International Journal of Toxicology and Environmental Health IJTEH
Vol. 4(2), pp. 079-088, September, 2019. © www.premierpublishers.org. ISSN: 1822-424X

Research Article

Health Effects of Occupational Lead Exposures among Informal Automobile Repair Artisans: A Case Study of Nakuru Town, Kenya

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Chronic, high-level lead exposure is known to be a risk factor for kidney and liver diseases. The health effect of low-level occupational exposure to lead is less well known, particularly among informal automobile repair artisans, a population that is at risk of occupational lead exposures due to their predisposing occupational tasks. The study assessed blood lead levels and associated health risks on estimated glomerular filtration rate (eGFR) and serum Alanine Aminotransferase (ALT) activity among the study participants. A descriptive comparative study was conducted and the participants included (n=30) occupationally exposed artisans and (n=30) non-exposed college students. Blood lead levels were analyzed using Atomic Absorption Spectrophotometry according to the NIOSH 8003 **method. Serum ALT activity and eGFR measurements were conducted using Reflotron automated biochemical analyzer. The eGFR was determined based on Modification of Diet in Renal Disease study (MDRD) equation. Data were analyzed using descriptive statistics, regression analysis, ANOVA, and t-test. The mean blood lead (BPb) level of the artisans (25.36µg/dl±2.62SE) was significantly higher than that of the control participants (14.17µg/dl±1.74SE), (t (29) =3.65, *p*=0.001) and exceeded the 20µg/dl WHO biological exposure index (BEI) of concern for adults, (*p*=0.049).The artisans had a significantly decreased eGFR (128.37 mL/min/1.73m^2 ± 4.37SE) compared to the control participants (152.93 mL/min/1.73m^2 ± 3.91SE), (t (29) = -4.49, *p* =0.000). Moreover, the artisans had a lower mean serum ALT activity of (18.50 IU/L±1.63SE) compared to the control participants (21.34 IU/L± 2.85SE). However, the difference was insignificant, (t (29) = 0.86, *p* = 0.40). The study concluded that the artisans were occupationally exposed to lead and risked chronic pathological effects on the kidney and liver functions. The key recommendation therefore is to institute public health intervention measures to curb such occupational health risk among the artisans.**

Keywords: Occupational lead exposure, estimated glomerular filtration rate (eGFR), Blood lead levels. Serum Alanine aminotransferase (ALT) activity, automobile repair artisans

INTRODUCTION

Despite of the occupational health risks involved in informal sector, accessibility to occupational health services among the working population in the sector is lower in the developing countries compared to developed nations (Rantanen and Lavicoli, 2013). Kenya as a developing country has high proportion of workers at the informal sector, currently standing at 83% (KNBS, 2018). Emerging occupational diseases among informal workers therefore should be of great concern to the government and the public. The informal automobile repair artisans are involved in car spray painting, soldering, welding and other

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repairing tasks that predispose them to gradual health risks from occupational lead exposures. Majority of these automobile repair enterprises in the study location are unregistered and are not inspected workplaces thus unlikely to benefit from any occupational health and safety system to curb such health risks. Lead exposure is a risk factor for non-communicable diseases because it primarily affects the peripheral and central nervous systems, renal and hepatic functions (ATSDR, 2019). Non-communicable diseases (NCDs) account for over 50% of total hospital admissions in Kenya (WHO, 2014). More often, individuals exposed to low lead levels are asymptomatic, however, with increased chronic exposures, symptoms may develop due to multiple organ dysfunctions (ATSDR, 2019). The kidney is the major route of lead excretion. Lead exposure can result in impairment of proximal tubular function, manifested by decreased eGFR, impaired tubular transport, and histopathological damage (ATSDR, 2019). Even at a blood lead level lower than 10µg/dl, lead intoxication can result in proximal tubular function impairment (Loghman-Adham, 1997). Studies suggest that low-level exposures to lead are a risk factor for chronic kidney disease (CKD) (Yu *et al*., 2004; Ekong *et al*., 2006). However, a study conducted on the effects of lead exposure among battery workers in Addis Ababa Ethiopia, showed no significant correlation between occupational lead exposures and kidney function (Ahmed *et al.*, 2008). Estimation of glomerular filtration rate (eGFR) is the most common method for clinically assessing kidney function in epidemiological studies (Spector *et al.,* 2011).

