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Effects of Carbon Monoxide on Haematological and Haemostatic Parameters among the Exposed Workers at Generator Servicing Centres in Benin City

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Abstract

Objectives: Carbon monoxide (CO) is an odourless and highly toxic gas produced from incomplete combustion of fuel. This gas has capacity to bind with haemoglobin to compete for oxygen uptake when inhaled, thereby altering the blood physiology. **Aim:** The aim of this study is to determine the effect of carbon monoxide on haematology and haemostasis parameters among the exposed workers at gasoline generators service centre in Benin City. **Methodology:** Eighty-eight participants (workers n = 44 and; controls n = 44) took part in this study. Carbon monoxide used for this study was sourced from the smoke being emitted by gasoline generators during repairs. The participants' haematological parameters were analysed using haematology autoanalyzer (Sysmex Poch 100i model, Germany), while PT and PTTK were assayed using standard methods. **Results:** The mean values of red blood cells (RBC), white blood cells (WBC), platelets (PLT), haemoglobin concentration (Hb), hematocrit (HCT), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and red cell distribution width coefficient variation (RDW-CV) observed in both the workers at generator service center and their controls fell within normal ranges, but the mean red cell distribution width standard deviation (RDW-SD) of workers at generator service center fell below normal as against the normal value for controls. There were no significant differences in serum concentrations of lymphocytes ($p = 0.134$), and granulocytes ($p = 0.584$). In contrast, significantly ($p < 0.001$) higher mean monocyte level was observed in the workers at the generator service center compared with the controls. Also, there was significantly lower mean platelet volume (MPV) ($p = 0.002$), platelet distribution width (PDW) ($p = 0.001$), platelet large cell ratio (PLCR) ($p = 0.013$) and higher plateletcrit (PCT) ($p = 0.001$) in the workers at the generator service center compared with the control group. PT and PTT values fell within normal range among the controls, while the values are higher among the exposed workers at the centres. **Conclusion:** In this study, carbon monoxide emitted during repairs has no deleterious effects on haematological and haemostasis parameters of the exposed workers at generator service centre in Benin City. However, PT and PTT exceeded normal value in the workers at the generator service centre compared to the controls. More work needs to be done especially on longer duration of exposure and at various concentrations of carbon monoxide exposure.

Keywords

Generator Smoke, Full Blood Count, Haematological, Haemostasis

1. Introduction

Carbon monoxide (CO) is a poisonous non-irritant gas produced by incomplete combustion of organic materials due to insufficient oxygen supply [1]. Automobile exhaust fumes emitted by unserviceable vehicles are one of the major sources of CO concentration in Nigerian environments. Other major sources of CO include exhaust fumes from gasoline and diesel power generating sets, burning of materials containing hydrocarbons, cooking with firewood and accumulated carbon monoxide found at every road intercession due to traffic hold-ups caused by non-functional traffic lights and bad roads. The resultant effect of all these emissions is an environment that is saturated with carbon monoxide.

Carbon monoxide poisoning is quite common among the population but there are certain occupational groups who carry a greater risk of exposure to this gas due to their occupation [2]. The workers at gasoline and diesel power generator servicing workshops fall into this category of workers. The use of gasoline and diesel power generators as a source of electricity generation has been embraced by majority of Nigerians, due to the collapse of the Nigerian economy which has severely affected the power sector. The influx of gasoline and diesel power generators into Nigeria, most especially the urban cities, has also attracted the migration of workers involved in servicing these generator engines, since they are bound to break down after repeated use. These men are therefore exposed to CO poison in the course of carrying out their works.

Carbon monoxide poison is among the most common type of fatal poisoning [3]. The greater affinity of carbon monoxide for binding sites of haemoglobin compared to oxygen limits erythrocyte oxygen transport and reduces tissue oxygen availability. Erythrocytes may be considered to be among the most susceptible cells to carbon monoxide effects since CO binds to hemoglobin with an affinity of about 200 times greater than oxygen. It also causes a leftward shift of the oxyhemoglobin dissociation curve; binds to many intracellular proteins and may affect adenosine triphosphate (ATP) production at the cytochrome level [4] [5]. There are several, non-specific symptoms of CO poisoning which range from mild exposure that manifest in form of dizziness, headaches, myalgia, or neuropsychological disorders to severe exposures which can result in, loss of consciousness and even death [6].

