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(RESEARCH ARTICLE)

Correlative study on the effect of toxic paint chemicals on the hepatorenal of paint factory workers in Enugu, Nigeria

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Abstract

Objective: Some chemical components of paint have been classified as toxigenic and carcinogenic to human health. The liver and kidney function markers have been found useful in assessing toxic effect of substances. This study assessed the liver and kidney function parameters of paint factory workers in Enugu, Nigeria.

Methods: One hundred and forty apparently healthy men, aged (21-40 years), were recruited for this cross-sectional study. Eighty paint factory workers (PFW) as test subjects and sixty non-paint factory workers (NPFW) as controls. Blood samples were collected from participants for the determination of serum electrolytes, urea, creatinine, alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), conjugated and total bilirubin using standard methods. Data were analysed using SPSS computer software version 22.

Results: The results showed that mean serum level of AST, ALP, Sodium and Chloride were significantly higher in PFW compared to NPFW ($P< 0.05$). Workers use of personal protective equipment were hand gloves (20%), goggles (7.5%), safety boots (52.5%), dust masks (20%), factory gown (36.25%). Self-reported occupational health problems amongst the PFW was also evaluated, and headache had the highest percentage (68.75%), followed by eye irritation (60%), skin irritation (56.25%), dizziness (23.75%), sleep disorder (20%), anxiety (12.5%), memory loss (0%).

Conclusion: This study shows that occupational exposure of humans to volatile organic compounds and heavy metals in paints may have long term deleterious effects on liver, kidney or brain function in paint factory workers.

Keywords: Paint factory-workers; Liver; Kidney; Hepatotoxicity; Nephrotoxicity

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1. Introduction

Paint has been in use for renovation and beautification of a place but its fumes have been found to contain toxic chemicals such as organic solvents and volatile organic compounds (VOCs) [1-3]. These VOCs and some heavy metals in the paint have been linked to generate free radicals that can lead to oxidative stress with its deleterious effect on individuals such as CNS effects (headache, nausea), cancer induction, liver and kidney damage, permanent brain damage, including loss of memory and confusion [4-7].

Paint manufacturing includes the following processes: mixing, milling, and shearing, during which the workers may become exposed to organic solvents which may cause a variety of unpleasant symptoms. These symptoms may manifest as transient symptoms of the CNS (e.g. euphoria, headache and dizziness) at low or moderate concentrations and serious symptoms such as fainting, respiratory and circulatory failure at high concentrations [8-10]. Solvents such as benzene, toluene, and xylenes (BTXs) are reported to be carcinogenic and therefore need effective control [11, 12]. Several studies have described the effects associated with its long-term exposure, particularly the damage to the Central Nervous System, such as cognitive and emotional deficits. In addition, solvent-related chronic encephalopathy (SRCE) has been described in other studies. Toxic effects of organic solvents were reported to harm liver, kidney and skin [7, 8, 13].

The growing number of industries across the globe has increased the need for different organic solvents. Although their inflammable and explosive nature remains a source of concern about their usage, attention has been drawn to their toxicological effects and health risk. The most important toxicological properties of organic solvents are their ability to evaporate and to dissolve fats. By dissolving fats, organic solvents can damage fat-rich hematopoietic tissues, the reproductive system, the nervous system, skin and all parenchymatous organs [14].

Recently, some studies have suggested that occupational exposure to paint may cause an increased risk of several kinds of cancer, organ failure/damage, distortion in biochemical and hematological parameters, lymphatic and hematopoietic tumors [15]. Workers in paint industries are vulnerable to toxic effects due to the exposure to toxic chemicals and solvents [16]. Chemicals (organic and inorganic) used in paint industries usually contain heavy metals such as cadmium, lead, chromium etc. which are well known for the risks they cause to human health [17]. The hazards posed by chemicals used in paint manufacturing can be better ascertained and understood by assaying the levels of biochemical and hematological parameters of these workers. Many clinical enzymes in the blood have continued to serve as diagnostic biomarkers for assessing necrosis of the liver cells. Many of these enzymes, such as lactate dehydrogenase (LDH), aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) are release from the liver following hepatotoxicity by harmful xenobiotics. Furthermore, the kidney is also major organ for assessing toxicity of harmful substances, because of its role in eliminating the substances. Liver and kidney function markers have been found useful in assessing toxic effect of any harmful substance. The chemical mixtures in paints differ among factories in different regions of the world, thus their degree of toxicity may differ significantly; and it is noteworthy that the level of health and environmental safety differs also. Therefore there is a need to monitor the early possible effects of these toxic substances in the exposed paint factory workers since most of them do not use personal protective devices in developing countries.