The liver on the other hand, is a critical organ that is involved in detoxification and excretion of metabolic products in the body. In the hepatic system, exposure to lead possibly causes and increases serum or plasma liver enzymes, and enlarges the liver (ATSDR, 2019). The liver enzymes are markers of hepatocytes damage. As a response to hepatocytes injury they can leak into the circulation and hence their serum activity is a reflection of the physiological state of the liver. Lead induced liver damage may be assessed indirectly by analyzing the activity of the enzymes released to the blood from damaged hepatocytes and the concentrations of other metabolic products e.g. bilirubin excreted by hepatocytes into the blood (Kasperczyk *et al.*, 2013). A study conducted on biochemical effects of lead exposure and toxicity on battery manufacturing workers of Western Maharashtra (India), reported a significant increase in serum Alanine aminotransferase (ALT) activity in workers compared to control participants (Kshirsagar *et al*., 2015). Significant human suffering related to occupational exposures often results in substantial financial loss due to the burden on health, which can negatively influence production and the national economy (Ahmed *et al.,* 2008). The purpose of this study therefore, was to assess the health effects of occupational lead exposures among the informal automobile repair artisans. The study used eGFR to assess kidney function and Serum ALT activity as an indicator of probable liver damage. The study contributes to the global efforts and the international action plan for preventing lead intoxication (UNEP, 2010).

MATERIALS AND METHODS

Study Location

The study was conducted in Nakuru town (0° 18' 11.1564'' S and 36° 4' 48.0900'' E) located 160 kilometers north west of Nairobi city, Kenya. It is the headquarters of Nakuru County with the major urban population in the County. In the 2014 Kenya Demographic and Health Survey (KDHS), the County had a population of 1,603,325 with 875,980 being urban. The town has a vibrant economy based on sectors such as manufacturing industry, commerce, tourism, agriculture and informal industry. The informal sector enterprises occupy a significant commercial space within the Central Business District (CBD) with the motor vehicle trade and repairs among the leading forms of businesses. The automobile repair workshops are sporadically established within the town with the majority being in an industrial area. Ten workshops were sampled in this study, the 11th site being a college as the comparative study site for non-artisans Figure 1).

Study Design and Sampling

A preliminary survey was conducted to collect primary data on the target population and to determine the study sites. Thereafter, a descriptive comparative study was conducted at the selected informal automobile workshops (n=10) for the artisans and a Medical Training College located within the study area for control participants. A sample size of 60 (n=30) for artisans and (n=30) for control participants was used. Proportionate sample size was collected in each workshop based on the population and tasks performed. In each stratum participants were randomly sampled targeting the following tasks: radiator repairs, lead-acid battery repairs, spray painting, welding and soldering, and general auto-mechanics. The inclusion criteria included artisans with one-year work experience and no history of chronic illness. The control participants as well had at least one year stay at the college and with no history of chronic illness. Data on personal characteristics such as age, sex, work experience, education and daily work hours were collected using a structured questionnaire.

Blood Sample Collection and Analyses

Standard precautions were applied during blood sample collection, transport, and storage (Cornelis *et al*., 1996). The blood lead concentrations were determined using Flame Atomic Absorption Spectrophotometry (FAAS) according to the National Institute for Occupational Safety and Health (NIOSH 8003) standard method (Smallwood**,** 1994). Working standard solutions were prepared and treated using the same method as blood samples.