Haematological parameters are different components of blood which include red blood cells, white blood cells and platelets. The major functions of these various parameters are transportation of nutrients round the body and removal of waste products, including gases. Body defence and clotting competence are also the duties of these blood components. When the relationship between the body and blood falters, there is bound to be a derangement which could result in morbidity or mortality. Studies investigating the effects of CO on red blood cell (RBC) properties and blood rheology mostly focused on smokers or individuals subjected to air pollution, who were exposed to relatively lower doses of CO for a longer time in combination with other gases or toxic substances [7]-[12].

To date, there is no known documented work on the effects of carbon monoxide poison on haematological parameters and haemostasis among individuals working at the power generator servicing centres, hence the justification of this study. The present study is therefore aimed at determining the effect of CO on the haematological and haemostatic parameters among workers exposed to gasoline and diesel power generator fumes in Benin City, Nigeria.

2. Methodology

2.1. Study Design

The present study is a purposive, non-random sampling, cross sectional study involving adult male workers at gasoline/diesel generator service centres in Benin City, who are occupationally exposed to CO fumes and non-occupationally exposed adult group. The study was conducted between October 2019 and March 2020 in Benin City, Nigeria. A total of forty-four (44) males working at generator servicing centres and forty-four (44) non-exposed controls, within the ages of 15 - 60 years participated in this study. The participants included generator mechanics and generator spare parts sellers, who were exposed to varied degree of carbon monoxide at the generator servicing centres. The control group comprises of unexposed healthy young men of same age range with the workers. Participants exposed to other sources of CO such as cigarette smoke, wood or cooking stove smoke and petrol or diesel fumes and those with a history of any acute or chronic illness, bleeding disorder or drug addiction were excluded from the study. Workers on part-time duties and those who were new on the job or have not spent up to six months on the job were also excluded from this study. The personal consent of individual participant was sought, after explaining the purpose of the research.

2.2. Sample Size

The sample size for the study was determined using the formula for comparison between two groups when endpoint is quantitative data: $n = 2SD^2 (Z\alpha + Z\beta)^2/d^2$ [13]. Where: n = the sample size (respondents that were interviewed); SD = 3.3 (standard deviation from previous study); $Z\alpha$ = 1.96 (Z score corresponding to 95% confidence interval); $Z\beta$= 0.84 (Z score corresponding to 80% confidence interval); d = 2 (the margin error that was accepted in this study).

On applying; $2SD^2 (Z\alpha + Z\beta)^2/d^2$

$$n = \left[2(3.3)^2 \times (1.96 + 0.84)^2\right] \div 2^2 = [21.78 \times 7.84] \div 4 = 170.8 \div 4 = 42.68$$

$n = 42 + 2$ (considering 5% dropout of study).

2.3. Questionnaire/Ethical Approval

A structured questionnaire was administered to every participant of this study. The questionnaire consisted of questions designed to elicit details about their personal data, sex, age, marital status, educational qualification, alcohol consumption, cigarette smoking, use of wood or kerosine stove to cook and length of time in occupation and daily hour of exposure to petrol and diesel fumes as well as history of drug addiction and underlying diseases. The Ethics committee of Ministry of Health, Edo State and leaders at the service centres approved this study.

2.4. Blood Collection and Analysis for Full Blood Count

Five millilitres of blood were collected and dispensed into an ethelynediamine-tetraacetic acid (EDTA) container. Analysis for haematological parameters was done immediately using haematology autoanalyzer (Sysmex Poch 100i model, Germany).

