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Assessment of Blood Lead Levels and Potential Toxic Effects among Car Spray Painters in Bayelsa State, Nigeria

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Abstract

Occupational lead exposure is a critical public health concern, particularly among workers in industries involving lead-based materials. This cross-sectional study evaluated blood lead levels (BLLs) and associated toxicological effects among 18 car spray painters compared to 18 controls in Bayelsa State, Nigeria. Blood lead concentrations measured by atomic absorption spectrophotometry revealed significantly elevated BLLs in spray painters ($23.2 \pm 3.4 \mu\text{g/dL}$) relative to controls ($4.1 \pm 0.6 \mu\text{g/dL}$, $p < 0.0001$). Haematological assessment indicated significantly lower packed cell volume (PCV) and hemoglobin (Hb) levels in exposed workers ($p < 0.05$), reflecting impaired haematopoiesis. Liver function tests demonstrated increased aspartate aminotransferase (AST), alanine aminotransferase (ALT), total bilirubin, and conjugated bilirubin with prolonged exposure ($p < 0.01$), consistent with hepatocellular injury. Kidney function biomarkers, including creatinine and uric acid, were significantly elevated among painters ($p < 0.01$), while electrolytes such as sodium, chloride, bicarbonate, and calcium showed significant declines correlating with years of exposure ($p < 0.05$). These findings reveal dose-dependent toxic effects of occupational lead exposure impacting hematologic, hepatic, and renal systems. The study underscores the urgent need for preventive interventions, routine health monitoring, and enforcement of occupational safety regulations to mitigate lead toxicity risks in car spray painters in Bayelsa State, Niger

Keywords: Lead exposure; Blood lead levels; Spray painters; Hepatotoxicity; Nephrotoxicity; Occupational health; Bayelsa State

1. Introduction

Lead exposure remains a significant public health concern due to its widespread use and toxic effects on multiple organ systems. Occupational exposure, particularly in industries such as automotive spray painting, battery manufacturing, and metalworking, continues to pose a high risk for lead poisoning among workers. Despite regulatory efforts to limit lead exposure, millions of workers worldwide remain at risk of adverse health outcomes due to prolonged contact with lead-containing materials [1]

Lead is a heavy metal with no known beneficial role in human physiology. Its toxicity arises primarily from its ability to interfere with enzymatic processes, induce oxidative stress, and accumulate in various tissues, leading to haematological, neurological, renal, and hepatic dysfunction [2, 3]. Chronic occupational exposure to lead has been linked to cognitive impairment, anemia, renal insufficiency, hypertension, and increased mortality [4, 5]. Notably, even low blood lead levels have been associated with adverse health effects, with no safe threshold identified [6, 7].

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Spray painting in the automotive industry involves the use of lead-based paints, which present hazardous exposure routes through inhalation of fumes and direct skin contact. Workers in this sector are vulnerable to elevated BLLs and subsequent toxic sequelae [8]. The World Health Organization (WHO) recommends a blood lead concentration threshold of 5 µg/dL as a trigger for intervention, emphasizing that no level of lead exposure is safe, particularly for vulnerable groups [9].

In Nigeria, occupational lead exposure among car spray painters remains an under-investigated health risk despite anecdotal evidence suggesting elevated lead burdens in such populations. This study addresses this gap by assessing BLLs among car spray painters in Bayelsa State, Nigeria, and evaluating associated toxic effects on hematological, hepatic, and renal biomarkers. Understanding exposure-related health impacts is crucial for informing occupational safety policies and protective interventions.

2. Material and Methods

This study employed a cross-sectional design, involving 18 car spray painters randomly selected from various workshops in Bayelsa State. A structured questionnaire was used to collect data on demographic characteristics, occupational history, and safety practices.

2.1. Study Population and Sampling

The total sample size for this study was thirty six (36) comprising of 18 spray painters (test group) and 18 lecturers (control group). Spray painters were randomly chosen per workshop provided the person met inclusion criteria for the study. The 18 lecturers were selected from different institutions of higher learning in the Bayelsa state.

2.2. Study Inclusion/Exclusion Criteria

The study was carried out on healthy adults aged 18years and above who had been working regularly for a minimum of one year and agreed to participate. It excluded individuals with serious health issues, recent x-ray exposure, or those taking certain medications. Other exclusions included smokers, narcotic users, and those using protective gear on the job.

