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Occupational health risk assessment of automobile painters in Owerri metropolis, Nigeria

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Abstract

The study evaluated the occupational health risks among automobile painters using biochemical indices. A total of 30 randomly selected male automobile painters and 32 age-matched control subjects were recruited in the study. Antioxidant and haematological indices were analysed by standard methods. Information about the life style of the test subjects revealed that 46.7% attained secondary level of education while 26.7% and 26.6% attained primary and tertiary level of education respectively. Fifty percent of the automobile painters were aware of the hazards involved while only 10% wore protective devices during painting activities. According to their duration of exposure, 50% were exposed for 5 years or less whereas 11% and 39% were exposed for 6-10 years and above 10 years respectively. The results showed a significant increase in the mean levels of serum malondialdehyde (MDA) in the automobile painters compared with the control subjects ($P<0.05$) while the mean serum levels of catalase, glutathione peroxidase activities and vitamin E concentrations in automobile painters were significantly lower than in the control subjects ($P<0.05$). There was a significant increase in the mean granulocytes concentration but significantly lower MCHC, platelets and mean platelet volume (MPV)($P<0.05$) in the test subjects relative to the control subjects. The mean C- reactive protein concentration was not significantly altered between the two groups ($P>0.05$). The antioxidant vitamin E and MDA significantly correlated with the years of exposure. The mean catalase level increased mildly ($P>0.05$) as the duration increased while glutathione peroxidase activity decreased as the duration of exposure increased. Conclusively, the results showed increased lipid peroxidation, oxidative stress and anaemia among automobile painters, with no significant inflammatory response. It is apparent that the automobile painters studied are at increased occupational risk.

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Introduction

Automobile painting is one profession where painters are potentially exposed to a wide range of chemical risks, such as metals, organic solvents and particularly, isocyanates. The health threats accompanying automobile painting materials can be lasting and severe to the employee, if the proper safety measures and licensed equipment are not used. The numerous chemical compounds used in paint production exposes the workers to various forms and levels of risk which may vary from those of painters (Hugo *et al.*, 2011, Kshirsagar *et al.*, 2019; Egoro *et al.*, 2021).

Spray paints have been reported to be toxic to human health due to the chemicals inherent in them (OSHA, 2009). Painters are commonly exposed by inhalation of the solvents and other volatile paint components especially during spray painting. Dermal contact is another major route of exposure. Painters could also be vulnerable to other chemicals that they or their co-workers use (IARC, 2010a.).

Antioxidants are micronutrients that defend tissues by blocking harmful chemical reactions caused by oxidation due to several environmental factors. There are evidences that exposure to chemical compounds and the work place condition could lead to the oxidative stress caused by free radicals in the absence of antioxidants (Anetor and Adeniyi, 2001; Ogbonna *et al.*, 2019; Zbigniew *et al.,* 2020). Reactive Oxygen Species (ROS), in turn, can prompt lipid peroxidation and produce products such as malondialdehyde (MDA), which can induce pulmonary inflammation (Rahman and Adcock, 2006). Inflammation is an important aspect of the body's immune reaction. It is the body's attempt to heal itself after an injury; defend itself against foreign invaders (Jessie, 2015).

The risk of chemical toxicity is highest in fast industrializing and developing economics (WHO, 1992). This scenario noticeably varies with the developed countries with sufficient amenities to reduce over exposure and the lethal effects of chemicals (Anetor and Adeniyi, 2001; Hormozi *et al.*, 2018; Goyal *et al.*, 2021). Proper work sanitation and pollution control techniques are frequently ignored at worksites in rapidly developing countries, where inexpensive labor and high poverty index coexist (Gomes *et al.*, 2001). It is worse for small factory employees where personal protective kits are considered a luxury and rarely provided (Gomes *et al.*, 2001).

The association between chemical compound exposure and human wellbeing is a significant world-wide problem. Solvents in car paints and paint-associated products are believed to be one of the worst environmental and occupational contaminants. Many disease symptoms may be associated with spray painting, primarily painter's asthma and dermatitis (DPPPS, 2004; Ishiaq, 2019). Neither of these two illnesses have substantial data to define their risk. There is sufficient evidence to warrant their concern, because chemicals, solvents, pigments and other additives in paint that become airborne upon spraying process, makes it challenging to compute the risks based on a particular hazard assessment, though career painters tend to be more susceptible to these diseases (DPPPS, 2004).