2.5. Blood Collection and Analysis for Haemostatic Parameters

2.5.1. Prothrombin Time (PT)

Blood Sample Blood (9 parts) is collected into 1 part of 3.2% trisodium citrate and the plasma obtained by centrifugation at 2500 g for 15minues. The plasma obtained was then analysed immediately for (PT), using Calcium Rabbit Brain-Thromboplastin reagent (Catalog number CRST000) from Diagnostic Reagents Limited.

2.5.2. Partial Thrombin Time and Kaolin (PTTK)

Blood Sample Blood (9 parts) is collected into 1 part of 3.2% trisodium citrate and the plasma obtained by centrifugation at 2500 g for 15 minues. The separated plasma was analysed immediately using commercially purchase kit, Kaolin Platelet Substitute Mixture (Catalog number KAP8050) from Diagnostic Reagents Limited.

2.6. Data Analysis

Data was expressed as mean and standard deviation. Comparative analysis was done using independent sample t-test and analysis of variance (ANOVA). Statistical significance was set at $p < 0.05$. All statistics were done using IBM/SPSS software (version 20.0).

3. Results

Table 1 shows the socio-demographic characteristics and lifestyle of the study population. The study population comprises 44 generator mechanics and a

Table 1. Socio-demographic characteristics and lifestyle of the study population.

Characteristics	Control, n = 44 N (%)	CO Exposed Workers, n = 44 N (%)	Total, n = 88 N (%)
Age (years)			
10 - 20	11 (25.0)	18 (40.9)	29 (33.0)
21 - 30	11 (25.0)	13 (29.5)	24 (27.3)
31 - 40	6 (13.6)	7 (15.9)	13 (14.8)
>40	16 (36.4)	6 (13.6)	22 (25.0)
Level of Education			
Primary	3 (6.8)	15 (34.1)	18 (20.5)
Secondary	26 (59.1)	26 (59.1)	52 (59.1)
Tertiary	15 (34.1)	3 (6.8)	18 (20.5)
Occupation			
Civil Servants	6 (13.6)	0 (0)	6 (6.8)
Self Employed (Skilled Workers)	15 (34.1)	44 (100.0)	59 (67.0)
Unemployed	23 (52.3)	0 (0)	23 (26.2)
Smoking Habit			
No	42 (95.5)	37 (84.1)	79 (89.8)
Yes	2 (4.5)	7 (15.9)	9 (10.2)
Drinking Habit			
No	37 (84.1)	29 (65.9)	66 (75.0)
Yes	7 (15.9)	15 (34.1)	22 (25.0)

matched number of healthy controls (n = 44). Data indicated that majority of the control subjects were of age > 40 years (36.4%), attained secondary level of education (59.1%), unemployed (52.3%), non-smokers (95.5%) and non-alcoholic drinkers (84.1%). A greater proportion of the generator mechanics were of age range 10 - 20 years (40.9%), attained secondary level of education (59.1%), self-employed (100%), non-smokers (84.1%) and non-drinkers (65.9%).

Table 2 shows the mean levels of hematological parameters of the study population. Data indicated that the mean values of RBC, WBC, PLT, Hb and HCT observed in both the workers at generator service centre and their controls fell within normal ranges for theses parameters (*i.e.* RBC, (4.0 - 6.20) × 10^6/µL; WBC, (4.0 - 12.0) × 10^3/µL; PLT, 150 - 400 cells/µL; Hb, 11.0 - 17.0 g/dl; HCT, 35.0% - 55.0%). However, independent sample t-test indicated no significant differences in RBC (p = 0.976), WBC (p = 0.649), PLT (p = 0.140), Hb (p = 0.872) and HCT (0.934) between the workers at generator service center and the controls.

The mean levels of red blood cell indices of the study population are expressed in Table 3. Data shows that the mean values obtained in MCV, MCH, MCHC and RDW-CV fell within normal ranges (MCV, 80 - 100 µm^3; MCH, 26 - 34 pg; MCHC, 31 - 35.5 g/dl; RDW-CV, 10% - 16%) in both workers at generator service centre and controls. The mean RDW-SD for control subjects also was within normal range (37 - 46 µm^3), while that of workers at generator service centre fell below

Table 2. The mean levels of hematological parameters of the study population.