2. Material and methods

2.1. Study Design/Selection

The study was a cross sectional study involving a total number of one hundred and forty (140) adult human volunteers aged (21-40 years) from Enugu metropolis. Eighty (80) subjects were recruited as Test group who are paint factory workers (PFW), while sixty (60) were recruited as controls who are non-paint factory workers (NPFW). Informed consent was obtained from each participant. Questionnaires were distributed and duly filled by the participants. Inclusion criteria for the test group were paint factory workers for up to two years duration, while control groups were students not in direct exposure to paint fumes. All the participants were non-smokers, non-alcoholics, apparently healthy and not on any drugs at the time of the study.

2.2. Sampling Techniques

Venous blood was collected into appropriately labelled five millilitre (5ml) plain tube. Sample was allowed to clot and retract, centrifuged at 5,000 rpm and the supernatant (serum) was separated into another labelled vial and stored at -20^{0}C until analysed, and the analyses were carried out within 48 hours of collection. All analysis of the samples was done by the researchers at the laboratory of Enugu State University Teaching Hospital Parklane.

2.3. Ethical Considerations and Informed Consents

Ethical approval was duly obtained from the ethics committee of the Enugu State University Teaching Hospital, Parklane, Enugu (ESUTHP/C-MAC/RA/034/204). Written consent of willingness to participate, in the study as subject, was obtained from all the participants.

2.4. Biochemical Analysis

All analysis was done using reagent kits manufactured by Randox Laboratories Ltd, Antrim, United Kingdom. Estimation of serum electrolytes (sodium, potassium, bicarbonate and chloride) were done using ion selective electrode (ISE). Aspartate and Alanine transaminase were estimated using Reitman-Frankel Colorimetric method [18]. Alkaline Phosphatase was assayed using Phenolphthalein monophosphate Substrate method [19], while **e**stimation of Bilirubin was determined using Powel method [20].Urea was determined using Berthelot's urease method [21], Creatinine estimation was by Jaffe Kinetic method [22] and Glomerular Filtration Rate (eGFR) was estimated using Cockcroft- Gault equation [23] which takes into account age, sex, serum creatinine and weight to determine the eGFR.

2.5. Statistical Analysis

Data obtained from this study was analysed using SPSS version 22. Data were presented as mean and standard deviation. Student's t-test was used to calculate differences between the means. All hypotheses tests were performed using two-tailed test and p-value <0.05 considered statistically significant.

3. Results

Table I. shows the mean±SD of total bilirubin, conjugated bilirubin, ALP, ALT and AST of paint factory workers (test) and non-paint factory workers (control). The result shows a statistically significant increase ($p < 0.05$) in the mean AST and ALP levels, and no significant difference in the mean of ALT, total bilirubin and conjugated bilirubin of the point factory workers compared to the non-paint factory workers.

Table 1 liver function parameters of paint factory workers (pfw) and non-paint factory workers (npfw)

Groups	**Total bilirubin (mmol/l) Mean ± SD**	**C. Bilirubin (mmol/l) Mean ± SD**	**ALP (iu/l) Mean ± SD**	**ALT (iu/l) Mean ± SD**	**AST (iu/l) Mean ± SD**
PFW (test) n= 80	11.16 ± 2.11	6.36 ± 8.75	90.48 ± 17.25	13.16 ± 11.25	14.32 ± 2.34
NPFW (control) n = 60	10.73 ± 1.92	4.52 ± 0.70	76.96 ± 23.94	9.72 ± 1.67	12.28 ± 2.76
P value	0.503	0.382	0.037*	0.207	0.012*

*Significant value $p < 0.05$; n = number of samples.