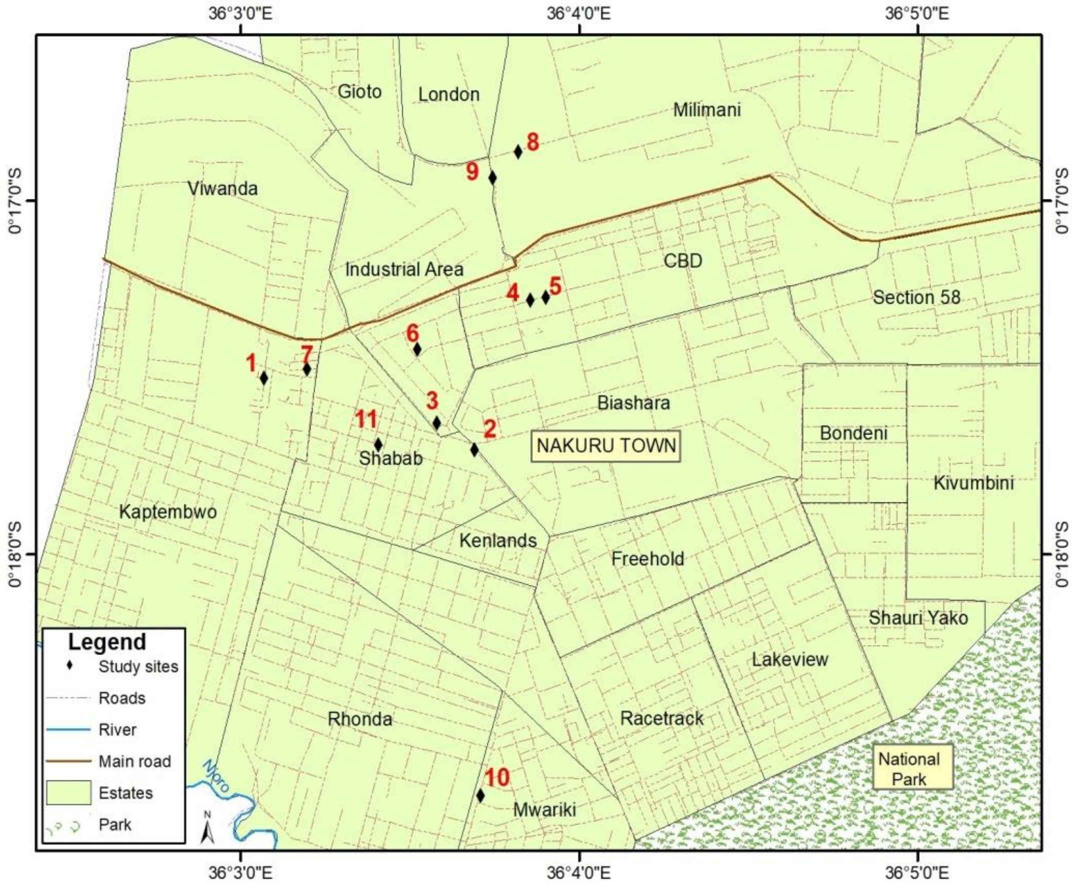

Figure 1: Map of Nakuru town showing the study sites

Determination of estimated Glomerular Filtration Rate (eGFR)

Serum creatinine was measured using Reflotron Assay method by Roche Diagnostics Ltd, United Kingdom (automated biochemical analyzer). The principle of the test was based on the method described by Peake and Whiting (2006). Creatinine values obtained were converted into estimated glomerular filtration rates (eGFR) using the eGFR calculator based on Modification of Diet in Renal Disease study (MDRD) equation (Levey *et al.,* 2007) as recommended by USA National Kidney Foundation.

Determination of serum Alanine aminotransferase (ALT) activity

Serum ALT activity was determined using fully automated biochemical analyzer i.e. Reflotron Assay method by Roche Diagnostics Ltd, United Kingdom. The principle being that ALT catalyzes the transamination reaction in which, α-ketoglutarate and Alanine are converted to pyruvate and glutamate. The pyruvate product in turn becomes a substrate for lactate dehydrogenase (LDH) in the indicator reaction in which NADH is oxidized to NAD^+. The decrease in the optical density of NADH measured photometrically (at 340nm) is directly proportional to the pyruvate concentration and thus to the ALT activity (Kasperczyk *et al.,* 2013). The enzyme activity was expressed in IU/l.

Ethical Considerations

The study was conducted in accordance with the World Medical Association Helsinki Protocols of 2013. To participate in the study, all the participants volunteered with informed consent and were all aged 18 years and above. The study protocol was approved by the Ethics Committee of Egerton University, Kenya National Commission for Science, Technology and Innovation (NACOSTI/P/17/10144/19789), and Ministry of Health-Nakuru County (S19/VOL.II/2017/30).

Statistical Analyses

Statistical analyses were conducted at 95% confidence intervals using SPSS version 22. Analysis of variance (ANOVA) was used to conduct comparisons of differences in blood lead exposures, eGFR and serum ALT activity in different occupational tasks. Linear regressions were used to assess associations between blood lead levels, estimated GFR and serum ALT activity. Student's t-test to compare the mean concentrations of BPb levels, estimated GFR and serum ALT activity between the artisans and the controls participants.