Parameters	Controls	CO Exposed Workers	t-statistics	P-Value
RBC (10^6/µL)	5.35 ± 0.69	5.36 ± 0.73	−0.03	0.976
WBC (10^3/µL)	5.91 ± 1.64	6.07 ± 1.52	−0.45	0.649
PLT (cells/µL)	177.04 ± 46.06	189.47 ± 30.60	−1.49	0.140
Hb (g/dL)	14.15 ± 1.33	14.20 ± 1.30	−0.16	0.872
HCT (%)	43.23 ± 3.95	43.16 ± 3.72	0.08	0.934

Abbreviations: CO, Carbon monoxide; RBC, Red Blood Cell; WBC, White Blood Cell; PLT, Platelet; Hb, Hemoglobin; HCT, Hematocrit.

Table 3. The mean levels of red blood cell indices of the study population.

Parameters	Control	CO Exposed Workers	t-statistics	P-Value
MCV (µm^3)	79.80 ± 6.96	80.68 ± 4.38	−0.71	0.479
MCH (pg)	27.13 ± 2.47	26.73 ± 1.54	0.92	0.358
MCHC (g/dL)	32.88 ± 1.39	33.39 ± 1.36	−1.72	0.089
RDW-CV (%)	14.90 ± 1.11	13.76 ± 3.34	2.22	0.029
RDW-SD (µm^3)	45.05 ± 5.70	34.12 ± 3.94	10.45	<0.001

Abbreviations: CO, Carbon monoxide; MCV, Mean Cell Volume; MCH, Mean Cell Hemoglobin; MCHC, Mean Cell Hemoglobin Concentration; RDWC, Red Cell Distribution Width Coefficient Variation; RDWS, Red Cell Distribution Width Standard Deviation.

normal. Independent sample t-test indicated no significant differences in mean MCV ($p = 0.479$), MCH ($p = 0.358$), MCHC ($p = 0.089$) between the mechanics and their controls. In contrast, the workers at generator service centre indicated significantly lower RDW-C (13.76% ± 3.34% vs. 14.90% ± 1.11%; $p = 0.029$) and RDW-S (34.12 ± 3.94 μm^3 vs. 45.05 ± 5.70 μm^3; $p < 0.001$) compared with the controls.

Table 4 shows the mean levels of white blood cell differential count of the study population. Data indicated that mean serum concentrations of the Lymphocytes, monocytes and granulocytes, fell within normal ranges (lymphocytes, (1.0 - 5.0) × 10^3/μL; monocytes, (0.1 - 1.0) × 10^3/μL; granulocytes, (2.0 - 8.0) × 10^3/μL) in both the mechanics and the control group. By percentage differentials, %lymphocytes in both groups fell within normal ranges of 25% - 50%. However, the mean percentages of monocytes were above normal range (2% - 10%) in both groups. In addition, the mean percentages of granulocytes were below normal range (50% - 80%) in both groups. Independent sample t-test indicated no significant differences in serum concentrations of lymphocytes ($p = 0.134$), and granulocytes ($p = 0.584$). In contrast, significantly ($p < 0.001$) higher mean monocyte level was observed in the workers at the generator service centre compared with the controls. No significant differences were observed in percentage lymphocytes ($p = 0.996$), monocytes ($p = 0.095$) and granulocytes ($p = 0.401$) between the two groups.

The mean levels of platelet indices of the study population are shown in Table 5.

Table 4. The mean levels of white blood cell differential count of the study population.

Parameters	Controls	CO Exposed Workers	t-statistics	P-Value
Lymphocytes (10^3/μL)	2.94 ± 0.71	3.16 ± 0.63	−1.51	0.134
Monocytes (10^3/μL)	0.64 ± 0.17	0.83 ± 0.28	−3.81	<0.001
Granulocytes (10^3/μL)	2.11 ± 0.66	2.18 ± 0.52	−0.55	0.584
Lymphocytes (%)	49.87 ± 6.48	49.88 ± 5.54	−0.01	0.996
Monocytes (%)	12.57 ± 3.64	13.75 ± 2.81	−1.69	0.095
Granulocytes (%)	37.52 ± 7.28	36.36 ± 5.51	0.84	0.401

Abbreviation: CO, Carbon monoxide.