2.3. Sample Collection

Blood samples were collected by venipuncture using sterile disposable syringes. Samples for measurement of biochemical parameters were collected into plain serum separating tubes. These were allowed to stand for 10-20 minutes after which they were centrifuged at 3,000 rpm for 20 minutes and the serum was separated using a Pasteur pipette. Samples for measurement of lead, PCV and Hb were collected into K₃ EDTA anti-coagulated bottles and mixed thoroughly by gentle repeated turning.

2.4. Laboratory Procedures

Agilent Technologies 240 FS AA flame atomic absorption spectrometer with deuterium lamp background correction was used for the measurement of lead levels. The following biochemical parameters: ALT, AST, ALP, albumin, total protein, uric acid, bilirubin, total calcium, urea, creatinine, albumin and total protein were analyzed colorimetrically using respective test kits sourced from Randox Health, United Kingdom. EA-1000B ISE electrolyte analyzer from Perlong Medical Equipment Company was used to measure potassium, sodium and chloride levels. PCV levels were measured with Hawksley, England microhaematocrit centrifuge and Hb levels by Mindray BC-5000 automatic haematology analyzer.

2.5. Data Analysis

Data was analyzed using Graph Pad Prism (version 9.5.1) software. One-way analysis of variance (ANOVA), independent t-test and Tukey's HSD Post Hoc analysis were used for the inferential statistics. P values less than 0.05 was accepted as significant for confidence intervals (CI) of 95%.

3. Results

Figure 1 shows the mean age of the study groups. The mean age for spray painters was 32.4 ± 2.8 years while the mean age for the control group (Lecturers) was 35.6 ± 2.6 years. The duration of exposure was in the range of 1 – 26 years with mean duration of exposure of 6.2 ± 1.4 years.

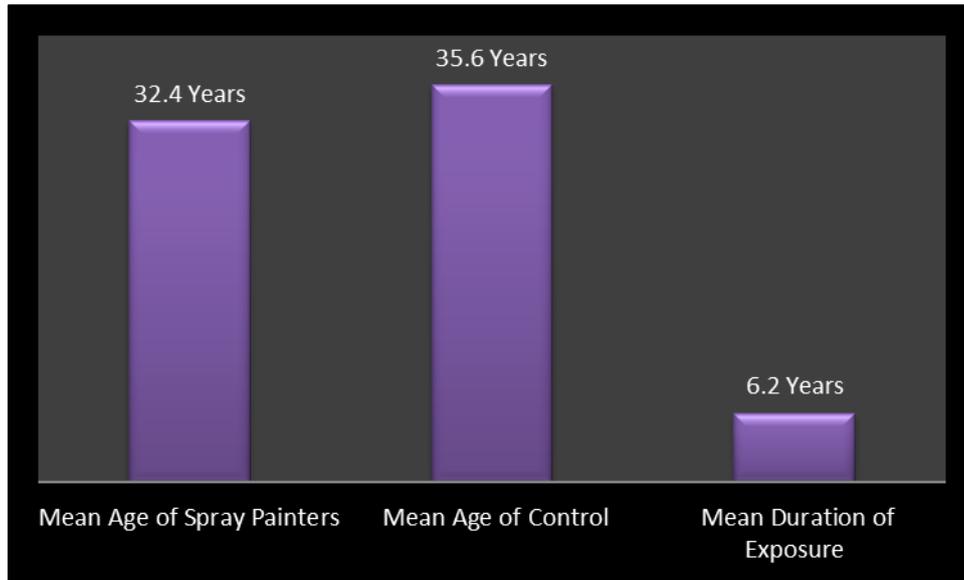


Figure 1 Age and Exposure Duration of the Study Groups

Figure 2 The measured blood lead levels in the two study groups. Spray painters had a mean blood lead level (BLL) of $23.2 \pm 3.4 \mu\text{g/dl}$, while the level in the control group was $4.1 \pm 0.6 \mu\text{g/dl}$. The observed differences were statistically significant ($p\text{-value} = < 0.0001$)

