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Carboxylhaemoglobin Concentration among Male Gasoline Generator Mechanics in Benin City, Nigeria

Adejumo Babatunde Ishola Gabriel*[1], Ireneh Ronke Uzuajemeh[1], Dimkpa Uchechukwu[2], Abdulkadir Usman Itakure[3], Abdulrahman Oladimeji Nasiru[4] and Simon Uzor[5].

1.Medical Laboratory Science Department, University of Benin, Benin City, Nigeria 2.Physiology Department, Nnewi Campus, Nnamdi Azikiwe University, Awka, Nigeria 3.Department of Medical Laboratory Science, College of Health Sciences and Technology, Markafi, Kaduna State, Nigeria. 4.Department of Medical Laboratory Science, College of Health Technology, Offa, Kwara state. 5.Department of Applied Science, Faculty of Health and Applied Sciences, University of West of England, Bristol, UK.

ABSTRACT

Aim: This study is aimed at determining the serum concentration of carboxylhaemoglobin among the gasoline generator mechanics in Benin City.

Methods: Forty-four participants and forty-four controls participated in this study. A structured questionnaire was administered to each participant to elicit details such as their personal data, residence, surrounding environment, medications, alcohol consumption, length of time in occupation and daily hour of exposure as well as history of underlying diseases. Blood samples were collected from the participants. The supernatant serum was separated into separate sterile tubes and stored at -20^{0}C for up to 2 weeks prior to analysis. Carboxylhaemoglobin concentrations of the samples were measured using ELISA method.

Results: Data shows that the mean HbCO concentration in both the generator mechanics (251.16 ng/ml) and their controls (37.30 ng/ml) indicated values far above the normal healthy limit (≤ 3.26 ng/ml). However, the generator mechanics indicated significantly higher mean HbCO values ($p < 0.001$) compared with the controls. **Conclusion**: Both the generator mechanics and the controls indicated high serum HbCO concentrations above normal limit, due to chronic exposure to CO gas in the environment. The greater HbCO concentration observed in the generator mechanics may be attributed to the greater exposure of the mechanics to generator exhaust fumes compared to the controls.

Key words: serum, carboxylhaemoglobin, male, generator mechanics, Benin City

***Correspondence**: babatunde.adejumo@uniben.edu: +2348181561300 ; ORCID:0000-0002-6620-073X

Authors' contributions: This work was carried out and approved in collaboration between all the authors who take responsibility for its accuracy and integrity. BIGA, IRU and DU designed the study. IRU, BIGA, DU, AUI, AON and SU sourced for fund; BIGA wrote the protocol; AUI, AON and SU contributed in literature search; BIGA and IRU did field work and laboratory experiments; DU, SU and AUI did statistical analysis; BIGA, DU, AON and SU contributed in discussions; BIGA and IRU drafted the manuscript; BIGA supervised the study. DU wrote the final manuscript. AUI, AON and SU proofread the final version for publication.

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INTRODUCTION

Since the early1990s, due to the dwindling Nigerian economy, which resulted in epileptic power supply, there has been an upsurge in the importation and unregulated use of power generators of various sizes. Almost every household in Nigeria has either of gasoline or diesel power generating sets. This has resulted in an unprecedented increase in the atmospheric pollution with fumes emanating from these generators. There are also several reports of frequent death occurrences from carbon monoxide poisoning resulting from such polluted and contaminated environments. With the increase in the use of power generating sets, came an increase in need for generator mechanics. These mechanics set up roadside workshops, where they repair or service power generators. These workshops have been identified as major sources of environmental pollution due to the unregulated activities of the mechanics. Unfortunately, the mechanics are neither aware of the amount of toxic fumes they are exposed to nor the deleterious effects it has on their health, thus they pay little attention to protecting themselves from the possible inhalation or ingestion of toxic environmental contaminants.

One of the environmental contaminants mostly encountered in the auto mechanic workshops is carbon monoxide. Carbon monoxide (CO) is a colourless and odourless toxic gas, that is produced mainly as a result of incomplete combustion of hydrocarbon fuels such as natural gas, coal, liquefied petroleum gas, and wood (1, 2, 3, 4, 5). In people's daily lives, environmental CO exposure is typically < 0.001% or 10 ppm (1, 2, 6). While an adult cigarette smoker is exposed to an estimated 400 to 500 ppm of CO during active smoking, an auto-engine exhaust may contain around 100,000 ppm of CO as measured inside a closed garage (1, 3, 7). Based on these values, the Air Quality Guidelines for Europe, which were published by the World Health Organisation, stated that a COHb level of 2.5% should not be exceeded depending on the CO levels in the environment and duration of exposure.

