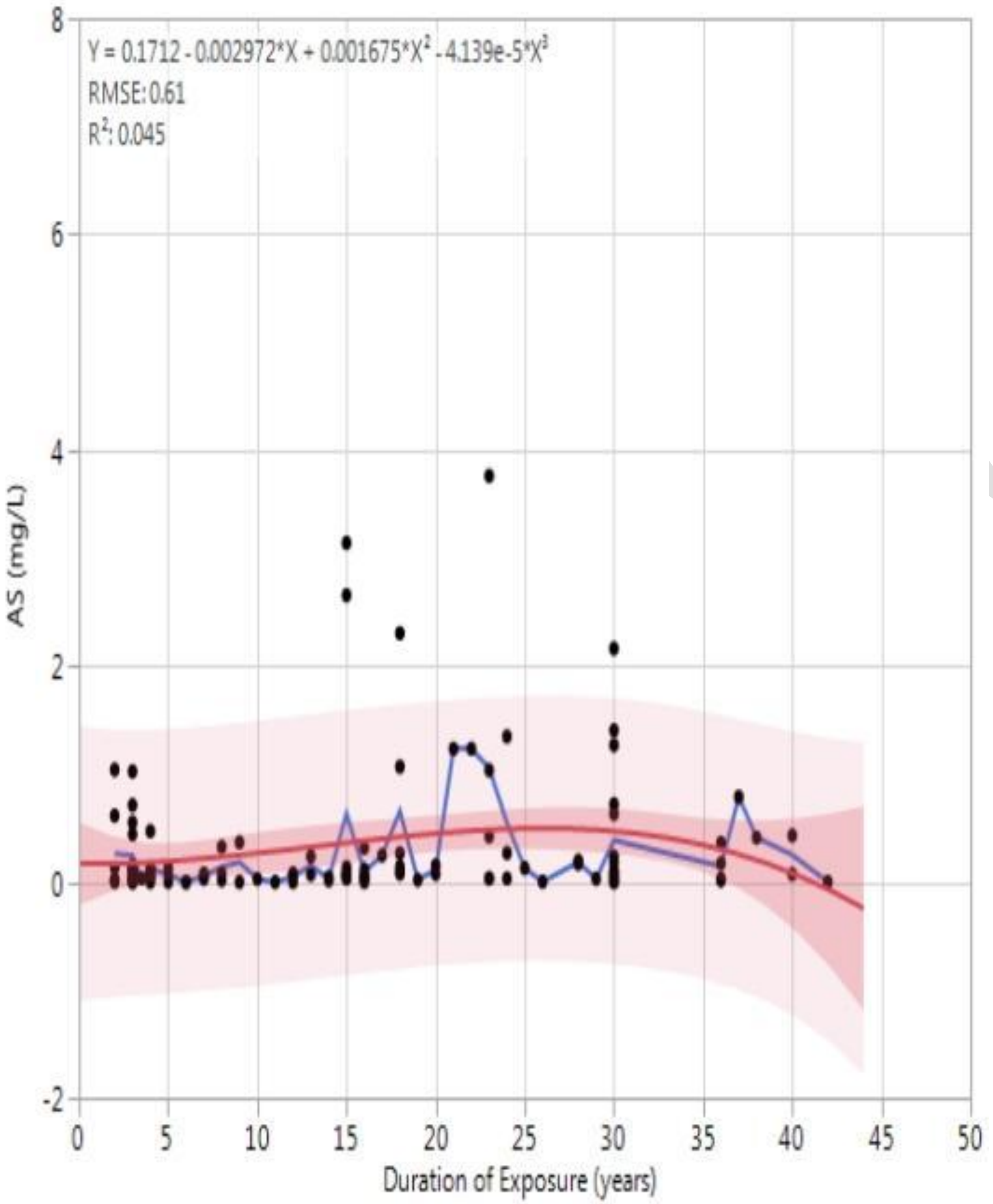

Figure 3: Bivariate Regression analysis of Arsenic (As) (mg/*L*) against the Duration of Exposure of Automechanics to Petrochemical Products and Showing the fitted line, and confidence regions for the fitted line and individual predicted values.