RESULTS

The occupation was dominated by male artisans (100%) probably because it is labour intensive in nature. As shown

(Table 1), the majority (66.6%) of the artisans (n=20) were aged between 18–27 years while 33.3% aged ≥28 years. Similarly, as a result of age matching, all the control participants were male college students, 90% aged between 18–27 years and10% ≥28 years. The average age among the artisans was 26 years±1.01 SE while the control participants were college students with an average age of 23 years± 0.3SE. Sixty percent of the artisans had been on the occupation for ≤5 years while 16.7% for ≥11 years. The average duration at the occupation was 6 years. Notable that the occupation was not a preserve of the uneducated, 46.7% of the artisans had attained secondary and 10% tertiary education.

Table 1: Socioeconomic variables of the participants

Variable	**Artisans (n=30)**	**Control subjects (n=30)**
Age		
Average age (Years ± SE)	26 ±1.01SE	23 ± 0.3SE
18 - 22 Years	33.33%	23.33%
23 - 27 Years	33.33%	66.66%
28 - 32 Years	16.67%	10%
≥33	16.67%	0
Daily work hours		College students
8 hours	43.37%	
10 hours	33.33%	
12 hours	23.30%	
Work experience		College students
≤ 5years	60%	
6 - 10 years	23.33	
≥11 years	16.67%	
Education		Tertiary
None	3.3%	
Primary	40%	
Secondary	46.7%	
Tertiary	10%	

Blood lead levels of the Study Participants

High blood lead was defined as ≥20µg/dl current biological exposure index (BEI) of concern for adults recommended by WHO and the American Conference of Governmental Industrial Hygienists (NIOSH, 2017b). The mean blood lead (BPb) level of the artisans was 25.36µg/dl ± 2.62SE (Table, 2). High BPb exceeding the BEI reference value were recorded among artisans involved in lead acid battery repairs, spray painting and welding repair activities (Table, 2). Consequently, there was a statistically significant difference in BPb levels among the artisans in the different occupational tasks, (F (4, 25) =4.52, *p*=0.007) (Table, 2).

The mean blood lead level for the control participants was 14.17µg/dl±1.74SE. Notably, the mean BPb level was significantly below the 20µg/dl biological exposure index (BEI). Paired sample t-test recorded a statistically significant higher mean blood lead levels for the artisans compared to control subjects at 95% confidence interval, (t (29) =3.65, *p*=0.001).

Estimated Glomerular Filtration Rate of the Study Population

The mean estimated glomerular filtration rate for the artisans (n=30) was 128.37 mL/min/1.73m^2 ± 4.37SE (Table, 3). The lowest eGFR was recorded among the artisans involved in spray painting and welding repair activities, implying a decreased kidney function among them compared to the other artisans. However, there was no significant difference in eGFR among the artisans in different occupational tasks (F (4, 25) =0.54, p=0.71) (Table, 3).

Table 2: Blood lead concentrations of artisans per occupational task

Occupational task	Mean Blood lead conc. (S.E) µg/dl	Range		
		Minimum	Maximum	
Radiator repairs	9.07 (8.28)	0.04	25.60	ANOVA F(4,25)= 4.52 *p*=0.007
Lead acid battery repairs	47.85 (13.53)	34.32	61.37	
Spray painting	26.62 (4.76)	5.74	46.18	
Welding	31.40 (3.81)	18.88	52.10	
General mechanics	18.40 (2.04)	10.36	27.69	
Total (n=30)	25.36 (2.62)	0.04	61.37	

Table 3: Artisans' estimated glomerular filtration rate per occupational task

Occupational task	Mean eGFR (S.E) mL/min/1.73m^2	Range		
		Minimum	Maximum	ANOVA
Radiator repairs	131.67(18.35)	109.00	168.00	F(4,25)=0.54, P=0.71
Lead acid battery repairs	148.50 (2.50)	146.00	151.00	
Spray painting	126.89(8.84)	89.00	186.00	
Welding	121.25(7.32)	100.00	161.00	
General mechanics	130.88(9.11)	91.00	157.00	
Total (n=30)	128.37(4.37)	89.00	186.00	