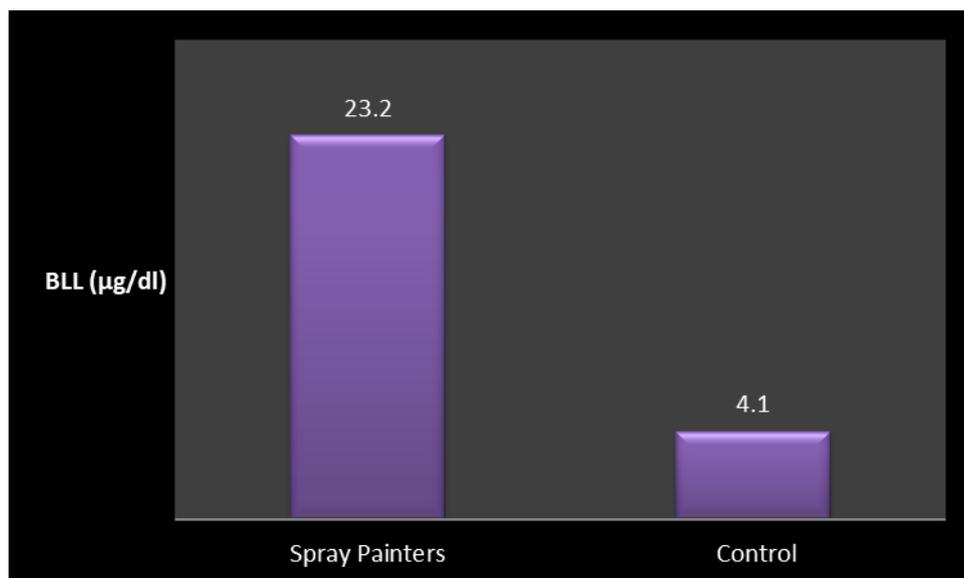


Figure 2 Blood Lead Levels in the Two Study Groups

Figure 3 is a presentation PCV and Hb levels measured in the two study groups. The observed levels of PCV in spray painters and the control group were 35 ± 2% and 41 ± 3% respectively. An Hb level of 12.1 ± 0.65g/dl was recorded in the spray painters while the control group had an Hb level of 13.8 ± 0.86g/dl. T-test analysis shows that both PCV and Hb levels were significantly lower in spray painters compared to the control group.

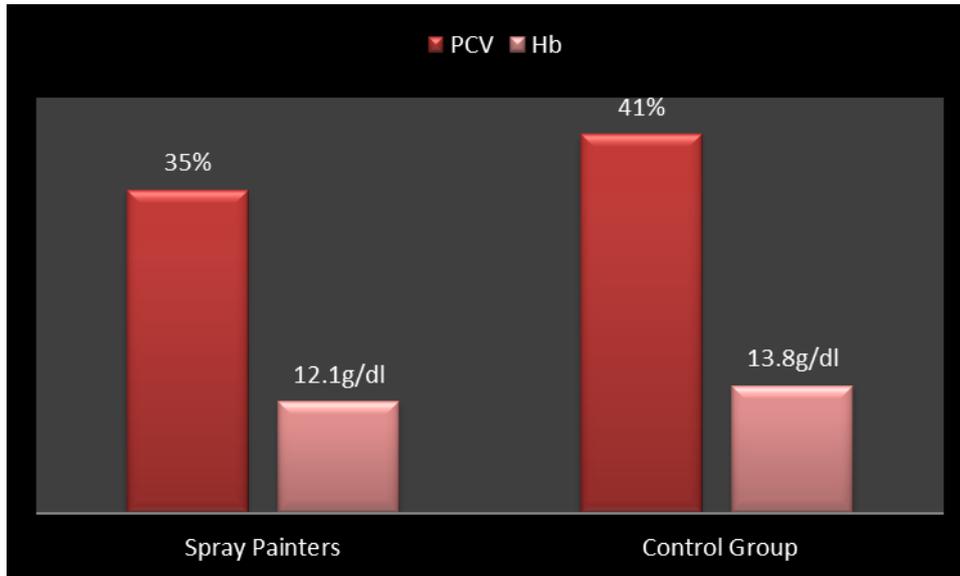


Figure 3 PCV and Hb Levels in the Test Groups

Table 1 presents lead, PCV and Hb levels in relation to years of exposure. It shows that lead levels increased with more years of exposure (17.6 ± 2.8 µg/dl for 1–10 years, 24.4 ± 2.5 µg/dl for 11–20 years, and 27.2 ± 2.1 µg/dl for 21–30 years). This rise is statistically significant (p-value = 0.0001). PCV Levels decreased slightly as years of exposure increased from 37 to 33%, but this change is not statistically significant (p-value = 0.1154). Hb levels also showed a slight decrease with longer exposure (from 12.6 to 11.7g/dl), but this observed difference is not statistically significant (p-value = 0.1847).