Table 2. Shows the mean±SD of sodium, potassium, bicarbonate, chloride, urea, creatinine and glomerular filtration rate (GFR) of paint factory workers and non-paint factory workers. The result shows a statistically significant increase ($p<0.05$) in the mean of sodium and chloride while there was no significant difference in the mean of potassium, bicarbonate, urea, Creatinine and GFR of the paint factory workers compared to that of the non-paint factory workers.

Table 2 kidney function parameters of paint factory workers (pfw) and non-paint factory workers (npfw)

Groups	**Sodium mmol/l**	**Potassium mmol/l**	**Bicarbonate mmol/l**	**Chloride mmol/l**	**Urea mmol/l**	**Creatinine mmol/l**	**GFR ml/mm/1.7m²**
PFW(Test) n = 80	140.16±2.15	4.12±0.33	26.68±1.79	100.60 ± 2.06	5.24± 2.11	108.04 ± 14.86	95.00±16.46
NPFW(control) n = 60	137.22±2.57	3.98±0.29	25.72±1.84	97.44 ± 4.57	5.16±1.75	105.56 ± 12.75	101.72±9.65
P value	0.000*	0.156	0.095	0.012*	0.730	0.103	0.101

Table 3 shows the awareness of occupation hazards and safety measure utilization amongst paint factory workers. The result shows that 48.75% are aware of the hazards associated with working in paint factory while 36.25% and 15% are not aware and did not respond respectively. Again 48.75% use personal protective equipment while 40% and 11.25% do not use and did not respond respectively. Also the result shows that only 16.25% of the paint factory workers regularly use PPE, while 32.5%, 40% and 11.25%, occasionally use, never use and did not respond respectively. Furthermore, the result also shows that 45%, 35% and 20% have knowledge of paint fumes, do not have knowledge of paint fumes and did not respond respectively. Also from the result, only 32.5% know the effects of the fumes on their health, while 47.5% do not know the effects on their health and 20% did not respond.

Table 3 Awareness of occupation hazards and safety measure utilization

Variable	**Frequency**	**Percent age (%)**
Awareness of the hazards associated with this job?		
Yes	39	48.75
No	29	36.25
No response	12	15
Total	80	100
Do you use personal protective equipment's?		
Yes	39	48.75
No	32	40
No response	9	11.25
Total	80	100
How often do you use PPE		
Regularly	13	16.25
Occasionally	26	32.5
Never	32	40
No response	9	11.25
Total	80	100
Knowledge of paint fumes		
Yes	36	45
No	28	35
No response	16	20
Total	80	100
Knowledge of its effects on health		
Yes	26	32.5
No	38	47.5
No response	16	20
Total	80	100

Table 4 shows the use of personal protective equipment amongst paint factory workers. The result shows that only 20% use hand gloves and 80% do not use hand gloves. Only 7.5% use goggles 85% do not use goggles and 7.5% did not respond. Also from the result 52.5% use safety boots, 31.25% do not use it while 16.25% did not respond; 20% use dust marks, 67.5% do not use it while 12.5% did not respond. Meanwhile, only 36.25% of the paint factory workers were wearing factory gowns during work, while 63.75% of the workers were not wearing factory gowns during work.

Table 4 The use of personal protective device among paint factory workers

Personal Protective Equipment	Frequency	Percentage (%)
Hand gloves		
use	16	20%
Don't use	64	80
No response	0	0%
Total	80	100
Goggles		
use	6	7.5
Don't use	68	85
No response	6	7.5
Total	80	100
Safety boots		
use	42	52.5
Don't use	25	31.25
No response	13	16.25
Total	80	100
Dust masks		
use	16	20
Don't use	54	67.5
No response	10	12.5
Total	80	100
Factory gown		
Use	29	36.25
Don't use	51	63.75
No response	0	0
Total	80	100

Table 5 shows some self-reported occupational health problems/disorders amongst paint factory workers. The result shows that 80% of the workers experience such symptoms while 20% don't experience any symptoms. Also 80% experience multiple symptoms. The table also shows that headache is the most reported health problem (68.75%) closely followed by eye irritation (60%), skin irritation (56.25%) and chronic fatigue (52.5%). Less experienced symptoms include, dizziness (23.75%), sleep disorder (20%), weight loss (16.25%) and anxiety (12.5%).