Table 4: Control participants' estimated glomerular filtration rate with age

Age groups	Mean eGFR (S.E) mL/min/1.73m^2	Range Minimum	Range Maximum	
18 - 22 Years	162.57 (9.90)	120.00	193.00	ANOVA F (2,27)= 6.32, P=0.006
23 - 27 Years	154.70(3.51)	126.00	182.00	
28 - 32 Years	118.67(6.43)	106.00	127.00	
Total (n=30)	152.93(3.91)	106.00	193.00	

The control participants on the other hand recorded an average eGFR of 152.93 mL/min/1.73m^2 ± 3.91SE, with a minimum value of 106 mL/min/1.73m^2 and a maximum of 193 mL/min/1.73m^2, all of which were within the normal reference value (>90 mL/min/1.73m^2) (Table, 4).

The artisans had a decreased and more dispersed eGFR compared to the control participants. Paired sample t-test showed a statistically significant decreased estimated glomerular filtration rate among the artisans at 95% confidence interval, (t (29) = -4.49, *p* =0.000).

Simple linear regression test showed no statistically significant association between blood lead levels and eGFR among the artisans, (r = 0.04, *p*=0.83). However, there was a statistically significant inverse association between BPb levels and eGFR among the control participants (r = -0.62, *p*=0.000). Further analysis of variance showed no significant difference in eGFR with age among the artisans (F (3, 26) = 2.64, *p*= 0.071), (Figure, 2).

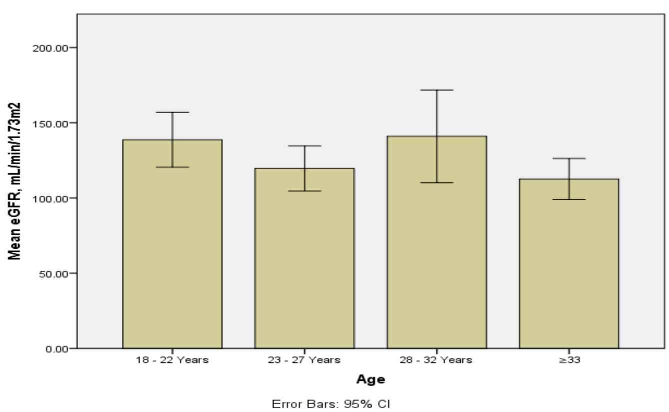

Figure 2: Artisans' estimated glomerular filtration rate with age

However, among the control participants, estimated glomerular filtration rate showed a significant decrease with increase in age (F (2, 27) = 6.32, *p*=0.006) (Figure, 3). Subsequently, simple linear regression showed an inversely significant relationship between the eGFR and age among the control participants (r = -0.62, *p*=0.000) (Table, 5).

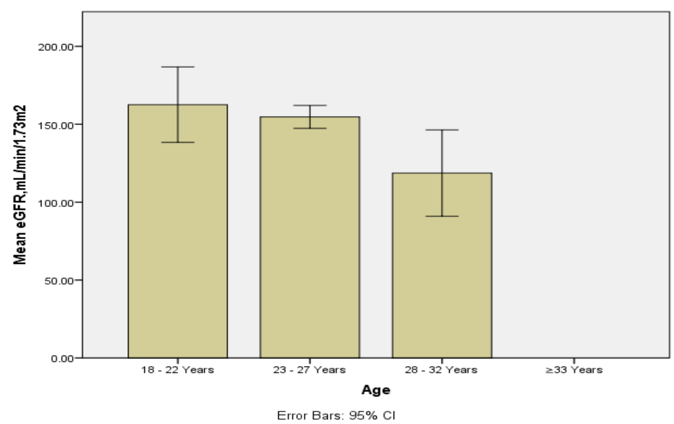

Figure 3: Control participants' estimated glomerular filtration rate with age

The estimated regression equation; eGFR (y) = 267.92 - 5.16β_1, where β_1 is the age of the control participants, significantly explained the influence of age on the eGFR (R^2 = 0.38, F (1, 28) =17.25, *p*=0.000). For every 1year age increase, eGFR decreased by 5.16mL/min/1.73m^2 (Table, 5). This probably reflects that eGFR decreases with age in a normal population.