Many studies have been conducted on the health implications of automobile painting, especially concerning its effect on cellular morphologies (Adu *et al.,* 2018; Bahram *et al.,* 2017) but not on its effect on oxidative stress and extent of inflammation. This study, therefore, was designed to evaluate the extent of oxidative damage and inflammation to automobile painters which could be used by relevant authorities to set occupational hygiene standards for automobile industries.

Materials and methods

Study area

This study was carried out in three mechanic clusters in Owerri, Imo State, namely Irete, Okigwe road and Avu. Owerri is the capital of Imo State and very metropolitan. The city is located in the South Eastern part of Nigeria.

Subjects and Sample Collection

A total of 62 male subjects were randomly recruited for the study, comprising of 30 automobile painters

and 32 age matched controls who have never been involved in painting activities. The leaders of the different mechanic villages were approached and their support and approval obtained. The automobile painters were then approached and the purpose of the study was explained to them. Thereafter those who gave their informed written consent were recruited for the study. Apparently healthy individuals who have been painting automobiles for at least two years were recruited for the study, while those who combine panel beating and automobile painting, and those who have chronic illness or on special medication were excluded from the study. Occupational exposure was taken as the number of years the subject has being involved in automobile spray painting. Questionnaires were used to obtain vital information as regards to age, sex, use of protective devices and duration of exposure, social habits and medications. Ten (10) millilitres of venous blood was collected from each individual into a well labeled ethylenediamine tetraacetic acid (EDTA) bottle and a plain tube, using standard methods. Three (3) millilitres was put into the EDTA bottle while 7 ml was put into the plain bottle. Ethical clearance was obtained from Federal Medical Centre, Owerri, Imo State (FMC/OW/HREC/206).

Biochemical Analysis

Serum levels of malondialdehyde was determined colorimetrically by the methods of Gutteridge and Wilkins (1982), glutathione peroxidase was determined by the method of Rotruck *et al.* (1973), catalase activity was determined as described by Hadwan and Abed (2016), vitamin E was determined by the method of Baker and Frank (1968) while C-reactive protein was determined using ELISA method.

Statistics

The statistical analysis was done using the Statistical Package for the Social Sciences (SPSS) version 21 to obtain the mean and standard deviation. The Student's T-test was used to compare the results of automobile painters and that of the controls. Pearsons correlation was used to correlate the results of the automobile painters with their duration of exposure while Analysis of Variance (ANOVA) was used to establish a post-hock among the three groups.

Results

The results in Table 1 show that a greater percentage of the test population attained secondary education (46.7%), while those who had primary and secondary education were about 26.7% and 26.6% respectively. It also shows that 50% of the test group is not aware of the hazards associated with spray car painting exposure and as a result only 10% use protective devices. Half of the population (50%) has worked for 5years or less (group A), 11% have worked for 6-10 years (group B), while the remaining 39% have being engaged in car painting for more than 10years (group C).

Table 1. Information from the questionnaires as regards to the life style of the automobile painters.

Social demographic information	Percentage occurrence (%)
Educational attainment	
Primary	26.7
Secondary	46.7
Tertiary	26.6
Use of protective device	10
Duration of exposure(years)	
0-5	50
6-10	11
≥10	39
Awareness of occupational hazard	50

The concentrations of antioxidants and inflammatory markers among automobile painters and control subjects are represented in Table 2. The results in Table 2 show a significant decrease in the mean catalase and glutathione peroxidase activities and also vitamin E concentration in the automobile painters compared to the control subjects ($P \leq 0.05$), while the mean levels of malondialdehyde was significantly higher in automobile painters than the control subjects ($P \leq 0.05$). The mean concentration of C-reactive protein was non significantly higher in automobile painters relative to the control subjects ($P \geq 0.05$).

The haematological indices among the two the groups are shown in Table 3. From the results in Table 3 there was a significant increase in the mean levels of granulocyte among automobile painters than the control subjects ($P \leq 0.05$), while the mean cell haemoglobin concentration, platelets, mean platelet volume were significantly lower in the automobile painters than their control subjects ($P \leq 0.05$).

The percentage levels of lymphocytes and monocytes decreased non significantly in automobile painters than the control subjects (P≥ 0.05). It also shows that the mean total white blood cell count, red blood cell count, mean cell volume, red cell distribution width and platelet distribution width were non significantly higher in the control subjects than in automobile painters (P≥ 0.05).

The results in Table 4 show the comparison of the different parameters with duration of exposure.