Table 5 self-reported occupational health problems amongst paint factory workers

Symptoms	Frequency	Percentage (%)
Headache	55	68.75
Memory loss	0	0
Dizziness	19	23.75
Sleep disorder	16	20
Weight loss	13	16.25
Chlorine fatigue	42	52.5
Eye irritation	48	60
Skin irritation	45	56.25
Anxiety	10	12.5
No symptoms	16	20
Multiple symptoms	64	80

4. Discussion

There is usually aerosols of chemicals in the work environment, and when inhaled and absorbed into the body, pose a potential risk for workers' health. There are reports of the interactions between air pollutants and living tissues, causing disturbances of Pro and anti-oxidant balance of the body. In this study, the serum levels of sodium and chloride were significantly ($p<0.05$) higher in the paint factory workers compared to the non-paint factory workers. This hypernatremia and hyperchloraemia seen in the occupationally exposed paint factory workers may be as a result of dehydration as well as kidney dysfunction caused by inhalation of some toxic chemicals in the factory. This finding is in line with the work of Onuegbu *et al* [24] who reported elevated serum sodium and chloride in test subjects occupationally exposed to lead but contradicts Orisakwe *et al* [25] who reported lower serum sodium in paint factory workers compared to non-paint factory workers in Nkpor Eastern Nigeria. The liver function tests of these participants were also determined and the result shows a significant ($p< 0.05$) increase in the serum Aspartate transaminase (AST) and Alkaline phosphatase (ALP) in the occupationally exposed paint factory workers (test subjects) compared to the non-paint factory workers (controls). This higher level of serum ALP in the paint factory workers could be as a result of liver diseases or bone disorders for example bile ducts blockage or inflammation of the gall bladder (cholecystitis). Again the higher level of AST activity seen in the paint factory workers may also be as a result of damage to the liver and a blockage in blood flow to the liver from inhalation and exposure to toxic substances in the factory. This report agrees with the findings of Orisakwe et al [25] which reported an increase in the serum level of AST and ALP in the occupationally exposed paint factory workers in Nkpor, Anambra state, Nigeria. This finding also agrees with Dioka *et al* [26] who reported higher serum AST though lower ALP in artisans occupationally exposed to lead in Nnewi town of Anambra state, Nigeria.

Furthermore, in this study awareness of occupationally hazards associated with paint factory was evaluated and we found out that only 48.75% (39/80) among the participants were aware of the hazards. Again the usage of personal protective devices (PPE) was also evaluated and from the eighty participants only 48.75% use PPE among which only 16.25% do use PPE regularly. The personal protective equipment evaluated in this study was hand gloves, goggles, safety boots, dust masks and factory gown. The study reported that only 20% of the participants use hand gloves, 7.5% goggles, 52.5% safety boots, 20% dust masks and 36.25% factory gown. This finding was in agreement with the work of Awodele *et al*. [27] which reported a lack of adequate work safety practices in paint factories of Lagos west senatorial district of Nigeria.

In addition self-reported occupationally health problems amongst paint factory workers were assessed, it was observed that only 20% of the respondents reported that they were symptoms – free, whereas the other 80% of the respondents had symptoms relating to hazard exposures with headaches being the most frequent (68.75%). Others include eye irritation (60%), skin irritation (56.25%), chronic fatigue (52.5%), and sleep disorder (20%). Although this study did

not directly link the cause of these effects/disorders to the chemicals (solvents and heavy metals containing raw materials) used in the industry, previous investigations have shown that they are linked according to the findings of Awodele *et al* [27] and padmanaban *et al* [16].

5. Conclusion

This study has shown that serum aspartate transaminase, alkaline phosphatase, sodium and chloride levels were significantly higher in the occupationally exposed paint factory workers compared to non-paint factory workers. Therefore, it can be said that exposure to volatile organic chemicals and heavy metals in the paint factory predispose the workers to develop liver and kidney dysfunctions. Again, this study found out that majority of these paint factory workers does not use personal protective devices during work. This may compromise liver and kidney function.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest, financial or otherwise.

Statement of ethical approval

Ethical approval was duly obtained from the ethics committee of the Enugu State University Teaching Hospital, Parklane, Enugu (ESUTHP/C-MAC/RA/034/204).

Statement of informed consent

Informed consent was obtained from all participants in this study before commencement.

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