Table 5: Regression of Age Vs eGFR for the artisans Coefficients [a]

Model		Unstandardised Coefficients B	Unstandardised Coefficients Std. Error	Standardized Coefficients Beta	t	P value	95.0% Confidence Interval for B Lower bound	95.0% Confidence Interval for B Upper Bound
1	(Constant)	267.918	27.862		9.616	0.000	210.846	324.99
	Age (raw)	-5.164	1.243	-0.617	-4.153	0.000	-7.711	-2.617

a. Dependent Variable: eGFR

Serum Alanine aminotransferase (ALT) Activity for the Study Population

The mean serum ALT activity for the artisans (n=30) was 18.50 IU/L ± 1.63 SE, (Table, 6). The highest mean serum ALT activity was recorded among spray painters, suggesting a probable progression of liver damage among them compared to the other artisans. However, all the mean values of serum ALT activities in all the occupational tasks were within the normal reference value (<45 IU/L). Consequently, the difference in serum ALT activity among the artisans in different occupational tasks was not statistically significant (F (4, 25) =1.38, *p*=0.27) (Table, 6).

Table 6: Artisans' serum ALT activity per occupational task

Occupational activity	Mean serum ALT activity (S.E) IU/L	Range		
		Minimum	Maximum	
Radiator repairs	17.67(4.77)	12.80	27.20	ANOVA F (4,25)= 1.38, P=0.27
Lead acid battery repairs	18.80(5.10)	13.70	23.90	
Spray painting	23.83(4.30)	11.80	51.00	
Welding	16.83(2.16)	11.10	30.10	
General mechanics	14.40(1.39)	9.77	21.60	
Total (n=30)	18.50(1.63)	9.77	51.00	

The control participants recorded an average serum ALT activity of 21.34 IU/L± 2.85 SE, (Table, 7). It was notable, that two control subjects recorded serum ALT activity greater than 45 IU/L reference value.

Table 7: Control participants' serum ALT activity with age

Age group	Mean serum ALT activity (S.E) IU/L	Range		
		Minimum	Maximum	
18 - 22 Years	17.47(2.77)	8.52	27.50	ANOVA F (2,27)= 0.81, P=0.455
23 - 27 Years	23.83(4.09)	10.80	76.40	
28 - 32 Years	13.76(1.51)	11.70	16.70	
Total (n=30)	21.34(2.85)	8.52	76.40	

The artisans had a lower mean serum ALT activity compared to the control participants. Nonetheless, paired sample t-test showed that the difference in mean serum ALT activity between the artisans and the control participants was not statistically significant at 95% confidence interval, (t (29) = 0.86, *p* = 0.40). The observed mean values of serum ALT activity for both the artisans and control participants were within the normal reference value (<45 IU/L).

Simple linear regression analyses showed that the association between blood lead levels with serum ALT activity among the artisans was not statistically significant, (r = 0.244, *p*=0.097). Neither was it significant among the control participants (r = -0.027, *p*=0.443).

DISCUSSION

High blood lead levels recorded among lead acid battery repairs were probable because of contamination with dust and fumes generated by directly handling leaded electrodes and lead oxides in the batteries. Suplido and Ong, (2000), reported consistent results in their study on lead exposure among small-scale battery and radiator mechanics in Philippines. They reported mean blood lead level that was significantly higher for battery workers (54.23 mg/dl) compared to other workers. Other reviewed studies have also recorded high blood lead exposure levels among lead acid battery workers (Gottesfeld and Pokhrel, 2011). There was a statistically significant difference in BPb levels among the artisans in different occupational tasks (Table, 2). This finding was inconsistent to findings from a study conducted to assess lead exposure among automobile technicians in Pakistan, where specific tasks performed by the technicians did not influence the BPb levels (Ahmad *et al*., 2018). However, the finding was plausible because the magnitude and the work processes in each task were distinct. Among the tasks that exceeded 20µg/dl BEI threshold included those with welding and spray-painting activities. This signified that such tasks were likely to have greater risks of occupational exposures to lead than the others. Welding or soldering requires that the material melt or fuse through heating which generates leaded fumes depending on the material being welded (NIOSH, 2017a). Besides, artisans carry out surface sanding and grinding activities prior to spray painting (Enander *et al*., 2004). Possibly, during these activities, fumes and dust that might contain lead particles is inhaled or ingested and thus the high blood lead levels observed among artisans undertaking these tasks.

