

Organic Solvent Exposure: Hepatotoxicity, Nephrotoxicity, and Haematotoxicity Assessment amongst Vehicle Spray Painters in Ile-Ife, Nigeria

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Abstract BACKGROUND: Exposure to different organic solvents have been reported to cause adverse effects on the functional integrity of different tissues in the biological systems. Vehicle spray painters are a group of artisan that could be occupationally exposed to health risk due to the constituents of materials used in spray painting, hence this study was designed to examine the effects of exposure to these solvents on liver, kidney and bone marrow function in this artisan in Ile-Ife, Nigeria. **METHODS:** A total of 75 Nigerian male vehicle spray painters with age range 28 – 59 years (X 47.5) were recruited for the study. They were classified into 5 groups based on duration of exposure with 15 in each group. Another group of 15 people of different professions of the same age and gender who were not exposed were recruited as control. Blood samples were collected, liver, kidney and bone marrow function parameters were determined using standard techniques. **RESULT:** Values obtained for total bilirubin (TB), conjugated bilirubin (CB), alanine transaminase (ALT) and aspartate transaminase (AST) were significantly higher ($P < 0.05$) in the exposed groups than the control groups, however, the values were within the reference range. There was no significant difference ($P > 0.05$) in all other liver function parameters between the exposed painter and non-exposed control. Kidney function profiles showed no significant difference ($P > 0.05$) between the exposed painters and non-exposed control. Haematological profiles revealed no significant difference ($P > 0.05$) in packed cell volume (PCV) between the exposed painters and non-exposed control, total white blood cell count (WBC) was significantly lower ($P < 0.05$) in exposed painters than in non-exposed control. **CONCLUSION:** In conclusion, the findings of this study neither reveal hepatotoxicity, nephrotoxicity nor haematotoxicity. Although we observed slight elevations and slight decrease in some of the liver function profiles and WBC respectively among the exposed painters when compared to non-exposed control, the values were within the reference range. Since these painters are constantly exposed to organic solvents from paints and because of adverse effects it may cause on their health without knowing when it may happen, it is important they do period medical check-up.

Keywords: organic solvent, hepatotoxicity, nephrotoxicity, haematotoxicity, vehicle spray painter

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1. Introduction

Vehicle spray painters are a group of artisan that could be occupationally exposed to health risk due to the constituents of materials used in spray painting [1]. Among the materials used in spray painting are cellulose thinner (which contains methanol, toluene, xylene, and butanol); hardener (which contains hexane, xylene, isocyanate); clearing agent (which contains decadenoic acid and autobase which contains *n*-butyl acetate [2,3].

Usual routes of exposure to environmental agents are oral, dermal, and inhalation [4]. These chemicals constitute health hazards in humans. Short term health effects that spray painting can cause are irritation, contact dermatitis, burns to the skin and eyes, vomiting and diarrhea, irritation to the nose, throat and lungs, headaches, dizziness, nausea and fatigue. Long term health effects include occupational asthma, allergic contact dermatitis, lung cancer, ‘painter’s syndrome’ which is prolonged inhalation of paints and solvents resulting in damage of the blood forming organs, central nervous system,

reproductive system, kidney, and liver [5-13]. The liver maintains a unique position within the circulatory system, this position aids the liver in its normal functions, which include (i) carbohydrate storage and metabolism; (ii) metabolism of hormones, endogenous wastes, and foreign chemicals; (iii) synthesis of blood proteins; (iv) urea formation; (v) metabolism of fats; and (vi) bile formation [14]. Toxicant may gain entrance into the system through inhalation, dermal contact and inadvertent ingestion [14] and distributed throughout the body, systemic effect may occur beyond the site of contact. The liver is often the target organ of chemical induced tissue injury, this is due to its unique position within the circulatory system and also because it is the primary organ for xenobiotic transformation [1,15].