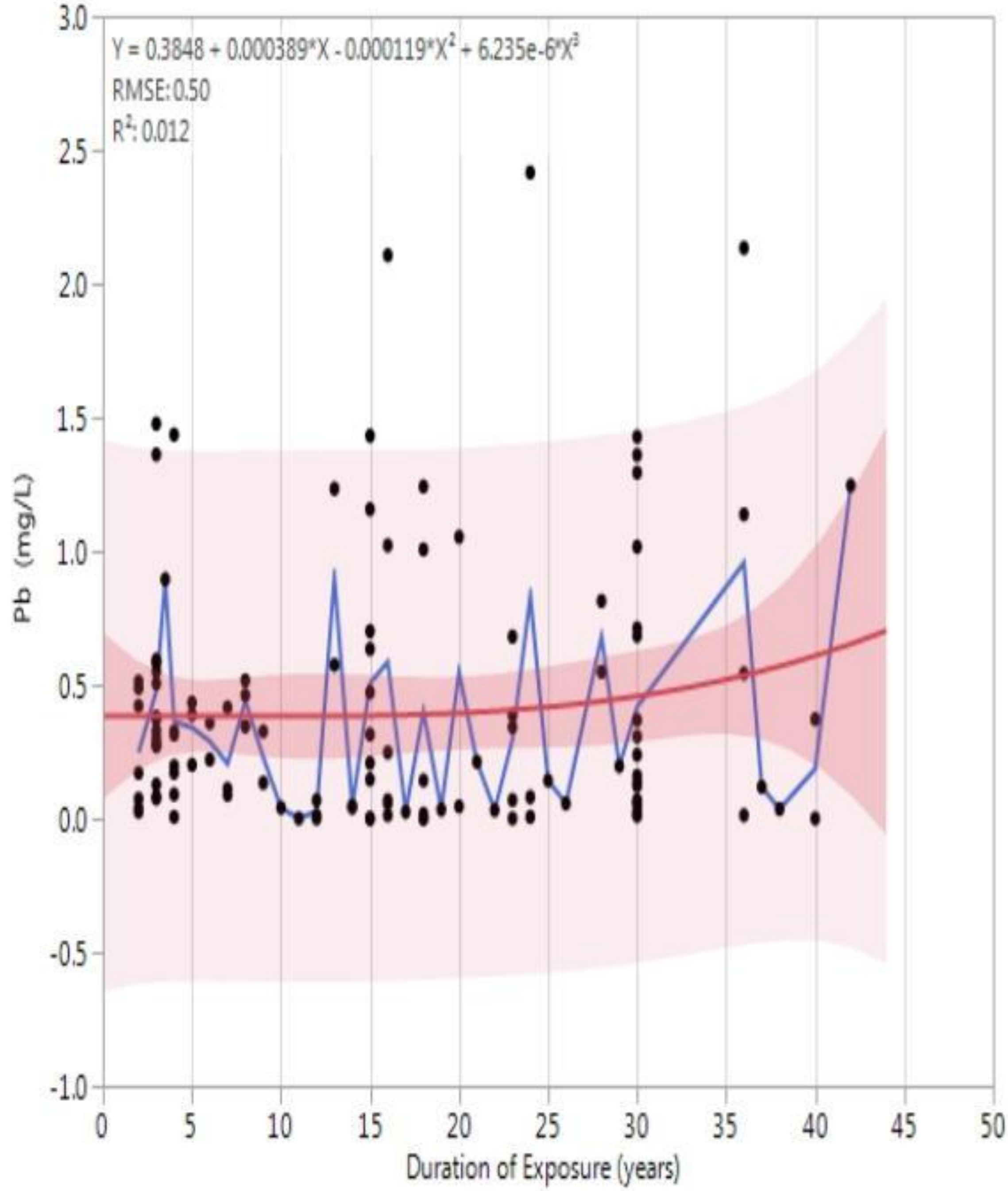

Figure 4: Bivariate Regression analysis of Lead (Pb)(mg/*L*) against the Duration of Exposure of Automechanics to Petrochemical Products and Showing the fitted line, and confidence regions for the fitted line and individual predicted values