Among the control participants, the observed blood lead levels could be as a result of environmental sources such as water and air pollutants among others. The control participants consisted of students from a college situated in the urban neighborhood of the informal automobile workshops. Therefore, perhaps, vehicular emissions and other sources of lead pollutants might have contributed to these findings. Studies have shown that urban setting where there is probably a high rate of environmental pollution records higher BPb levels compared with rural areas e.g. Njoroge *et al.*, (2008) reported higher prevalence rate of environmental lead exposure to the general public in Nairobi compared to Olkalou, a rural setting. The artisans' blood lead levels were higher and more dispersed compared to control participants. This could indicate the likelihood of occupational exposures among the artisans since the control participants were not likely to be occupationally exposed. Similar findings were recorded by Ashraph *et al*., (2013) in their study among informal sector workers in Mombasa, Kenya.

Estimated glomerular filtration rate (eGFR) is the mostly used method to clinically assess kidney function for epidemiologic studies (Jin *et al.,* 2008, Spector *et al.,* 2011). A decline in eGFR precedes the onset of kidney failure; therefore, a persistently reduced eGFR is a diagnostic criterion for chronic kidney disease (CKD). The USA National Kidney Foundation guidelines for chronic kidney disease based on eGFR, consider an eGFR exceeding 90 mL/min/1.73m^2 as normal kidney function, eGFR of 60 to 89 is mildly decreased, an eGFR of 30 to 59 as moderately decreased and may signify "renal insufficiency", an eGFR of 15 to 29 mL/min/1.73m^2 is considered severely decreased, and an eGFR of less than 15 is considered kidney failure (Levey *et al*., 2003). Significant decrease in eGFR among the artisans suggests that the kidney function among the artisans could be gradually deteriorating and this may be because of occupational lead exposures. Similar findings were recorded by Ashraph *et al*., (2013), in their study on health effects of occupational lead exposure among "Jua Kali" workers in Mombasa, Kenya. They reported low eGFR among the exposed workers than the non exposed. Studies on renal effects of environmental and occupational exposure to lead have associated lead exposures with reduced eGFR (Yu *et al*., 2004). The lowest eGFR were recorded among the artisans involved in spray painting and welding repair activities. These occupational tasks also recorded higher blood lead levels compared to others (Table, 2), suggesting a decreasing kidney function with increasing blood lead levels. This was consistent with a study conducted on blood lead level and kidney function among adolescents in the USA by Fadrowski *et al*., (2010), who reported that higher blood lead levels were associated with lower eGFR. Greater risk of chronic nephropathy has been recorded in occupations with workers having blood lead >60 µg/dl (Kshirsagar *et al.,* 2015). In the current study, the average blood lead of the artisans was 25.4±14.3µg/dl thus perhaps unlikely to cause a significant impact on the kidney function. Other studies on renal effects of environmental and occupational exposure to lead have associated chronic lead exposure of ≤20µg/dl with reduced eGFR (Loghman-Adham, 1997).The findings in this study therefore, do not rule out a gradual lead nephropathy that may result to renal insufficiency if the artisans continue to be exposed at such work environment.

Estimated glomerular filtration rate may be influenced by a number of factors including existence of an underlying disease like cardiovascular disease, age and diet among others. Unlike among the artisans, eGFR decreased with age among the control participants (Table, 5, Figure, 2).This was plausible because occupational exposures to lead among the artisans may be intermittent compared to control participants who were a representative of the normal population. Generally, in a normal population, it is believed that eGFR declines with age at an average rate of 1 ml per year after the age of about 30 years (Morrissey and Yango, 2006).

Unlike among the artisans, there was a statistically significant inverse association between BPb levels and eGFR among the control participants. The findings were consistent with other studies in the literature. Pollack *et al.,* (2015) recorded a decrease in eGFR with increased blood lead among non-exposed premenopausal women in a prospective cohort study in Maryland USA. Besides, in a related study in Mombasa, statistically non significant association between blood lead and eGFR with spearman's correlation coefficient of (0.272) for the exposed subjects and (-0.113) for the non-exposed (p>0.05) were reported (Ashraph *et al.*,2013).