The kidney is the chief regulator of all body fluids and is primarily responsible for maintaining homeostasis, or equilibrium of fluid and electrolytes in the body. The kidney main functions are urine formation, regulation of acid-base balance, excretion of waste products of protein metabolism, protein conservation and hormonal function [16,17,18]. Ingvar et al [7] and Al-Ghamdi [19] reported some studies that suggested exposure to organic solvent may induce glomerulonephritis whereas other studies did not find an increased risk. Haematological profiles provide important information about the internal environment of a given organism, exposures to organic solvent, insecticides and pesticides were reported to cause adverse effects on the haematological profiles in animal and humans [20-29].

Although data on effect of exposure to organic solvents on blood biochemistry and haematology among artisans occupationally exposed to paints are widely reported, none has been documented among vehicle spray painters in Ile-Ife, Nigeria, hence this study was undertaken to assess liver, kidney and bone marrow function status among this artisan in Ile-Ife.

2. Subjects and Methods

2.1. Study Design

This study was conducted on 75 adult Nigerian male vehicle spray painters categorized into 5 group based on duration of exposure. Group 1 (1 – 10years), group 2 (11-20years), group 3 (21 – 30years), group 4 (31 – 40years), group 5 (41 – 50years), their age ranges between 28 – 59 years (X 47.5 years). Group 6 (non – exposed control) were 15 artisans of different professions and were age and sex matched with the painters. Questionnaires about socio-economic status, duration and frequency of exposure were administered. Their blood pressure (BP) and pulse rate were also taken, subjects who's BP and pulse rate fell outside the normal limit, were excluded from the study. Subjects with any sign of jaundice were also excluded from the study.

2.2. Ethics

This study has been conducted according to the Declaration of Helsinki. The study participant gave their informed consent and the protocol was approved by our Institution's ethical review committee.

2.3. Collection of Blood Samples for Biochemical and Haematological Analysis

Blood samples were collected from vehicle spray painters during their weekly meetings at their Conference Hall at Olokun Quarters, off Fajuyi Road, Igboya, Ile-Ife, Nigeria.

Twelve ml of fasting blood specimen was obtained from each of the subjects through clean venipuncture. 3.5 ml was dispensed into tripotassium ethylene diamine tetra acetic acid (K_3EDTA) for lipids profiles determination; total cholesterol (T.Chol), high density lipoprotein (HDL), low density lipoprotein (LDL) and triglyceride (Trig). Five ml into lithium heparin for total bilirubin (TB), conjugated bilirubin (CB), total protein (TP), albumin (ALB), aspartate aminotransferase, (AST), alanine aminotransferase, (ALT), alkaline phosphatase (Alk.phos); Na^+ , K^+ , HCO_3^- , Cl^- , Urea, (U), Creatinine, (Cr), Calcium, (Ca) and Inorganic phosphorus (In Phos). The remaining 3.5 ml into K_2EDTA for complete blood count, packed cell volume (PCV), total white blood cell count (WBC) and differential; and erythrocyte sedimentation rate, (ESR). Blood was centrifuged at 3500rpm for 5min, the plasma separated from the cell, and the analysis carried out within 6 hours of blood collection.

2.4. Biochemical Analysis

Estimation of plasma total protein [30], albumin [31], TB and CB [32], AST and ALT [33], Alk.phos [32], T.Chol [34], HDL [34], Trig [35], were performed using commercial kits from RANDOX (RANDOX Laboratory, Ltd., UK). Na^+ , K^+ , were estimated by flame photometry [31]; HCO_3^- , Cl^- , Urea, Cr, uric acid, Ca and Inorg Phos [32].

2.5. Haematological Analysis

PCV was done using microhaematocrit centrifuge, white blood cell counted using bulk dilution method, differential leucocyte counted after staining with Leishman stain. ESR was estimated using Westergren method [36].

3. Statistics

Results are presented as Mean $\pm$ S.E.M. Statistical significance was evaluated by one-way analysis of variance (ANOVA) using SPSS 19. Differences with $P < 0.05$ were considered significant.