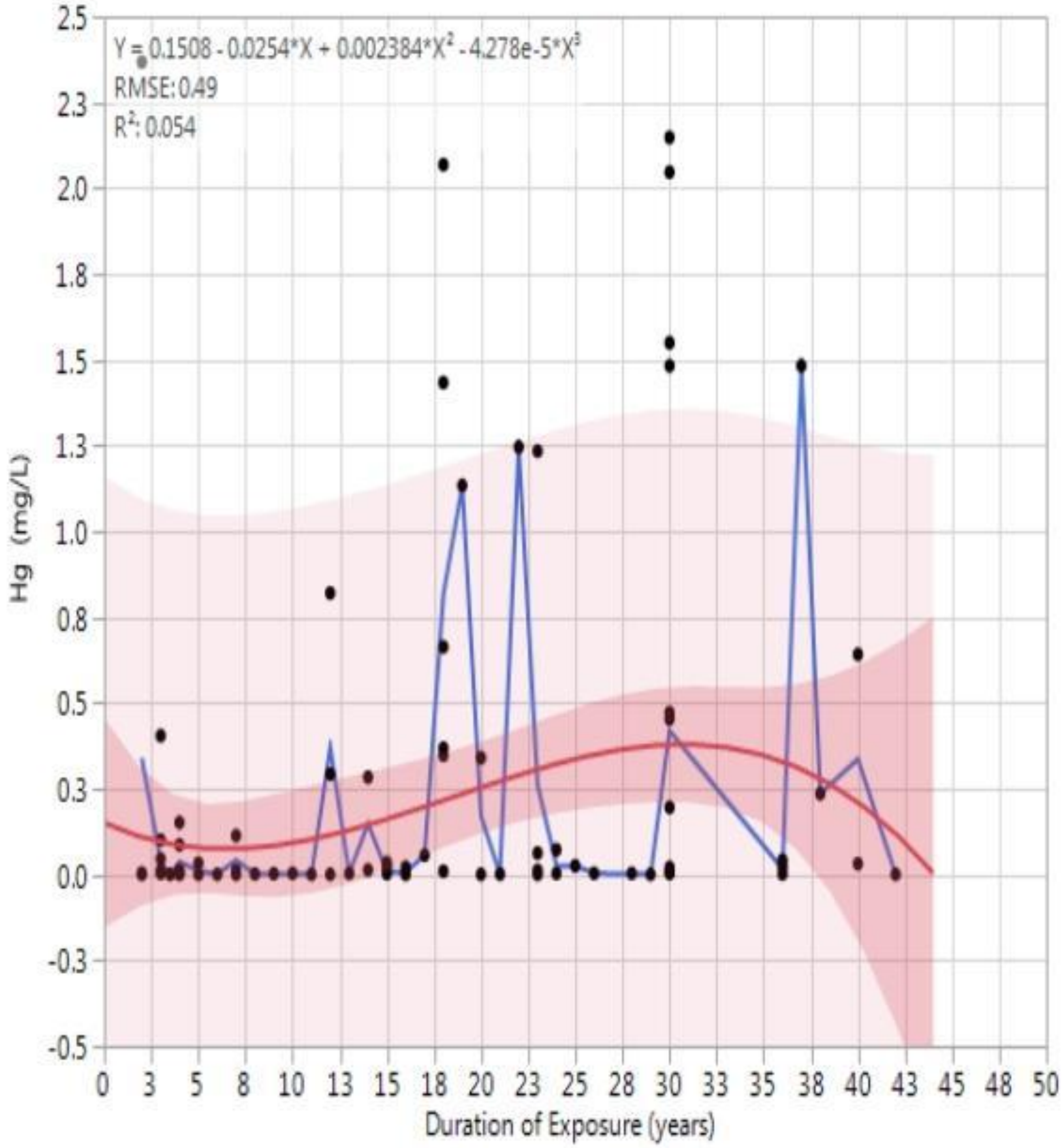

Figure 5: Bivariate Regression analysis of Mercury (Hg)(mg/*L*) against the Duration of Exposure of Automechanics to Petrochemical Products and Showing the fitted line, and confidence regions for the fitted line and individual predicted values.