The mean catalase activity increased nonsignificantly with the duration of exposure (P≥ 0.05). The mean vitamin E concentration and glutathione peroxidase activity were lowest in those with the least duration of exposure (0-5 years) while malodialdehyde concentration was highest in the spray painters with the least duration of exposure and decreased non significantly as the duration of exposure increased (P> 0.05). The C-reactive protein concentration was highest in the automobile spray painters that have spent between 6-10 years.

Table 2. Levels of antioxidants and inflammatory markers among automobile painters and control subjects.

Parameters	Automobile painters N= 30	Control N=32	T-test	P-Value
Catalase (kU/l)	19.40±3.05	32.06±1.91	-4.76	<0.001
Vitamin E (mg/dl)	10.14±1.22	11.42±1.39	-3.83	<0.001
Malondialdehyde (nmol/l)	4.84±1.35	3.35±1.20	4.62	<0.001
Glutathione Peroxidase (U/l)	0.76±0.93	0.89±0.15	-4.06	<0.001
C-Reactive protein (mg/l)	2.38±4.21	2.12±3.72	0.26	0.796

Results are mean ± SD of triplicate readings (P < 0.05)

Table 3. Levels of some haematological indices among automobile painters and control subjects.

Parameters	Automobile painters N= 30	Control N=32	T-test	P-value
Total White blood cell (x10^9/l)	5.06±1.33	4.90±0.95	0.53	0.600
Lymphocytes (%)	52.23±5.59	57.92±6.13	-1.364	0.178
Monocytes (%)	7.45±5.63	9.31±4.97	-1.38	0.174
Granulocytes (%)	40.48±16.0	32.97±9.92	2.24	0.029
Red blood cell count (x10^9/l)	4.56±0.40	4.47±0.47	0.97	0.337
Haemoglobin (g/dl)	13.28±1.16	13.90±1.68	-1.67	0.101
Packed cell volume (%)	43.54±5.89	43.84±4.56	-0.22	0.824
Mean cell volume (fl)	104.36±19.48	98.00±7.64	1.71	0.092
Mean cell haemoglobin (pg)	29.10±2.54	30.97±2.71	-2.81	0.007
Mean cell haemoglobin concentration (g/dl)	28.73±4.29	31.66±1.96	-3.50	0.001
Red cell distribution width (%)	17.42±1.64	16.91±0.85	1.55	0.126
Platelet (ul)	198.23±68.13	246.63±90.63	-2.36	0.021
Plaetocrit (ml/l)	0.18±0.57	0.21±0.09	-1.821	0.074
Mean plasma volume (fl)	7.97±0.99	8.64±0.81	-2.91	0.005
Platelet distribution width (%)	39.74±4.75	38.65±6.24	0.79	0.446

Results are mean ± SD of triplicate readings (P < 0.05)

Table 4. Mean Levels of some antioxidants and inflammatory markers at different duration of exposure in auto mobile painters.

Duration (years)	Catalase (kU/l)	VitaminE (mg/dl)	Malondialdehyde (nmol/l)	Glutathione peroxidase (U/ml)	C-Reactive Protein (mg/l)
0-5 (A) n=23	15.61± 14.02	9.74±0.84	5.68±0.99	0.79±0.12	2.38±4.29
6-10 (B) n=5	17.43±4.67	11.65±1.40	4.34±0.26	0.73±0.03	5.55±7.14
>10(C) n=18	21.72±9.40	10.20±1.30	4.44±1.40	0.74±0.07	2.03±4.02
F-test	1.021	2.260	3.331	1.126	0.612
P-value (< 0.05)	0.374	0.124	0.051	0.339	0.550
A vs B	0.832	0.045	0.180	0.368	0.346
A vs C	0.171	0.326	0.018	0.166	0.838
B vs C	0.606	0.110	0.920	0.845	0.278

The results in Table 5 show that there was a non-significant increase in the level of total white blood cell count, granulocyte, and monocytes in group A (P> 0.05). The mean plasma level of lymphocytes showed the highest level in group C and the least level in group B though the increase in group C was not significant (P> 0.05), while the packed cell volume and haemoglobin values increased progressively and had the highest level in group C though the progressive increase was not significant. The results also show that there was a non-significant increase in the mean cell haemoglobin, mean cell haemoglobin concentration and mean plasma volume level in group B compared to group A and C (P> 0.05), while the mean cell volume and platelet distribution width non significantly increased in group C compared to group A and B (P >0.05).

Table 5. Levels of some haematological Parameters at different duration of exposure in auto mobile Painters.