Carbon monoxide enters the body through the lungs and reversibly binds to oxygen, which carries the component of haemoglobin to form carboxyhemoglobin (COHb). It decreases the carrying capacity of oxygen in haemoglobin in binding to iron (II) atoms, where CO binds Hb 200-250 times more readily (10). Carbon monoxide increases cytosolicheme levels, causes oxidative stress, and binds to platelet heme proteins and cytochrome c oxidase. It interferes with cellular respiration, and causes the production of reactive oxygen species, which in turn causes neuronal necrosis and apoptosis. Carbon monoxide exposure also causes inflammation through several pathways that are not dependent on the hypoxic pathway, which results in neurological and cardiac injury (11). As compensation, the body will increase the process of erythropoiesis, which can increase Hb production, hence increase in Hb levels in the blood (12). Symptoms of CO poisoning are not specific. Mild exposure causes dizziness, headaches, myalgia, or neuropsychological disorders. Severe exposures to CO result in loss of consciousness, and even death (11).

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 (8). These occupational groups include auto service maintenance personnel, exhaust pipe repairmen, chefs using ovens or grills in which charcoal is

used, gasoline pumpers, and traffic policemen. Although chronic exposure of these people to CO gas has been reported previously, insufficient scientific data exist concerning possible chronic daytime CO exposure of these individuals, particularly the ones who work in auto service workshops (9). To date, there is no known documented work on the level of carboxylhaemoglobin among gasoline generator mechanics in Benin City in particular and Nigeria in general, hence the justification for this study. The present study is therefore aimed at determining the serum level of carboxylhaemoglobin among gasoline generator mechanics, who are frequently exposed to generator fumes as a result of their occupation.

METHODS

Study Location

This study was conducted in Benin City, Edo state. Benin is a commercial centre, civil service city and the capital of the state. Preliminary observations therefore reveal a large presence of both commercial and private motor vehicles. Similarly, there is high use of power generating sets by the general population due to the epileptic power supply in the city, thus giving rise to influx of generator mechanics into the town.

Study Design

The present study is a purposive, non-random sampling, cross sectional study involving adult male mechanics, who are occupationally exposed to CO fumes compared with a non-occupationally exposed adult group. A total of eighty eight males (44 generator mechanics; 44 controls) within the ages of 15-60 years volunteered to participate in this study. The generator mechanics were selected from various generator service workshops in Benin City. The control group comprises of apparently healthy adults of the same age range, who are not generator mechanics or reside or work near the generator service workshops. The control group did not indicate any CO related symptoms or any disease conditions. Workers on part-time duties and those who spent less than six months on the job were excluded from this study. The personal consent of individual participant was sought after explaining the purpose of the research. A structured questionnaire was administered to every participant of this study.

Sample Size

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

On applying; $\frac{2SD^2 (Z_\alpha + Z_ß)^2}{d^2}$

$n = \frac{2 (3.3)^2 \times (1.96 - 0.84)^2}{2^2} = \frac{21.78 \times 7.84}{4} = \frac{170.8}{4} = 42.68$

n = 42 +2 (considering 5% dropout of study participants) = 44 participants

Questionnaire / Ethical Approval

Questionnaire consisted of questions designed to elicit details about the participants' personal data, residence, surrounding environment, medications, alcohol consumption, length of time in

occupation and daily hour of exposure as well as history of underlying diseases. The Ethical Committee of the Ministry of Health, Edo State approved the study (approval number: HA – 737/28; Date of approval: 28th November, 2019). The heads of the generator servicing centres were well informed of the nature of the study and their permission was sought and obtained before the commencement of the study.

Blood Collection and Analysis

Five millilitres of blood was collected and dispensed into a plain container. The non anticoagulated blood was allowed to clot, spun at 1500 rpm for 10 minutes and the supernatant serum was separated into a separate sterile tubes. The serum was stored at -20^{0}C for up to 2 weeks prior to analysis. Analysis for carboxylhaemoglobin was done using commercially purchased ELISA kit from Calibiotech U.S.A.