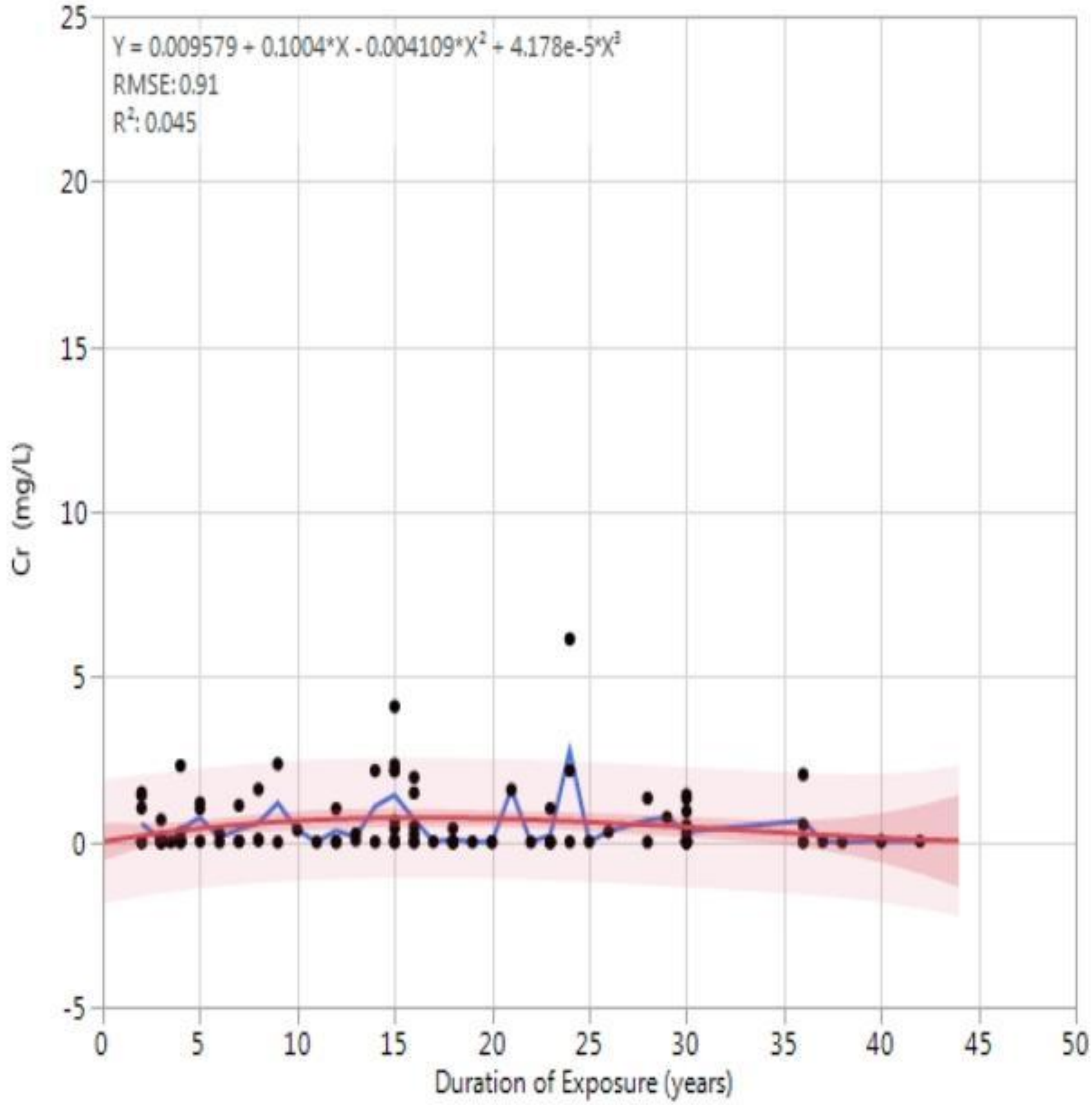

Figure 6: Bivariate Regression analysis of Chromium (Cr)(mg/*L*) against the Duration of Exposure of Automechanics to Petrochemical Products and Showing the fitted line, and confidence regions for the fitted line and individual predicted values