Table 1 Lead, PCV and HB Levels in Relation to Years of Exposure

Marker	1–10 Years (n=5)	11–20 Years (n=8)	21–30 Years(n=5)	p-value
Lead (µg dl)	17.6 ± 2.8	24.4 ± 2.5	27.2 ± 2.1	0.0001
PCV (%)	37 ± 3.5	35 ± 2.8	33 ± 2.0	0.1154
Hb (g/dl)	12.6 ± 0.81	12.0 ± 0.77	11.7 ± 0.64	0.1847

Table 2 shows the comparisons of lead, PCV and Hb levels in relation to years of exposure using Tukey’s HSD Post-Hoc analysis. The results show that there is a significant increase in lead levels with years of exposure. Specifically, lead levels were significantly higher in individuals exposed for 11-20 years and 21-30 years compared to those exposed for 1-10 years. However, the difference in lead levels between the 11-20 year and 21-30 year groups is not statistically significant. While both PCV and Hb levels tend to decrease with increasing years of exposure, none of the differences between the exposed groups reached statistical significance.

Table 2 Tukey’s HSD Post Hoc Results for Lead, PCV and Hb levels in Spray Painters

Marker	1-10 vs 11-20 (p-value)	1-10 vs 21-30 (p- value)	11-20 vs 21-30 (p- value)
Lead	0.009	0.001	0.295
PCV	0.531	0.094	0.436
Hb	0.593	0.142	0.720

Table 3 provides mean and standard deviation values for various liver function markers in the two groups. It shows that Spray painters had significantly higher levels of AST, ALT, ALP, total bilirubin and conjugated bilirubin than controls ($p < 0.001$). They also had a higher level of albumin but this was not statistically significant ($p = 0.2634$). Protein level was higher in the control group but not statistically significant $p = (0.1449)$.

Table 3 Liver Function Parameters in Spray Painters and Controls

Marker of Liver Function	Spray Painters n = 18	Control n = 18	P- Value
AST (U/L)	15.07 ± 1.48	8.70 ± 0.55	< 0.0001
ALT (U/L)	14.54 ± 1.41	5.80 ± 0.71	< 0.0001
ALP (U/L)	27.19 ± 2.23	24.40 ± 5.90	0.068
Total bilirubin (µmol/L)	10.20 ± 1.10	7.13 ± 1.00	< 0.0001
Conjugated bilirubin (µmol/L)	5.10 ± 0.66	2.63 ± 0.87	< 0.0001
Albumin (g/L)	36.20 ± 0.82	36.63 ± 1.23	0.224
Total protein (g/L)	66 ± 1.95	67.00 ± 1.84	0.123

Table 4 shows the measured kidney function parameters in the two study groups. It shows that spray painters had the highest levels of potassium (4.1 ± 0.24mmol/L), creatinine (88.20 ± µmol/L), urea (4.2 ± 0.25mmol/L), and uric acid (241.50 ± 5.3 µmol/L). Significant differences were observed only in creatinine and uric acid. On the other hand, the control group had the highest levels of sodium 139 ± 0.72mmol/L), bicarbonate (26 ± 0.8mmol/L) and calcium (2.31 ± 0.07mmol/L) and the observed differences were not statistically significant.

Table 4 Biomarkers of Kidney Function in Spray Painters and Controls

Kidney function Parameters	Spray Painters n = 18	Control Group n = 18	P Value
Sodium (mmol/L)	137 ± 0.74	139 ± 0.72	0.061
Potassium (mmol/L)	4.1 ± 0.24	4.0 ± 0.18	0.707
Chloride (mmol/L)	101 ± 1.6	101 ± 0.9	1.000
Bicarbonate (mmol/L)	25.7 ± 0.85	26 ± 0.8	0.655
Calcium (mmol/L)	2.30 ± 0.05	2.31 ± 0.07	0.828
Creatinine (µmol/L)	88.20 ± 3.3	80.5 ± 4.4	0.008
Urea (mmol/L)	4.2 ± 0.25	4.0 ± 0.16	0.065
Uric acid (µmol/L)	241.50 ± 5.3	202.13 ± 6.3	< 0.001

Table 5 presents the mean, standard deviation of liver function markers across the three groups based on years of occupational exposure (1–10, 11–20, and 21–30 years), along with the ANOVA p-values for each marker. Means of AST and ALT increased with years of exposure (AST: 13.47 → 15.32 → 16.41, ALT: 12.60 → 15.15 → 15.87). The calculated p-values from ANOVA (AST = 0.004, ALT = 0.006) were both significant.