Duration	Red blood cell ($x10^9$/ul)	Packed cell volume (%)	Haemo globin (g/dl)	White blood cell ($x10^9$/ul)	Lympho cyte (%)	Monoc yte (%)	Granulo cyte (%)	Mean cell haemo globin (pg)	Mean cell Hb conc (g/dl)	Mean cell volume (fl)	Platelet	Platocrit	Platelet distribut ion width	Mean plasma volume
0-5(A)	4.53±	41.65±	12.60±	5.08±	45.39±	8.55±	46.56±	27.92±	29.30	99.47±	207.7±	0.174±	39.08±	8.03±
n=23	0.37	6.92	0.84	1.41	23.66	5.47	18.58	2.74	±3.32	22.62	52.73	0.035	3.89	0.85
6-10(B)	4.30±	42.50	13.60±	5.25±	37.0 ±	14.65±	48.35±	31.60±	32.05	98.80±	157.0±	0.14±	37.30±	9.00±
n=5	0.12	±4.53	0.71	0.21	0.71	6.85	6.15	0.71	±1.77	7.78	33.9	0.12	4.53	1.27
>10 (C)	4.63±	44.71	13.62±	5.03±	57.73±	6.04±	36.23±	29.47±	28.04	107.69±	198.11±	0.19±	40.37±	7.82±
N=18	0.44	±5.38	1.21	1.40	18.43	5.15	14.27	2.29	±4.83	18.52	78.32	0.067	5.27	1.03
F-test	0.664	0.892	2.917	0.023	1.842	2.662	1.673	2.478	0.916	0.644	0.426	0.890	0.503	1.320
P-value	0.523	0.422	0.071	0.977	0.178	0.088	0.207	0.103	0.412	0.533	0.657	0.422	0.610	0.284
A vs B	0.457	0.854	0.244	0.875	0.593	0.151	0.884	0.060	0.416	0.965	0.364	0.427	0.638	0.214
A vs C	0.570	0.201	0.025	0.932	0.130	0.244	0.106	0.115	0.464	0.300	0.756	0.466	0.503	0.596
B vs C	0.286	0.621	0.984	0.835	0.176	0.039	0.308	0.248	0.222	0.550	0.434	0.229	0.401	0.120

Table 6. Levels of some haematological parameters at different durations of exposure in auto mobile Painters.

Duration (years)	Mean cell haemoglobin (pg)	Mean cell haemoglobin concentration (g/dl)	Mean cell volume (fl)	Platelet	Platocrit	Red cell distribution width	Platelet distribution width	Mean plasma volume
0-5 (A) N=23	27.92±2.74	29.30±3.32	99.47±22.62	207.7±52.73	0.174±0.035	17.32± 0.85	39.08±3.89	8.03± 0.85
6-10(B) N=5	31.60±0.71	32.05±1.77	98.80±7.78	157.0±33.9	0.14±0.12	17.30±0.57	37.30±4.53	9.00±1.27
>10 (C) N=18	29.47±2.29	28.04±4.83	107.69±18.52	198.11±78.32	0.19±0.067	17.49±2.04	40.37±5.27	7.82±1.03
F-test	2.478	0.916	0.644	0.426	0.890	0.037	0.503	1.320
P-value	0.103	0.412	0.533	0.657	0.422	0.964	0.610	0.284
A vs B	0.060	0.416	0.965	0.364	0.427	0.988	0.638	0.214
A vs C	0.115	0.464	0.300	0.756	0.466	0.803	0.503	0.596
B vs C	0.248	0.222	0.550	0.434	0.229	0.882	0.401	0.120

Discussion

Vehicle spray painters are a group of artisans that could be occupationally exposed to health risk due to the constituents of materials used in spray painting. The findings of this study revealed generally that malondialdehyde (MDA), being a marker of lipid peroxidation, significantly increased in automobile painters than the controls. This was in line with a study carried out by Mohammed *et al.* (2008). This increase in MDA level could be due to increased oxidative stress (OS) induced by substances inhaled from the paint mixtures over the years during their painting activity, catalyzing the formation of reactive oxygen species and further leading to lipid peroxidation and MDA production. Comparing the level of MDA at different duration of exposure, the result showed that there was a decrease in the mean level of MDA in group B than group A and a little increase in group C than group B but not as high as group A.

This decrease was only significant between groups A versus group C. The decrease in MDA as duration increased did not correspond with other similar study (Oduola *et al*., 2015).