Table 5. The Mean Levels of Platelet Indices of the Study Population

Parameters	Controls	CO Exposed Workers	t-statistics	P-Value
MPV (μm^3)	9.29 ± 1.15	8.71 ± 0.38	3.13	0.002
PCT (%)	0.16 ± 0.05	0.19 ± 0.03	−3.48	0.001
PDW (%)	13.41 ± 2.31	11.69 ± 2.30	3.49	0.001
PLCR (%)	18.16 ± 5.29	15.96 ± 2.27	2.53	0.013

Abbreviations: CO, Carbon monoxide; MPV, Mean Platelet Volume; PCT, Plateletcrit; PDW, Platelet Distribution Width; PLCR, Platelet Large Cell Ratio.

Data indicated that mean levels of MPV, PDW and PLCR for both the workers at the generator service centre and their controls fell within normal ranges for these parameters (MPV, 7.0 - 11.0 μm^3; PDW, 10% - 18%; PLCR, 12% - 42%). However, the mean percentages of PCT in both groups were below the normal range (0.20% - 0.50%). Independent sample t-test indicated significantly lower MPV ($p = 0.002$), PDW ($p = 0.001$), PLCR ($p = 0.013$) and higher PCT ($p = 0.001$) in the workers at the generator service centre compared with the control group.

The mean prothrombin time (PT) of the generator service centre workers and their controls are shown in **Figure 1**. Data shows that the mean PT in control (14.06 ± 1.50 seconds) fell within normal range of 11 - 15 seconds, while that of generator service centre workers (62.93 ± 8.37 seconds) was above the normal range. Independent sample t-test indicated that the mean prothrombin time of the generator service centre workers was significantly ($P < 0.001$) longer than that of the controls.

The mean partial prothrombin time (PTT) of the generator service centre workers and their controls are shown in **Figure 2**. Data shows that the mean PTT in control (36.81 ± 7.33 seconds) fell within normal range of 20 - 45 seconds, while that of generator service centre workers (73.38 ± 13.83 minutes) was above normal range. Furthermore, independent sample t-test indicated that the mean partial prothrombin time of the generator service centre workers was significantly ($P < 0.001$) longer than that of the controls.

4. Discussion

The status of the hematological parameters has been established as a very important diagnostic tool used in routine clinical evaluation of health, while

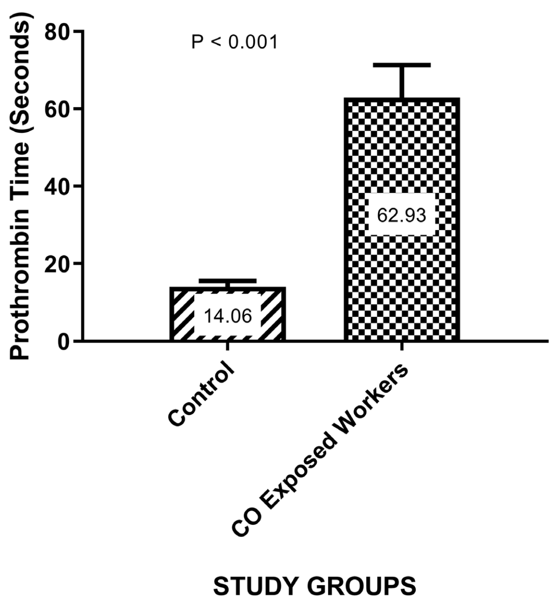

Figure 1. Mean prothrombin time in exposed generator service centre workers and their controls.