4. Results

Distribution of vehicle spray painters based on duration of exposure is presented in Table 1. The mean $\pm$ S.E.M. of liver function parameters were presented in Table 2. Comparison of liver function tests among different groups of exposed painters (groups 1 to 5) showed no statistical significant difference ($P > 0.05$). However, when values of all the parameters in each of the exposed group (group 1 to 5) were compared with those of non-exposed group (group 6), there were statistical significant differences in

some of the parameters ($P < 0.05$), although the values were within the reference range.

Table 1. Distribution of Vehicle Spray Painters and duration of exposure

Group	Years of Exposure	No	Percentage
1	1 -10	15	16.6
2.	11 -20	15	16.6
3.	21 -30	15	16.6
4.	31 – 40	15	16.6
5.	41 -50	15	16.6
6.	Non-exposed control	15	16.6

Total number of participants =90.

Table 3 shows Mean $\pm$ S.E.M. of kidney function parameters in different group of exposed painters and non-exposed group (control). There was no statistical significant difference ($P > 0.05$) in the values of the parameters between the exposed group and control group. Haematological profiles in different groups of vehicle spray painters and control groups is shown in Table 4. There was no statistical significant difference ($P > 0.05$) in PCV values between the control and the exposed groups. There was statistical significant difference ($P < 0.05$) in WBC values between the control and the exposed groups. There was statistical significant difference ($P < 0.05$) in the ESR values between the control and groups 1, 2 and 5 while there was no statistical significant difference between the control and groups 3 and 4.

Table 2. Liver function profiles in different groups of vehicle spray painters

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
TB $\mu\text{mol/l}$	10.60 $\pm$ 1.31	9.60 $\pm$ 1.18	11.13 $\pm$ 0.96	10.60 $\pm$ 2.13	10.27 $\pm$ 1.14	4.73 $\pm$ 0.36
CB $\mu\text{mol/l}$	4.53 $\pm$ 0.75	4.83 $\pm$ 0.56	5.01 $\pm$ 0.66	4.13 $\pm$ 0.39	4.40 $\pm$ 0.56	1.73 $\pm$ 0.23
AST U/l	10.60 $\pm$ 1.10	9.80 $\pm$ 2.16	10.53 $\pm$ 0.73	9.97 $\pm$ 0.68	10.13 $\pm$ 1.10	5.33 $\pm$ 0.25
ALT U/l	12.20 $\pm$ 0.50	11.13 $\pm$ 1.30	10.93 $\pm$ 0.52	11.97 $\pm$ 0.06	12.60 $\pm$ 0.62	4.20 $\pm$ 0.03
Alk.pho U/l	93.47 $\pm$ 5.70	91.73 $\pm$ 3.29	93.07 $\pm$ 2.10	94.13 $\pm$ 6.70	90.27 $\pm$ 1.16	92.73 $\pm$ 2.56
TP g/l	71.60 $\pm$ 1.49	70.13 $\pm$ 2.53	69.40 $\pm$ 2.08	70.07 $\pm$ 1.22	68.80 $\pm$ 1.22	70.40 $\pm$ 0.77
ALB g/l	39.60 $\pm$ 0.93	40.47 $\pm$ 1.29	37.98 $\pm$ 1.50	38.93 $\pm$ 1.38	38.87 $\pm$ 1.38	38.17 $\pm$ 0.57
T.chol mmol/l	3.95 $\pm$ 0.22	3.93 $\pm$ 0.21	4.10 $\pm$ 0.30	3.97 $\pm$ 0.31	4.08 $\pm$ 0.18	4.05 $\pm$ 0.07
HDL mmol/l	0.92 $\pm$ 0.05	0.89 $\pm$ 0.49	1.05 $\pm$ 0.06	1.15 $\pm$ 0.08	0.95 $\pm$ 0.04	1.07 $\pm$ 0.05
LDL mmol/l	3.10 $\pm$ 0.29	2.98 $\pm$ 0.26	3.16 $\pm$ 0.30	2.98 $\pm$ 0.24	3.00 $\pm$ 0.20	2.95 $\pm$ 0.16
Trig mmol/l	0.94 $\pm$ 0.17	1.01 $\pm$ 0.13	1.09 $\pm$ 0.15	1.00 $\pm$ 0.12	1.02 $\pm$ 0.10	0.98 $\pm$ 0.05

N = 15 for each group.