Serum ALT activity has been regarded as a reliable and sensitive marker of liver damage. It is generally elevated in disease status that causes hepatocellular damage thus can effectively identify an ongoing liver disease progression (Kim *et al.,* 2008). Serum ALT levels greater than the upper limit of the normal (ULN) range (45 IU/L) suggest a potentially active liver disease process (Lee *et al.,* 2008). In this study, the difference in serum ALT activity among the artisans in different occupational tasks was not statistically significant. However, the highest mean serum ALT activity was recorded among spray painters, suggesting a probable progression of liver damage among them compared to the other artisans (Table, 6). All the mean values of serum ALT activity among the artisans in all the occupational tasks were within the normal reference value (<45 IU/L). Similar findings were reported by Bhagwat *et al*., (2008) in their study on occupational lead exposures and liver function among workers involved in manufacturing and recycling of lead batteries around Kolhapur (Maharashtra)-India. They recorded no effects on liver functions at considerably high blood lead levels in the range of 25.8–78 µg/dl. Although, the findings were in contrast to a study by Kapaki *et al*., (1998) in Athens, Greece, who reported significantly increased serum ALT activity among workers occupationally exposed to lead. The findings could be probable due to comparably low blood lead levels in the study compared to earlier studies that had linked lead exposures to hepatocellular damage.

There was no statistically significant difference in mean serum ALT activity between the artisans and the control participants (p = 0.40). However, control participants had a slightly higher serum ALT activity compared to the artisans. This was inconsistent with most studies in the literature. A study conducted to evaluate effects of automobile workshop on the health status of auto-mechanics in Pakistan, recorded increased concentrations of serum ALT activity (104.4 ± 49.46 IU/L) in workers compared to the control participants (Khan *et al.,* 2010). Another contrasting finding was recorded in a study in Nigeria, which reported elevated serum ALT activity among different groups occupationally exposed to lead compared to non-exposed groups (Onyeneke *et al.,* 2016). Slightly higher serum ALT activity among the non-exposed participants reported in this study could result due to different factors that may influence serum ALT activity such as body mass index (BMI) and triglyceride levels, age, and time of the day (Salvaggio *et al.,* 1991), which were not controlled in the study. For example, serum ALT activity is reported to be greater in the afternoon than early morning and increases with old age (Prati *et al.,* 2002; Ruhl *et al.,* 2013). Further, there was no statistically significant association between the blood lead levels and serum ALT activity among both the artisans and the control participants. Consistent findings have been reported in the literature by Kasperczyk *et al*., (2013) in their study on the function of the liver and bile duct in humans exposed to lead in Poland. Nonetheless, a study conducted in the United States reported that occupational exposures to lead played a significant role in initiating and promoting adverse hepatobiliary clinical outcomes (Obeng-Gyasi *et al*., 2018). Probably, in order to ascertain the impact of lead exposure among such study population, longitudinal studies, serum ALT activity coupled with other indices of liver dysfunction are necessary.

CONCLUSIONS

The findings of the study showed that informal automobile repair artisans had elevated blood lead level compared to the control study population. Further, the mean estimated glomerular filtration rate of the artisans was significantly impaired compared to the control participants, signifying reduced kidney function among the artisans. However, artisans recorded low serum ALT activity that was however not significantly different compared to the control participants', signifying normal liver function among the study participants. In conclusion, the artisans were therefore occupationally exposed to lead and risked chronic pathological effects on kidney and liver functions. The study recommends public health intervention measures at the informal automobile repair workshops to curb such occupational health risks among the artisans.

ACKNOWLEDGEMENT

Special thanks to all the participants for their voluntary participation and consent to the study. The authors are also grateful to the departments of health services, and county commissioner, Nakuru County for their cooperation during the research study. Finally, thanks to the departments of Biochemistry and Environmental Science Egerton University for their technical assistance and research facilities.

DECLARATIONS OF INTEREST

Funding for this research study was provided by Kenya National Research Fund (NRF). The authors declare that there are no known conflicts of interests.

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Accepted 18 September 2019

Citation: Odongo AO, Moturi WN, Obonyo M (2019). Health Effects of Occupational Lead Exposures among Informal Automobile Repair Artisans: A Case Study of Nakuru Town, Kenya. International Journal of Toxicology and Environmental Health, 4(2): 079-088.