Table 5 Liver Function Parameters in Relation to Years of Exposure

Marker	1–10 Years (n=5)	11–20 Years (n=8)	21–30 Years (n=5)	p-value
AST (U/L)	13.47 ± 1.48	15.32 ± 1.21	16.41 ± 1.5	0.004
ALT (U/L)	12.60 ± 1.41	15.15 ± 1.23	15.87 ± 1.45	0.006
ALP (U/L)	25.47 ± 4.53	27.44 ± 3.65	28.67 ± 3.6	0.278

Total bilirubin (µmol/L)	5.20 ± 0.78	7.54 ± 0.87	8.66 ± 0.66	0.001
Conjugated bilirubin (µmol/L)	2.10 ± 0.54	2.8 ± 0.72	3.0 ± 0.77	0.049
Albumin (g/L)	37.3 ± 2.8	36.5 ± 2.0	36.1 ± 2.4	0.624
Total protein (g/L)	67 ± 1.8	66 ± 2.2	65 ± 1.5	0.231

Table 6 is a presentation of the result of Tukey’s HSD Post-Hoc analysis of liver function parameters in relation to age of exposure. Significant differences between 1–10 vs 11–20 and 1–10 vs 21–30 years, but not between 11–20 vs 21–30 years were observed in AST and ALT levels.

The analysis for total bilirubin shows significant differences between the 1–10 and 11–20 years groups ($p < 0.01$), the 1–10 and 21–30 years groups ($p < 0.001$), and the 11–20 and 21–30 years groups ($p = 0.0489$). No significant differences between any groups were observed in ALP, Albumin and Total Protein.

Table 6 Tukey’s HSD Post Hoc Results for Liver Function Parameters

Marker	1-10 vs 11-20 (p-value)	1-10 vs 21-30 (p-value)	11-20 vs 21-30 (p-value)
AST (U/L)	0.037	0.004	0.221
ALT (U/L)	0.041	0.008	0.315
ALP (U/L)	0.412	0.298	0.671
Total bilirubin (µmol/L)	0.009	0.0004	0.034
Conjugated bilirubin (µmol/L)	0.045	0.011	0.287
Albumin (g/L)	0.551	0.412	0.763
Total protein (g/L)	0.238	0.174	0.489

Table 7 shows kidney function parameters in relation to years of exposure in the two study groups. The table shows that sodium levels decreased as years of exposure increased (from 138 to 136 mmol/L), with a highly significant p-value of 0.0002. There was no clear trend in potassium levels, and the p-value of 0.191 indicates that this change was not significant. Chloride levels also decreased with increased exposure (from 102 to 100 mmol/L), which was statistically significant ($p = 0.011$). Bicarbonate levels showed a slight decrease with more exposure ($p = 0.037$, significant). Calcium levels also decreased slightly as years of exposure increased, with a significant p-value of 0.049.

Table 7 Biomarkers of Kidney Function Parameters In Relation to Years of Exposure

Parameter	1-10 yrs (n=5)	11-20 yrs (n=8)	21-30 yrs (n=5)	p-value
Sodium (mmol/L)	138 ± 0.88	137 ± 0.72	136 ± 0.52	0.0002
Potassium (mmol/L)	4.3 ± 0.22	4.0 ± 0.18	4.1 ± 0.44	0.191
Chloride (mmol/L)	102 ± 1.3	101 ± 0.9	100 ± 0.55	0.011
Bicarbonate (mmol/L)	26.2 ± 0.55	25.8 ± 0.8	25.2 ± 0.64	0.037
Calcium (mmol/L)	2.32 ± 0.04	2.30 ± 0.07	2.27 ± 0.12	0.049
Creatinine (µmol/L)	81.5 ± 3.7	90.5 ± 4.4	92.6 ± 5.2	0.001
Urea (mmol/L)	4.0 ± 0.23	4.1 ± 0.16	4.5 ± 0.55	0.021
Uric acid (µmol/L)	235.3 ± 7.5	242.1 ± 6.3	247.0 ± 5.6	0.037

Table 8 shows the result of Tukey’s HSD Post-Hoc analysis of kidney function parameters in relation to duration of exposure. It shows that there were significant differences in the levels of sodium and chloride across all the group pairs. Significant differences in creatinine levels were observed between 1–10 vs 11–20 years and 1–10 vs 21–30 year. Urea

levels were significant between 1–10 vs 21–30 and 11–20 vs 21–30. Uric acid, bicarbonate and calcium levels were significant only between 1–10 vs 21–30 years. No significant differences were observed in potassium levels.

