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Research Article

Toxic and Oxidative Effects of Paint Chemicals on Paint Workers in a South-eastern State of Nigeria

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Abstract

Paint handling in developing countries is primarily artisanal, with minimal to no government oversight. Occupational exposure to paint chemicals has been linked to organ toxicities. However, its effects on these artisanal workers have not been fully elucidated. This study assessed changes in liver enzymes and lipid profiles in paint workers in Enugu metropolis, Enugu State, Nigeria. The study employed a cross-sectional design, involving 60 paint workers aged between 20 and 60 years, and 60 age-matched, apparently healthy subjects who had never worked with paint (controls). Serum activities of some liver enzymes, ALT, AST, and ALP, and concentrations of lipid parameters, total cholesterol, HDL, LDL, VLDL, and triglycerides were determined. Results showed that paint workers had statistically significantly increased activities of ALT and AST (p = 0.000, each), and concentrations of LDL (p = 0.001), when compared with the controls. HDL was significantly reduced in paint workers (p = 0.000) when compared with the controls, while other parameters did not show any significant differences (p > 0.05, each). ALT, AST, total cholesterol, and LDL showed positive correlations with work duration (p = 0.000, each), while HDL had a negative correlation with work duration (p = 0.009). Other parameters did not show any significant change with work duration (p >0.05, each). These results indicate that paint workers in Enugu metropolis are at risk of toxic liver damage and lipid peroxidation, increasing the risk of cirrhosis and cardiovascular diseases. Mandatory use of personal protective equipment by workers, improved workplace ventilation, stricter regulatory oversight, and annual health evaluations are essential to mitigate these risks.

Introduction

Paint is a liquefiable resin used for domestic and industrial purposes, usually for decorative and protective functions. Paint contains a lot of toxic chemicals, including heavy metals, free radicals, and various Volatile Organic Compounds (VOCs) like pigments, extenders, binders, solvents, and additives [1]. These chemicals are known to be toxic to human organs [2,3] and increase oxidative stress by disrupting the metabolism of some antioxidants in the body [4]. Paint industry workers and painters in developing countries are mainly artisans, with low educational and socioeconomic status [5]. They do their jobs with little or no protection, and may be involved for a long period as long as the job helps them meet their daily needs. Hence, for the short-term and long-term exposure, they inhale paint fumes in poorly ventilated working environments or together with other air pollutants in industrial areas [6]. In addition, these chemicals can be contacted dermally or by ingestion, mostly from contaminated water bodies as well as eating food materials from contaminated soil [7]. Apart from organ toxicities, paint chemicals have also been linked to birth defects, cancers, and central nervous system changes like loss of memory, confusion, seizures, allergies, neuropsychological, and respiratory problems [8,9]. However, the magnitude of the effect is known to depend on the nature of the chemical in the paint, duration, and method of exposure [10]. Hence, lack of use of personal protective equipment (PPE), and poor working environment have long been recognized as factors in the development of the damages [11].

The liver plays a crucial role in the metabolism and detoxification of harmful substances or chemicals, such as those present in paints, and some endogenous wastes, which

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influence its metabolic and hemodynamic processes. It is therefore expected that repeated and/or prolonged exposure to toxic paint chemicals may manifest as altered liver enzyme activities, like those of Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), and Alkaline Phosphatase (ALP), the enzymes used as a gold standard to differentially diagnose and monitor hepatotoxicity [12,13]. ALT and AST are the hepatocellular enzymes that tend to increase in activity whenever there is damage to the liver cells, while ALP activity increases mainly in obstructive conditions. Thus, when such alterations are left unchecked, this can lead to more serious liver degeneration, like liver cirrhosis or cancer. Factors suspected to be leading causes of paint-associated liver damage include long hours of working in very poorly ventilated environments, lack of Personal Protective Equipment (PPE), and poor automobile spray rooms [14]. Artisanal paint workers spend years on the job, and few of them use PPE while working; hence, they are greatly predisposed to liver damage. The mechanisms of the actions of these paint toxicants may include oxidative stress, inflammation, dysfunction of cytochrome $P_{450,}$ and mitochondrial dysfunction [15], given that paints contain heavy metals that induce oxidative stress and inflammation, and VOCs that cause inflammation and induce mitochondrial dysfunctions [1,16]. It has also been suggested that long-term exposure to low concentrations of these toxicants can lead to asthma, reduced lung function, cardiovascular disease, and cancer [17].

Paint contains aromatic hydrocarbons, substances suspected to be involved in the causation of cardiovascular diseases [18]. Cardiovascular diseases are conditions affecting the heart and blood vessels. These diseases account for 32% of total deaths and 38% of deaths due to non-communicable diseases in 2019 [19]. Among the known risk factors for these diseases are high cholesterol [20] and hydrocarbons that impair blood circulation and cause oxidative damage [21]. Hydrocarbons cause oxidative damage through the generation of free radicals, and these free radicals go on to cause lipid peroxidation [22]. Thus, exposure to paint chemicals may not only cause organ damage but also lipid peroxidation, a situation suspected of being involved in familial cardiovascular diseases [18]. Thus, there is a possibility that paint chemicals can cause lipid derangements.