Data Analysis

Data was expressed as mean and standard deviation. Comparative analysis was done using independent sample t-test and analysis of variance (ANOVA). Correlation analysis between HbCO and duration of exposure and age of generator mechanics was done using Pearson's bivariate correlation test. Statistical significance was set at $p < 0.05$. All statistics were done using IBM/SPSS software (version 20.0).

RESULTS

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

Characteristics	Control, n = 44 N (%)	Generator Mechanics, 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)

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

Characteristics		Frequency	Percentage
Duration of Job	1-5yrs	25	56.8
	6-10yrs	13	29.5
	Above 10	6	13.6
Awareness of Health Risk of Job	No	35	79.5
	Yes	9	20.5
CO Related Health Symptoms	Choking experience	5	11.4
	Eye diseases	2	4.5
	Headache/Dizziness	28	63.6
	Difficulty in Breathing	9	20.5
Use of PPE	No	0	0 (0)
	Yes	44	100.0
Protective Clothing Used	Overall Gown	44	100.0
Hours of Work	5 hours	1	2.3
	More than 10 hrs	43	97.7
CO Related Medical Challenge	No	42	95.5
	Yes	2	4.5
Specific Medical Challenge	None	42	95.5
	Ulcer	1	2.3
	Weak erection	1	2.3
Medication	No	43	97.7
	Yes (Cimetidine)	1	2.3

Abbreviations: CO, Carbon Monoxide; PPE, Personal Protective Equipment

Table 2 shows some clinical characteristics of the generator mechanics. Of the 44 mechanics, majority (56.8%) have spent between 1 to 5 years on the job. A greater percentage were not aware of the health risk of their job (79.5%); make use of PPE (100%); make use of overall gowns (100%); spend more than 10 hours of work (97.7%);

generally have no CO related medical challenge (95.5%); have experienced no specific medical challenge (95.5%); and were not on medication (97.7%). Of the CO related health symptoms the subjects have experienced, headache/dizziness were the most frequent (63.6%), followed by choking experience (11.4%), difficulty in breathing (20.5%) and eye problems (4.5%).

Figure 1 shows the mean concentrations of the carboxyl hemoglobin in the study population. Data shows that the mean HbCO in both the generator mechanics (251.16 ± 180.43 ng/ml; range, 99.30 – 940.90 ng/ml; median, 38.50 ng/ml) and their controls (37.30 ± 13.17 ng/ml; range, 10.0 – 60.20 ng/ml; median, 196.20 ng/ml) indicated values far above the normal healthy limit (≤ 3.26 ng/ml). However, the generator mechanics indicated mean HbCO values significantly greater ($p < 0.001$) compared with the controls.

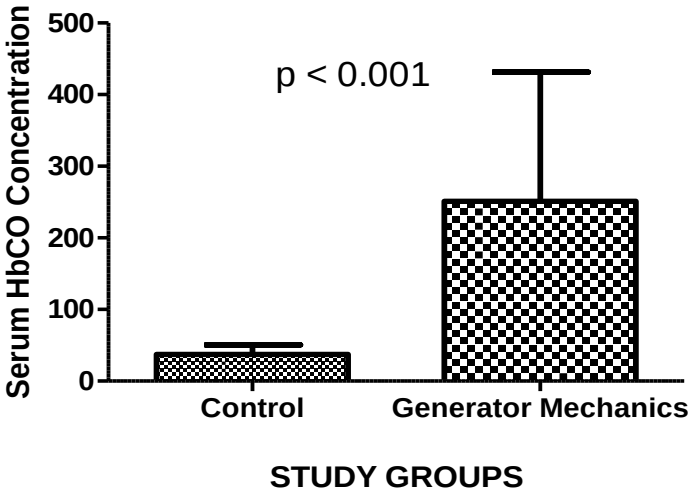

Figure 1. Mean carboxylhemoglobin concentrations in the study population

Table 3. Pearson's Bivariate correlation of mean HbCO concentration with duration of occupation exposure to CO and age of the generator mechanics

HbCO Concentration vs.	Correlation Coefficient	P – Value
Age (yrs)	-0.190	0.217
Duration of Occupational Exposure (yrs)	-0.278	0.068

Abbreviations: Carboxyhemoglobin; CO, Carbon Monoxide

Table 3 shows the correlation between mean HbCO concentration and duration of occupation exposure to CO and age of the generator mechanics. Pearson's bivariate correlation test indicated no significant relationship between HbCO and duration of exposure ($p = 0.217$) and age of the generator mechanics ($p = 0.068$).