Table 8 Tukey's HSD Post Hoc Results for Kidney Function Parameters

Parameter	1-10 vs 11-20 (p-value)	1-10 vs 21-30 (p-value)	11-20 vs 21-30 (p-value)
Sodium	0.003	<0.001	0.003
Potassium	0.241	0.531	0.819
Chloride	0.049	0.002	0.049
Bicarbonate	0.412	0.019	0.134
Calcium	0.712	0.048	0.231
Creatinine	0.002	<0.001	0.412
Urea	0.819	0.022	0.049
Uric acid	0.241	0.019	0.531

4. Discussion

This study highlights the significant occupational risk of lead exposure among car spray painters in Bayelsa State, Nigeria. The results demonstrate that car spray painters exhibit considerably elevated blood lead levels (BLLs) with a mean of $23.2 \pm 3.4 \mu\text{g/dL}$ compared to $4.1 \pm 0.6 \mu\text{g/dL}$ in the control group, indicating substantial lead absorption likely due to inhalation of lead-containing paint fumes. The difference in BLLs was highly significant ($p < 0.0001$). Moreover, BLLs increased significantly with the duration of exposure, confirming a dose-response relationship consistent with cumulative lead toxicity. These findings are in agreement with previous studies documenting elevated lead levels in similar occupational settings [10-12].

Hemoglobin (Hb) and packed cell volume (PCV) levels were significantly lower in spray painters, suggesting that lead exposure adversely affects hematopoietic function, likely through impairment of heme synthesis and red blood cell production. Despite a trend of decreasing Hb and PCV with increasing exposure duration, the variations were not statistically significant—a pattern consistent with previous occupational lead studies [2].

Elevations in liver enzymes (AST, ALT), total and conjugated bilirubin among spray painters signify hepatocellular injury and impaired liver function, with both AST and ALT levels rising significantly with longer exposure durations. These biochemical changes highlight chronic hepatic stress resulting from lead toxicity, corroborating findings from animal and human studies [13, 14]. In contrast, albumin and total protein remained comparable between groups, indicating preserved synthetic liver function at this stage.

Kidney function markers also revealed significant toxic effects, with spray painters showing elevated creatinine, urea, and uric acid levels, evidencing early renal impairment attributable to lead nephrotoxicity. Significant reductions in sodium and chloride levels with increasing exposure further indicate electrolyte imbalance. These renal effects align with established literature on lead-induced nephropathy [15, 16].

Taken together, the results underscore the health hazards posed by occupational lead exposure in spray painters. The dose-dependent alterations in haematologic, hepatic, and renal biomarkers reflect the cumulative toxicity associated with chronic lead absorption. This study calls for urgent implementation of preventive strategies including use of personal protective equipment, regular health monitoring, and enforcement of occupational safety regulations to mitigate lead exposure and its sequelae in this workforce.

5. Conclusion

This study demonstrates that car spray painters in Bayelsa State, Nigeria, are exposed to significantly elevated levels of lead compared to unexposed controls. The findings reveal a clear association between prolonged occupational exposure and adverse effects on haematological, hepatic, and renal functions. Elevated blood lead levels were correlated with decreased haemoglobin and packed cell volume, increased liver enzyme activities, and impaired kidney biomarkers, highlighting the systemic toxicity of lead in this population. These results underscore the urgent need for

comprehensive occupational health interventions, including routine blood lead monitoring, enforcement of safety regulations, use of personal protective equipment, and worker education to mitigate exposure risks. Addressing these concerns is critical to preventing long-term health complications and improving the wellbeing of car spray painters in Bayelsa State and similar occupational settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The study protocol was approved by the Research and Ethics Committee of Faculty of Medical Laboratory Science, Federal University, Otuoke, Bayelsa state.

Statement of informed consent

Informed consent to participate was obtained from each subject after explaining the aim and study protocol of the study.

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