The effects of these paint toxicants on the general well-being of paint workers, especially the artisanal paint workers, have not been fully evaluated. This study presents the activities of the gold standard liver enzymes and the lipid profiles in artisanal paint workers (paint mixers, dispensers, loaders, and painters) in Enugu metropolis, Enugu State, Nigeria. This will expose the occupational hazards encountered by these workers, especially those who have been on the job for a long time. The study will encourage these workers to use personal protective equipment, stimulate paint manufacturers to provide good working environments, and constantly evaluate the health conditions of their workers, and cause the governments to enact legislation for proper working environments for the paint industry.

Materials and methods

Ethical clearance

Ethical clearance for this study was obtained from the Ethical Committee of the Faculty of Basic Medical Sciences, College of Medicine, Enugu State University of Science and Technology, Enugu, Nigeria (ESUT/FBMS/EC/2024/081). Informed consents of the participants were also sought and obtained from each participant after the reason and procedure for the study were fully explained to them.

Study area

The study was carried out in Enugu metropolis of Enugu State of Nigeria, between June and December 2024. Enugu State is in the South-eastern part of the country with 2025 estimated population of 907,000 and a growth rate of 3.54% [23].

Sample size

Sample size was determined using the Taro Yamane Formula.

$n = (Z^2 \times P \times (1-P)) / E^2$

Where

n = sample size

Z = 1.96 (for 95% confidence)

P = 0.25 (estimated proportion of paint workers)

E = 0.11 (margin of error)

Calculation:

$n = (1.96^2 \times 0.25 \times (1-0.25)) / 0.11^2$

$n = (3.8416 \times 0.25 \times 0.75) / 0.0121$

$n = 0.7203/0.0121$

$n = 59.53$

$n \approx 60$

Inclusion criteria

All paint factory workers involved in mixing, dispensing, and loading of paints, and who have done the work for at least one year, were recruited for the study. Also recruited were artisanal painters who had been painting for at least one year before the study.

Exclusion criteria

People excluded from the study included paint factory workers and painters who had not spent up to one year on the job. Also excluded were other factory workers, like administrators and security personnel, who were not directly involved in the paint production or usage.

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Sample collection

A total of 3.0ml of blood sample was collected from each subject and put into a clean, grease-free glass test tube. It was allowed to clot and retract before being spun in a centrifuge at 5000 rpm for 5 minutes. The resulting serum was then stored frozen at -20 °C until needed for analysis.

Laboratory analyses

The activities of Alanine Transaminase (ALT), Aspartate Transaminase (AST), and Alkaline Phosphatase (ALP) were assayed using kinetic methods [24,25] as prepared by Randox. All instructions were strictly followed to obtain reproducible results. The concentrations of the lipid profile parameters were determined as previously reported [26].

Data analyses

The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS version 23). One-way analysis of variance (ANOVA) was used for the comparison of the mean differences between and among groups, respectively, at a 95% confidence interval. A p - value of 0.05 or less was considered statistically significant. The validity of data collected was ensured by double entry and random checks for errors.

Results

Table 1 shows the comparisons of the mean ± SD of all the studied parameters in both paint workers and control subjects. ALT and AST showed significantly elevated activities in painter workers compared to controls (p = 0.000, each). Also, the concentration of LDL-cholesterol was significantly higher in painter workers than in controls (p = 0.000), while HDL-cholesterol was significantly lower in paint workers than in controls (p = 0.001). However, there was no statistically significant difference between the activities of ALP in both paint workers and controls (p = 0.327). Likewise, there were no statistically significant differences between the concentrations of total cholesterol, VLDL-cholesterol, and triglycerides in paint workers and those of the controls (p > 0.05, each).

Paint workers were then grouped according to the number of years already spent on the job (duration of exposure to paint chemicals). The results showed that there were strong positive correlations between the activities of ALT and AST, as well as concentrations of total cholesterol and LDL-cholesterol, and work duration (p = 0.000, each). There was also a negative correlation between HDL-cholesterol concentration and work duration (p = 0.009). However, ALP activity and concentrations of VLDL-cholesterol and triglycerides showed little but non-significant variations across exposure periods (Table 2).

Table 1: Mean ± SD activities of liver enzymes in paint workers and controls.

Parameters/Subjects	All subjects N = 120	Paint workers N = 60	Control N = 60	p - value	Sig
ALT (IU/L)	19.48 ± 20.41	35.03 ± 18.57	3.93 ± 1.53	0.000	S
AST (IU/L)	29.72 ± 29.29	51.47 ± 27.49	7.97 ± 3.30	0.000	S
ALP (IU/L)	50.20 ± 13.25	48.51 ± 14.18	51.89 ± 12.45	0.327	NS
Tot-chol (mmol/L	5.37 ± 0.71	5.45 ± 0.79	5.29 ± 0.60	0.270	NS
HDL-chol (mmol/L)	1.46 ± 0.39	1.31 ± 0.39	1.62 ± 0.33	0.000	S
LDL-chol (mmol/L)	3.40 ± 0.71	3.63 ± 0.78	3.18 ± 0.54	0.001	S
VLDL-chol (mmol/L)	0.51 ± 0.31	0.51 ± 0.37	0.50 ± 0.23	0.938	NS
TG (mmol/L)	1.12 ± 0.67	1.13 ± 0.81	1.11 ± 0.51	0.856	NS

TG: Triglycerides; S: Significant; NS: Non-significant

Table 2: Mean ± SDs of enzyme activities and lipid concentrations with work duration.