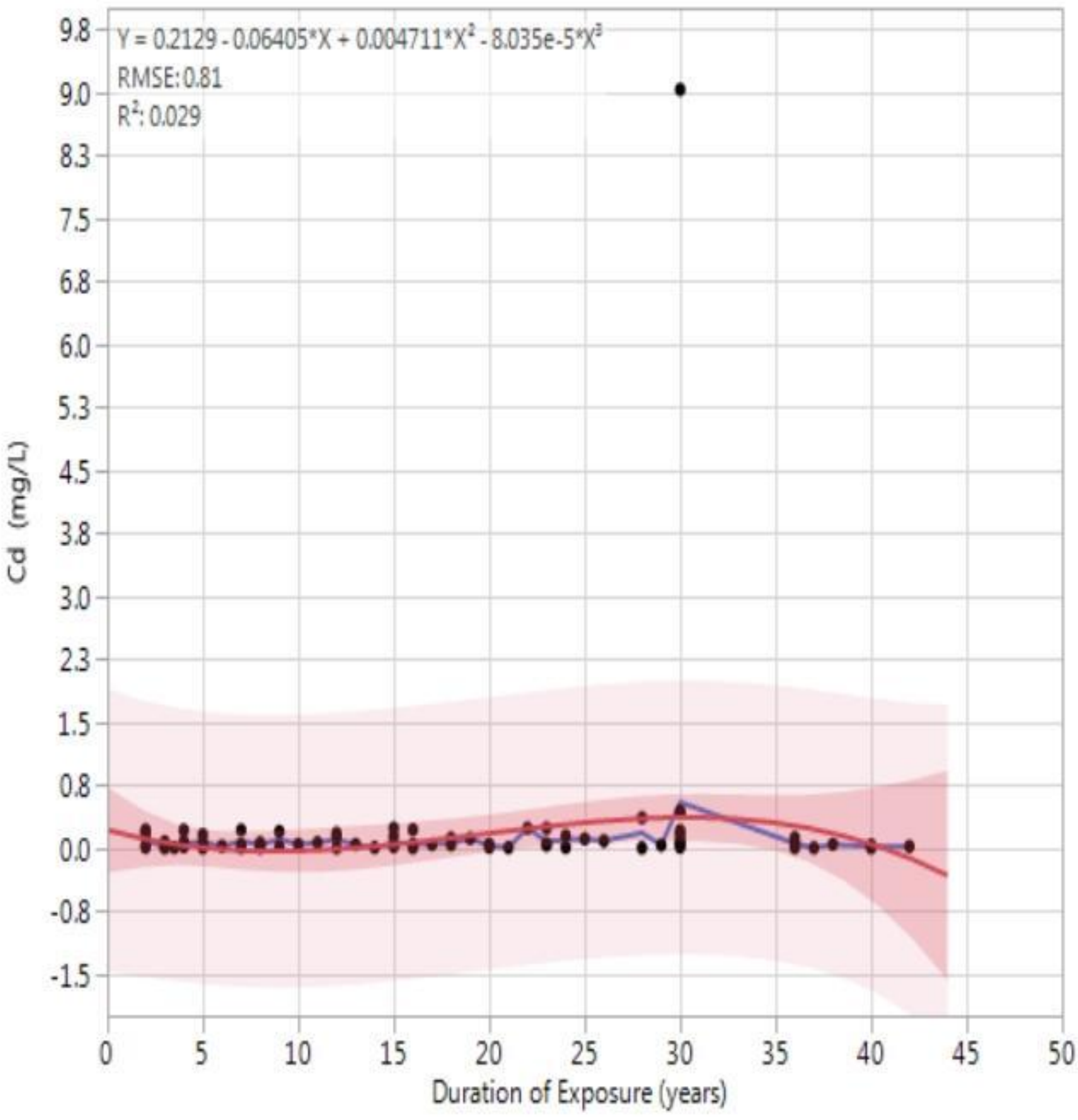

Figure 7: Bivariate Regression analysis of Cadmium (Cd)(mg/*L*) against the Duration of Exposure of Automechanics to Petrochemical Products and Showing the fitted line, and confidence regions for the fitted line and individual predicted values

4. DISCUSSION

Exposure of automechanics in Aba metropolis to environmental contaminants such as petrol and petroleum products was the main focus in the study. Non automechanics chosen as control group were mainly undergraduates and civil servants. The age of participants in relation with treatment groups (control and exposed) and duration of exposure were considered for all the parameters tested.

The mean value for the age of all participants was 33.7 ± 12. A higher mean of37.1 ± 2.9 was observed for the exposed group compared to28.5 ± 9.4 recorded for the control group. Females were not included in this study because throughout the field work, there was no female automechanic seen. Though, it was learn that, there were few females, many years ago, who attempted this occupation, but could not continue because of their physical inability, lifestyle, domestic involvement and child bearing responsibilities. In this study the highest number of years of exposure recorded was 30years and the lowest 2 years with mean duration of exposure as 16.5 ± 11.4 yrs.