5. Discussion

Exposure to different organic solvents has been reported to cause adverse effects on the functional integrity of different tissues in the biological systems [37]. From our findings, none of the values obtained for liver function parameters were suggestive of hepatotoxicity (Table 2). The present study showed no statistical significant difference ($P > 0.05$) in the values obtained for liver function parameters among the exposed groups, hence this study revealed no relationship between duration of exposure and effect on the liver, this agrees with Chen et al(8) who reported no association between the liver function parameters and exposure among paint workers. However, this is in contrast with the findings of Mahdy and Radwan (38) who reported significant increase

in the levels of ALT and AST in the exposed painters in relation to the duration of exposure. We observed significant increase ($P < 0.05$) in the values of TB, CB, ALT and AST in the exposed groups than the control groups, however, the values were within the reference range. This finding was also not in agreement with the findings of Mahdy and Radwan (38) who reported no significant increase in the values of ALT and AST between the exposed painters and non-exposed control group, but tallied with Orisakwe et al (39) who reported slight elevations in ALT and AST values in exposed paint workers. Values obtained for ALP, TP and albumin showed no significant difference ($P > 0.05$) between control group and the exposed painters. There were no significant differences ($P > 0.05$) in the values obtained for total cholesterol, triglycerides, HDL and LDL between the control group and exposed painters.

Table 3. Kidney function profiles in different groups of vehicle spray painters

Parameter	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 6
Na ⁺ mmol/l	133.00 $\pm$ 0.63	133.33 $\pm$ 0.59	134.07 $\pm$ 0.96	136.60 $\pm$ 1.09	134.27 $\pm$ 0.91	133.87 $\pm$ 0.94	133.87 $\pm$ 0.94
K ⁺ mmol/l	3.92 $\pm$ 0.14	4.07 $\pm$ 0.21	3.81 $\pm$ 0.16	3.20 $\pm$ 0.16	3.75 $\pm$ 0.14	3.71 $\pm$ 0.10	3.71 $\pm$ 0.10
HCO ₃ mmol/l	23.20 $\pm$ 0.66	24.73 $\pm$ 0.85	24.53 $\pm$ 0.82	23.87 $\pm$ 0.55	24.33 $\pm$ 0.58	24.87 $\pm$ 0.39	24.87 $\pm$ 0.39
Cl ⁻ mmol/l	96.67 $\pm$ 0.94	94.20 $\pm$ 0.99	96.47 $\pm$ 1.05	95.73 $\pm$ 0.82	97.27 $\pm$ 0.87	95.93 $\pm$ 0.54	95.93 $\pm$ 0.54
Urea mmol/l	3.61 $\pm$ 0.27	3.74 $\pm$ 0.26	3.39 $\pm$ 0.99	3.39 $\pm$ 0.18	3.31 $\pm$ 0.15	3.40 $\pm$ 0.10	3.40 $\pm$ 0.10
Cr $\mu\text{mol/l}$	91.33 $\pm$ 2.69	89.73 $\pm$ 2.90	87.80 $\pm$ 2.91	90.20 $\pm$ 1.84	89.53 $\pm$ 2.52	88.13 $\pm$ 2.04	88.13 $\pm$ 2.04
InPO ₄ mmol/l	1.05 $\pm$ 0.09	1.09 $\pm$ 0.12	1.00 $\pm$ 0.09	1.10 $\pm$ 0.08	0.91 $\pm$ 0.09	1.04 $\pm$ 0.04	1.04 $\pm$ 0.04
Uric A mmol/l	0.26 $\pm$ 0.02	0.29 $\pm$ 0.03	0.28 $\pm$ 0.03	0.27 $\pm$ 0.11	0.25 $\pm$ 0.07	0.27 $\pm$ 0.03	0.27 $\pm$ 0.03
Ca ²⁺ mmol/l	2.11 $\pm$ 0.08	2.15 $\pm$ 0.07	2.06 $\pm$ 0.05	2.03 $\pm$ 0.04	2.05 $\pm$ 0.04	2.19 $\pm$ 0.04	2.19 $\pm$ 0.04

Also, none of the values obtained for kidney function were suggestive of nephrotoxicity (Table 3). The electrolytes, Na⁺, K⁺, Cl⁻, HCO₃⁻, urea and creatinine values showed no statistical significance difference ($P > 0.05$) among the exposed painters and the unexposed

controls. There was no correlation between duration of exposure and kidney function parameters. This finding is in agreement with the findings of Hoeck et al [40] and Hassan et al [41]. The same for uric acid, inorganic phosphorus and calcium.