Parameters/Duration	1-4years N = 16	4-7years N = 23	>7years N = 21	p - value	Sig
ALT (IU/L)	8.75 ± 13.11	36.36 ± 18.21	52.82 ± 23.21	0.000	S
AST (IU/L)	15.25 ± 15.12	54.36 ± 14.33	74.91 ± 21.54	0.000	S
ALP (IU/L)	51.74 ± 29.35	43.88 ± 21.21	50.79 ± 28.17	0.406	NS
T-chol (mmol/L)	5.01 ± 0.58	5.58 ± 1.05	5.98 ± 0.37	0.000	S
HDL-chol (mmol/L)	1.45 ± 0.42	1.23 ± 0.39	1.06 ± 0.20	0.009	S
LDL-chol (mmol/L)	3.17 ± 0.32	3.73 ± 1.19	4.20 ± 0.29	0.000	S
VLDL-chol (mmol/L)	0.39 ± 0.11	0.61 ± 0.62	0.60 ± 0.30	0.109	NS
TG (mmol/L)	0.85 ± 0.24	1.36 ± 1.35	1.35 ± 0.65	0.097	NS

TG: Triglycerides; S: Significant; NS: Non-significant

Discussion

The results of this study showed that liver enzymes, particularly ALT and AST, increased significantly in paint workers when compared with non-workers. This finding is consistent with earlier studies on similar subjects [6,27,28]. However, the present study showed that ALP did not change significantly in paint workers compared with non-workers, contrary to the findings of one earlier study [28]. ALT is a vital enzyme primarily found in the liver, although it can also be detected in a few other organs, including the kidneys, heart, and muscle cells [29,30], making it a primary indicator of liver damage. AST is a pyridoxal phosphate-dependent enzyme that is also found abundantly in the liver, heart, skeletal muscle, kidneys, and blood cells [31]. Although it can be found throughout the body, AST is most commonly associated with liver health. Both enzymes have jointly formed the basic biomarkers of hepatocellular damage. Therefore, their significant increase in paint workers is an indication of the hepatotoxicity of the constituents of paint. The liver is regarded as the powerhouse of the body, where most biotransformation of toxicants, including heavy metals and volatile organic chemicals [3,32], occurs. These toxicants are known risk factors for human health [33]. Thus, in the process of discharging its detoxification duty, the liver can be overwhelmed and damaged by the toxicants.

Again, the results of this study showed that the activities of these enzymes, particularly ALT and AST, increased with increased work duration. This implies that the longer the paint workers stay on the job, the more certain it becomes that such workers will develop liver problems, cirrhosis, or hepatoma. This is because more paint chemicals are inhaled or ingested and retained by the body. This has been demonstrated earlier among workers in other areas that involve inhalation or ingestion of heavy metals [3].

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This study also showed that LDL-cholesterol increased significantly in paint workers when compared with controls. LDL-cholesterol is regarded as the bad cholesterol and implicated in the causation of cardiovascular diseases [34], implying that paint workers might be liable to develop the diseases, especially those who have spent long years on the job. The assumption that older workers might be more liable to develop cardiovascular diseases is confirmed by the finding, from this study, that LDL-cholesterol and triglycerides have strong positive correlations with work duration. In addition, HDL-cholesterol, which is regarded as good cholesterol, had a statistically significant negative correlation with work duration. High LDL-cholesterol and triglycerides, with low HDL-cholesterol, are confirmed risk factors for cardiovascular diseases [33,35-37]. Hence, these workers are not only liable to develop liver problems but also cardiovascular problems. Furthermore, dyslipidemia has been implicated in a cluster of conditions referred to as metabolic syndrome [38] that include hypertension, insulin resistance, and obesity. It is also possible that some paint chemicals, like lead, may accumulate in the kidney and inactivate Catecholamine-O-Methyltransferase (COMT) involved in the regulation of epinephrine, norepinephrine, and dopamine [39], causing hypertension. There is suspicion that VOCs can cause DNA double-strand breaks, and DNA derangements can be inherited by offspring. DNA double-strand breaks have been suspected to cause familial cardiovascular diseases [18]. Therefore, prolonged stay in this job without proper protective measures and constant health evaluations can cause a plethora of problems for the workers, as well as their offspring.

Conclusion

This study has shown that paint workers are exposed to hazardous chemicals that impact their health. Particularly, there is a profound effect on the liver, with dyslipidemia. This implies hepatotoxicity and cardiovascular diseases, and that those who have cardiovascular diseases as a result of dyslipidemia, and have been on the job for a long time, can transfer such to their offspring (familial cardiovascular diseases). Therefore, there is a need for education of intending paint workers on the compulsory use of personal protective equipment, annual evaluation of the health status of these workers, and government legislation for good working environments in the paint industry.

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