DISCUSSION

The principal findings of this study indicate that the serum concentration of carboxylhaemoglobin in both generator mechanics and their controls were high and exceeded the normal healthy limit. In addition the mean HbCO value was significantly higher among the generator mechanics compared with the controls. There were no significant correlations between mean HbCO concentration and duration of exposure and age of the generator mechanics.

It is noteworthy that, no previous studies have explored possible chronic CO exposure among gasoline generator mechanics. The present study which indicated above normal HbCO serum concentration among the generator mechanics may be attributed to the compacted and non-ventilated working environment and the presence of high level of generator exhaust fumes in the generator mechanic's workshop and surrounding environment. Interestingly, the non-mechanic controls also presented values of serum HbCO concentration above normal limit. This may be attributed to exposure to environmental CO. An environmental CO exposure typically less than 0.001% or 10 ppm has been reported in people's daily lives (1, 2, 6). The present finding among the control group may be attributed to the presence of large number of slow movement of vehicles on the road due to bad roads as well as bad or non-functional traffic light which gives rise to heavy hold-ups of vehicles at every road junction. These can lead to higher level of atmospheric CO, thus accounting for the elevated serum HbCO concentration among the controls in this study.

The greater serum concentration of HbCO observed in the generator mechanics may be attributed to the greater exposure of the mechanics to generator exhaust fumes compared to the controls. Some of the generator mechanics also agreed that they felt some symptoms of CO poisoning ranging from headache/dizziness (63.6%), choking (11.4%) and slight difficulty in breathing (20.5%) during working hours, when the serviced engines are test - run. However, majority (95.5%) reported no chronic CO reactions. It is believed that the reversibility and fragile nature of the bond between carbon monoxide and haemoglobin may have prevented chronic and acute phase of the reaction to set in, especially when the mechanics are occasionally exposed to free air. The occasional breathing in of fresh air by the mechanics as they go out of the workshop to attend to other needs may have dislodged the toxic carbon monoxide from haemoglobin. To the best of our knowledge, no previous studies have compared the serum HbCO concentration between gasoline generator mechanics and non-mechanic controls. However, many studies have investigated the effects of chronic CO exposure in different occupational groups. Castelden et al. (14), in their study, reported significantly higher mean HbCO value for smokers compared with non-smoking employees working in different occupations. Another study by Abdollahi et al. (15), indicated that bus drivers working in the city centre were found to have significantly higher blood COHb values compared to those of the control group. Niza et al. (16), conducted a study with employees working in toll bridges and offices in the surrounding area and found higher serum COHb concentrations among toll bridge workers than office employees. The COHb levels among the bridge worker were especially more elevated during the rush hour when the traffic intensity increased than the non-rush hours (16).

It is thought that the higher concentration of HbCO among the mechanics, which may have resulted from an elevated level of CO pollutant from the exhaust fumes emanating from the mechanic workshops, may also be due to utter disregard for workshop ethics and non-compliance with all the preventive measures and workshop ethics by the auto workers. The result of this study suggests that none of the generator mechanics is aware of the need to always use personal protective equipment (PPE). Similarly, majority (79.5%) of the mechanics were not aware of the health risks of CO, hence their nonchalant attitude to comply with the preventive and protective measures regulating automobile workshops. More worrisome is the lack of effective government regulation and monitoring of laws controlling environmental pollution in Benin City and Nigeria generally.

The lack of significant correlation between serum HbCO concentration and the duration of exposure and age of the generator mechanics, suggests that the working hour blood level of HbCO may not be affected by ageing or the number of years an individual has been occupationally exposed to CO.

CONCLUSION

In conclusion, the result of the present study suggests that generator mechanics were chronically exposed to a substantial amount of CO gas during their working hours irrespective of time spent at the work. Also, we observed that average citizens (controls) were equally exposed to CO due to various activities that release CO to their surroundings. Furthermore, age of participants and duration of occupational exposure to CO did not affect serum HbCO concentration of the generator mechanics. We recommend that the government should embark on health education, acquire more effective protective gadgets and enforce their usage. There should also be containment or restriction of fume emission by the compulsory issuance of certificate of practice to all workshop owners as well as certificate of road worthiness to all vehicle owners. These should also be monitored with monitoring devices to safeguard the health of these workers and their host communities.

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Conflict of Interest
None

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