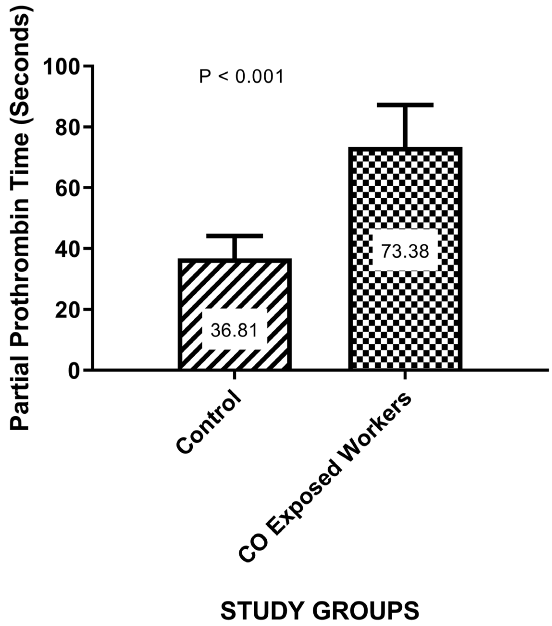

Figure 2. Mean partial prothrombin time in exposed generator service centre workers and their controls.

haemostatic parameters have been shown to be useful physiological markers of organ and tissue damage and dysfunction [14] [15] [16]. Haematological parameters commonly employed in disease and poisoning diagnosis and management include, red blood cells, white blood cell, haemoglobin concentration, hematocrit, platelets, mean corpuscular volume or cell, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration [17]; on the other hand, hemostatic parameters include platelet indices, bleeding time, prothrombin time and partial thromboplastin time [18]. These blood parameters are very vulnerable to alterations by several factors and conditions due to the circulatory nature of the body. The deleterious effects of carbon monoxide on blood indices have been well documented. Works to unearth these alterations in blood compositions have been carried out extensively by researchers on various groups of workers who are exposed to detectable level of carbon monoxide from different sources. However, it is not clear if individuals who work in an environment exposed to CO emission from gasoline and diesel generator sets, are in danger of the CO-related hematological and hemostatic alterations.

In the present study no significant differences were observed in RBC, WBC, Hb, Hct, PLT, MCV, MCH and MCHC. Previous studies involving smokers exposed to CO, have shown increased concentrations of Hb, RBC count, Hct, and MCH among the smokers compared to nonsmokers of same age groups [19]. Other studies Anandha *et al.* [20]; Vanuxem *et al.* [21]; Whang and Choi, 1990 [22]; Song-Su and Saing, 1994 [23] have also indicated increased levels of WBC with increase in CO exposure. In another study involving rats continuously exposed to 500 ppm CO for 42-day [24], results showed increased MCV and MCH among the exposed rats compared with control. In a study by Muhammad, *et al.* [19] the results of the increase in values of MCV and MCHC were found less marked and non-significant between smokers and non-smokers. Findings on chronic carbon monoxide exposure, as shown by Agoro *et al.* [25] indicated that RBCs, were significantly raised, whereas platelets, WBC, MCV, MCH and MCHC were significantly decreased. It is noteworthy that the generator workers presented values that fell within normal ranges for RBC, WBC, Hb, Hct, PLT, MCV, MCH and MCHC, suggesting that exposure of these workers to CO emission from power generating sets did not alter their hematological parameters.

Furthermore, we observed significantly lower RDW-C and RDW-S in the workers at generator service centers compared with the controls. Red blood cell distribution width (RDW) is a measure of the variability in the size of circulating erythrocytes and an independent predictor of long-term mortality in patients with CO poisoning [26]. A previous study has demonstrated that patients with CO poisoning had increased RDW level than control subjects [26]. This finding further suggests that exposure of these workers to CO emission from power generating sets did not alter the formation or growth of the RBCs.