There was a significant decrease in catalase and gluthathione peroxidase activity among automobile painters compared to their control subjects. The decrease in catalase activity corresponds with the study done by Awodele *et al.* (2013) and Mohammed *et al.* (2008) on painters while the decrease in glutathione peroxidase activity corresponds with the research done by Alev Karagözler *et al.* (2002) on painters and Halofoeglu *et al.* (2000) on paint thinner inhalation. The decrease in catalase and glutathione peroxidase could have been due to the exhaustion of the enzyme by hydrogen peroxide and lipid peroxides. As a result of these excess of hydrogen peroxide could not be neutralized completely in these subjects. If the level of free radicals is not efficiently neutralised after oxidative stress, it gets to a critical level and lipid peroxidation starts occurring which is evident with an increase in malondialdehyde levels. The mean level of catalase activity increased progressively from group A, through group B and group C. This progressive increase was not significant ($P>0.05$). The mean level of glutathione peroxidase activity decreased non significantly in group B than in group A and increased a little in group C though not significant but had its highest level in group A. Paint products contain many chemical compounds like pigments, extenders, binders, additives and solvents (toluene, xylene, ketones, alcohols, esters, and glycol ethers). Toxicity of these products depends on the types of pigments and solvents used in its manufacture (Scélo *et al*., 2009). In the case of individuals occupationally exposed to automobile paints, an increase in oxidative damage has been demonstrated (Moro *et al*., 2012).

A significant decrease was observed in vitamin E (α-tocopherol) among auto painters compared to the control subjects. Arinola and Akiinibu (2006) observed similar results in their study on individuals occupationally exposed to chemicals.

This decreased level could have resulted from decreased intake compared to the high level of lipid peroxidation. A significant increase was observed in the mean levels of vitamin E in group B more than group A and a slight decrease in group C though not significant.

The rate of inflammation among automobile painters was assessed in this study by the measurement of high sensitive C- reactive protein levels, and the results showed that the mean levels of C-reactive protein increased in automobile painters than in the control subjects but this increase was not significant. This was in line with a research work done by Ibeneme *et al.* (2017). Comparing the mean levels of C- reactive protein with the duration of exposure revealed that there was an increase in group B more than group A and group C but the increase was not significant.

This study further assessed the effect these inhaled solvents had on different haematological parameters of the automobile painters. The present results showed that there was a significant increase in the mean level of the granulocyte in the test group than the controls and a significant decrease in the mean level of the mean cell haemoglobin concentration, mean platelet volume and platelets compared to the control subjects. The significant increase in graulocytes from this study varied from the findings of Maksoud *et al.* (2018). Oduola *et al.* (2015) also revealed from their study on vehicle spray painters that there was a significant reduction in their neutrophils while there was no significant difference in basophils and eosinophils. The increase in granulocyte levels may be due to inflammatory and immunologic response that occurs when inhaled toxic substances come in contact with the respiratory region leading to the recruitment of granulocytes and further increase in its level.

This study also showed a decrease in mean values of mean cell haemoglobin concentration (MCHC), mean cell haemoglobin (MCH), haemoglobin concentration (Hb) and packed cell volume (PCV) among automobile painters compared to their control subjects.

The results showed that only the decrease in the mean value of the mean cell haemoglobin concentration was significant while the other three parameters decreased non-significantly. Also a nonsignificant increase in the mean level of red blood cell count (RBC) and mean cell volume (MCV) among the automobile painters was observed. This was similar to the study by Maksoud *et al.* (2018) but unlike this study in which only MCHC significantly decreased, the mean levels of MCHC, PCV, MCH, RBC and Hb significantly decreased while the MCH and MCV decreased non-significantly. The significant decrease in MCHC could be attributed to the contaminated air they breathed instead of the oxygen rich air which is what enhances the haemoglobin content of the cell.

The automobile painters tend to constantly inhale contaminated air which displaces the oxygen molecules in the inhaled air making the cells hypochromic hence the decrease in mean cell haemoglobin concentration. A post hock on the duration of exposure among different groups revealed an increase in packed cell volume (PCV) and haemoglobin (Hb) levels as the years of exposure increased but only the haemoglobin levels of those in group C showed a significant increase against those in Group A . There was equally a significant increase in the mean monocytes level of those in group B against those of group C.

However, it can be concluded that there was a significantly increased oxidative stress on the automobile painters, as indicated by the increased concentration of lipid peroxidation products coupled with decreased concentrations of the antioxidant enzymes and vitamins. Also, haematological changes were observed as indicated in the decreased levels of haemoglobin and increased levels of granulocytes. There was a nonsignificant inflammatory response as indicated in changes in C-reactive protein levels. It is apparent that the automobile painters studied are at increased occupational risk. It is therefore, recommend that painters should be educated on the hazards of their work and should be encouraged to make use of protective devices.

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