Table 4 shows haematological profiles in the exposed painters and non-exposed control. Reports of haematological profiles in vehicle spraying painters just like those on liver and kidney function parameters varied widely from one author to another. In a study conducted by Ibrahim et al [42], CBC results revealed that WBC, RBC, and platelets were decreased among exposed workers compared with the non-exposed controls. In El-Mahdy and Radwan's [38] work, CBC results showed normal levels with no difference between exposed and controls, but some parameters decreased with increased duration of exposure. Arafa et al [43], in a study among Egyptian car painters observed no significant difference between exposed and control groups in leucocyte count and platelet count but there was a highly significant difference between RBCs count between the exposed and control groups. In this study, there was no significant difference ($P>0.05$) in PCV values between the controls and exposed painters. Total leucocyte count values were significantly

reduced ($P<0.05$) in all groups of exposed painters than in non-exposed control, our observation with respect to total WBC is in agreement with Ibrahim et al's [42] finding. Neutrophils values were significantly reduced ($P<0.05$) in exposed painters than in non-exposed control and lymphocyte counts were significantly higher ($P<0.05$) in exposed painters than in non-exposed controls. There was no significant difference in Monocytes and Eosinophils values between the exposed painters and non-exposed control. The morphological appearance of red blood cells and white blood cells in thin stained blood film of exposed painters and non-exposed control were all normal, no red cell inclusion bodies nor white cell abnormalities seen. The ESR values were significantly higher ($P<0.05$) in groups 1, 2 and 5 of the exposed painters than the non-exposed controls while there was no significant difference ($P>0.05$) between the groups 3 and 4 of the exposed painters and non-exposed control.

Table 4. Haematological profiles in different groups of vehicle spray painters

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
PCV %	45.80± 1.82	45.60± 2.26	46.33± 3.13	44.33±3.20	44.80± 3.49	45.13 ± 2.72
WBC $\times 10^3/\text{mm}^3$	3176.6± 1066.35	3276.67 ± 7.23.77	3116.67± 427.06	3300.00 ± 867.056	3390.00 ± 299.52	4743.33 ± 919.99
N %	39.53± 7.91	41.80±11.05	40.00± 21.95	41.33±17.33	42.53± 9.33	52.07 ± 5.12
L %	57.40± 7.18	55.93± 12.22	56.73± 21.30	56.00±15.42	55.07± 9.16	45.17 ±5.24
E %	3.00± 4.22	2.57±3.83	2.47±0.52	2.00±1.69	2.90±1.12	2.80 ±1.40
M %	0.80± 1.01	1.00± 0.76	1.07±1.28	1.00±0.85	0.00±0.00	0.86 ± 0.74
ESR mm/hr	9.00± 5.68	8.60 ±4.91	6.07±4.09	5.93± 3.52	9.93± 5.08	6.40 ± 1.96

N = 15 for each group.

In conclusion, from our findings we have not observed hepatotoxicity, nephrotoxicity or haematotoxicity amongst vehicle spray painters in Ile-Ife, some parameters that showed significant increase in exposed painters were within the reference range but there is need for period medical test to evaluate their health status so that any developing disease can be detected at an early stage. The Ministry of Environment should also embark on enlightenment campaign on the need for all categories of self-employed workers that are occupationally exposed to hazards to protect themselves and for employers of such workers either in Government or Private Establishment to provide protective materials for them.

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Conflict of Interest

There was no conflict of interest in any form.

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limitations

The authors could not assay more sensitive markers due to lack of fund.

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