Lymphocytes, neutrophils, monocytes, eosinophils and occasionally, basophils provide detail information on white blood cells in the circulation and give insight into the immunological protection conferred on individuals. Our study indicated no significant differences in lymphocytes, monocytes and the granulocytes (neutrophils, eosinophils, basophils), whereas, the serum level of monocytes (cells/μL) indicated significantly higher values compared with controls. Interestingly, the mean serum concentrations of the lymphocytes, monocytes and granulocytes, fell within normal ranges among the workers, suggesting that exposure to CO emissions from gasoline or diesel power generators did not cause any toxic changes on WBCs. A previous work by Anandha *et al.* [20] has reported leucocytosis among cigarettes smokers exposed to CO. Another study by Agoro *et al.* [25] indicated that lymphocytes and basophils were significantly raised, whereas neutrophils, monocytes, eosinophils, were significantly decreased due to chronic carbon monoxide exposure. The higher monocyte count observed in the workers compared with the control could be attributed to inflammatory responses to toxic changes and hypoxic activity of CO poisoning.

Increased platelet activation and aggregation, increased thrombotic tendency due to endothelial damage, increased platelet stickiness, and alterations in the fibrinolytic pathway have been reported to occur in CO poisoning [27]. We investigated the changes in hemostatic parameters including platelet indices, prothrombin time and partial thromboplastin time among gasoline and diesel generator workers who were exposed to carbon monoxide. Among the platelet indices investigated were, plateletcrit (PCT), mean platelet volume (MPV), platelet distribution width (PDW) and platelet large cell ratio (PLCR). Our results indicated significantly lower MPV, PDW and PLCR, but higher PCT in the workers at the generator service center compared with the control group. Furthermore, mean PT and PTT of the generator service center workers were significantly longer than that of the controls.

Platelet indices are markers of platelet activation, and are related to platelet's morphology and proliferation kinetics [28]. In this study, MPV, PDW and PLCR fell within normal range for both the CO exposed workers and control, suggesting that there was no platelet activation or pseudopodia formation in both groups. Lower values observed in exposed workers may be attributed to inflammation responses arising from CO exposure which has been shown to implicate platelets and their activation products in the altered microvascular function [29] [30] [31] [32]. A previous study by Karabacak *et al.* [33] has reported a significantly higher MPV in the CO poisoning group compared with the control. Another study by Akin *et al.* [27] also indicated that mean platelet volume and platelet distribution width levels were significantly higher, while platelet count and plateletcrit were significantly lower in patients with CO poisoning compared with control. The lower but normal range mean MPV and PDW may suggest that the workers at the power generator servicing centers may not be at risk of thromboembolic complications due to platelet activation. The mechanism behind the abnormally low platelecrit among the workers is not well understood, and the effect of CO on platelets is not well documented. However, a previous study Sogarum *et al.* [34] has shown that plateletcrit decreases with an increase in blood COHb. There is therefore a possibility that chronic CO exposure can cause decreased production of platelets in the bone marrow.

Prothrombin time and activated partial thromboplastin time are important clinical parameters for assessing extrinsic and intrinsic factors/pathways of the coagulation system [35]. The findings of this study show significant increases in the prothrombin time and activated partial thromboplastin time of CO-exposed power generator workers when compared to those of the unexposed control. In addition, the mean PT and PPT values of the workers were above normal reference values. The increases in these parameters could be due to increased thrombotic tendency due to endothelial damage, increased platelet stickiness, and alterations in the fibrinolytic pathway which have been reported to occur in CO poisoning [27].

Limitations of Study

The major limitation of this study is our inability to measure the atmospheric level of CO at the power generating servicing centers as well as the blood carboxyhemoglobin level to ascertain the level of CO exposure of the workers.

5. Conclusion

The present study indicated no significant differences in most of the hematological parameters between the CO-exposed worker and their controls. In addition, normal values of hematological parameters were observed in workers exposed to CO. However, PT and PTT values exceeded normal values in the workers compared to controls, suggesting alterations in the fibrinolytic pathway due to chronic CO exposure. More works need to be done to ascertain the effects of CO from power generator fumes on hematological and hemostatic parameters at longer and varied concentrations of CO exposure.

Acknowledgements

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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