The serum concentration of heavy metals in reducing order, were Cr $>$ Pb $>$ As $>$Hg $>$ Cd in the exposed individuals. In the control subjects, the order from the highest concentrationwas ; Cr $>$ Pb $>$As $>$ Cd $>$ Hg. The reason for this high chromium concentration in the control group might be adduced to a poor source of drinking water and some agricultural products consumed within the mechanic workshops [16, 25.26.27] even if we know that automechanics are expose toradiator repairs, welding, spray painting, and automobile battery recycling among others which could have increase the chromium levels. On the other hand, these workers are exposed to various toxic chemicals including lead (Pb) and polycyclic aromatic hydrocarbons [28] which could be absorbed into the body through direct skin contact, ingestion, or inhalation. This might be the reason for the observed increased level of lead in the exposed auto mechanic samples. The lead content of Nigerian petrol is approximately 0.67mg/gallon, compared with the petrol in US which contains 0.05mg per gallon as approved by American Environmental protection Agency [4]. The sources of lead include use of leaded gasoline, automobile batteries, radiators, scrap metals,exhaust fumes, and paints whose adverse health effects include hypertension, cardiovascular diseases, renal failure, liver damage, cancer, and so on [29]. Mercury (Hg) is a common constituent of battery and body of cars. This may have contributed to Hg contamination and significant increase in the exposed compared to the control subjects.The dermal route as an entry of the contamination might have been contributory to the observation. There was no significant difference in the mean of As, Cr and Cd concentration, between the exposed and the control group. It is possible that the automechanics havean adequate bio-machinery for mopping away these toxic chemicals from their system. Good nutrition is also known to reduce the accumulation of toxic chemicals in the body via efficient detoxification and excretion processes [7]. There was significant increase in the mean Pb and Hg concentration in the exposed compared with the control group ($P < 0.05$). This is in agreement with similar study by Boskabady*et al*., [30]. Lead contamination has been described as a leading heavy metal contaminant in the world especially in underdeveloped nations such as Nigeria. The reference value for lead, arsenic, mercury, chromium and cadmium are; < 0.1mg/L, < 0.5mg/L, 0.01mg/L, < 0.04mg/L and ≤ 0.02mg/L respectively. In this study, the data showed increased heavy metal contamination above reference value for health. This could be attributed to the occupational exposure of automechanics with a poor sanitary ambient in most automechanic workshops in Aba as could be seen in a study byDurumin-Iya et al, [31].This is in accordance with earlier studies by Romero-zarazu*et al.,*[32]. The heavy metal level in the exposed, were higher than WHO's recommended and acceptable range for humans, with studies by Ibeto and Okoye, [19] and of Bibi *et al.,*[20].Thisstudy is also in agreement with the study Mohammed *et al.,*[33] where blood lead levels were increased compared to the control in a gasoline exposed station workers in their study.

There was no significant difference in the mean As, Pb, Hg, Cr and Cd concentration between the groups in respect to the duration of exposure ($p > 0.05$). This study shows that duration of exposure may not be the only factor that might determine an increase blood heavy metal level but other factor like; the nutritional statusconcentration in relation to environmental toxicants [34] or other compounds found in petrol [35]. Hence, the need to look beyond occupation as a risk factor for exposure to some heavy metals such as lead. It implies the possible contamination of persons by other potential indirect sources apart from direct contact with petrochemical products. There is need to explore other potential sources of contamination such as soil, water, consumed food items as well as commodities that people are constantly exposed to[36, 37, 38]. This is because some health risks especially with toxicity of heavy metals with the organs has been discovered by studies conducted on auto mechanics [16, 39].Also, as a result of the compounded risk associated with the use of petrol and its products, compressed natural gas (CNG) might serve as an alternative fuel in motor engines and servicing of most motor parts thereby reducing to a greater extent the risk of heavy metal contamination through exhaust emission or other fuel characteristics as automechanics work in the mechanic work place [40].

5. CONCLUSION

From this study, it can be implied that the exposure of the mechanics to petrol and petroleum products might pose a multiplicity of health problems to the individual especially as they age on due to the handling and use of petrol and petroleum products which contain various heavy metal constituents. The blood levels of Lead and mercury exceeded the acceptable concentration of world health organization.

6. RECOMMENDATIONS

Contamination may not necessarily be due to occupational exposure of automechanics but probably through other sources. Automechanics should be careful to wear protective devices while at work and periodic workshop training is recommended for the automechanics. This will create the desired awareness of the dangers in the exposure to toxic chemicals and the need to comply with the standard procedure of practice in the mechanic workshops. Health education and sensitization as well as policies that would regulate exposure of persons to heavy metals should be implemented in Nigeria to mitigate heavy metal pollution and protect the health and well being of auto mechanics and the surrounding communities

Ethical Approval

Ethical approval was given by Abia State Ministry of Health Umuahia, Abia State with Reference number AB/MH/AD/904/T.151.

Consent:

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

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