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Impact of Gas Flaring on Cardiopulmonary Parameters of Residents in Gas Flaring Communities in Niger Delta Nigeria

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Authors' contributions

This work was carried out in collaboration with all authors. Authors ICJ and ACP designed the study and wrote the protocol. Author OSI wrote the first draft, managed literature searches, carried out field work, data collection and analysis. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to evaluate the impact of gas flare on cardiopulmonary parameters in some states of the Niger Delta. The study aimed to determine the impact of gas flare on blood pressure, pulse rate, respiratory rate, peak expiratory flow rate and associated changes of these parameters with duration of exposure to gas flare. Two communities (a test and a control) were studied in five states in the Niger Delta - Edo, Rivers, Akwa Ibom, Bayelsa, and Delta. The study adopted the direct administration of questionnaire, observation, recording and free medical checkup methods. The stratified random sampling method was used. The sample size was 1008 participants (504 in gas flaring communities and 504 in non-gas flaring communities). The electronic blood pressure kit was used to measure blood pressure and pulse rate of participants. Respiratory rate of participants was manually recorded while the peak flow meter was used to measure the peak expiratory flow rate of participants. The questionnaire was directly administered to obtain vital information from participants. Data generated were expressed as mean ± SD. A significant

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difference between the means was determined by student t-test and one-way analysis of variance (ANOVA). A level of $p \leq 0.05$ was accepted as significant. Findings showed that gas flare increases mean blood pressure (GFC-184.96±24.07, NGFC- 123.00±2.96), pulse rate (GFC-100.37±3.79, NGFC-78.09±4.68) and respiratory rate (GFC-33.63±0.80, NGFC-23.83±0.82) of residents in gas flaring communities. There was a decrease in mean peak expiratory flow rate (GFC-272.78±16.79, NGFC-460.83±6.53) of residents in gas flaring communities. Findings also showed that these cardiopulmonary parameters increases with longer duration of exposure (blood pressure >10 years -125.10±7.47, 1-5 years -117.25±3.81, pulse rate >10years-91.84±1.77, 1-5 years- 85.16±5.14 and respiratory rate-26.64±2.08, 1-5 years 24.00±1.51), except peak expiratory flow rate that decreases with duration of exposure (>10 years 301±88, 1-5 years 313.87±35.64).

Keywords: Impact; gas flaring; cardiopulmonary parameters; residents; Niger Delta.

1. INTRODUCTION

Air pollution is a significant risk factor for multiple health conditions, including respiratory infections, heart disease, and lung cancer [1]. The health effects resulting from air pollution have been reported to include several respiratory syndromes and worsening cardiopulmonary conditions. These effects have been reported to cause an increase in medications and hospital consultations. The human health effects of inadequate air quality are enormous, but majorly affect the body's cardiopulmonary system [1]. Health status, the level of exposure, pollutant type has been implicated in individual response to air pollution [1]. Presently, there are so many flaring sites in the region, making Nigeria one of the highest emitter of greenhouse gases in Africa [2]. The common sources of air pollution include particulates, ozone, nitrogen dioxide, and sulfur dioxide. An earlier report has shown that indoor and outdoor air pollution has caused approximately 3.3 million deaths worldwide [1].

Much of the natural gas gotten from oil wells in the Niger Delta is flared into the atmosphere at a rate that approximates 70 million /m3 per day. This amounts to 40% of African natural gas consumption and occupies a major source of greenhouse gas emissions on the earth [3-5]. In a comparative study of air pollution concentration in the Niger Delta area, it was demonstrated that pollutant concentrations were higher in the Niger delta areas and that some greenhouse gasses emitted in this area contribute significantly to global warming [6].

Gas flaring is the burning off of gas, which sends a cocktail of poisons into the atmosphere. In the mix are carbon dioxide and methane that are major causes of global warming. Pollutant predominated in the Area include Benzene, Toluene, Xylene, Particulate matter, Hydrogen sulphide, Styrene, Nitrogen oxide, sulphur dioxide.

It leads to a reduction in farm yields and affects human health, lives, and livelihoods. Gas flaring raises the risk of respiratory ailment and cancer. It often causes painful breathing, chronic bronchitis, decreased lung function, body itching, blindness, impotency, miscarriages and premature deaths [7].

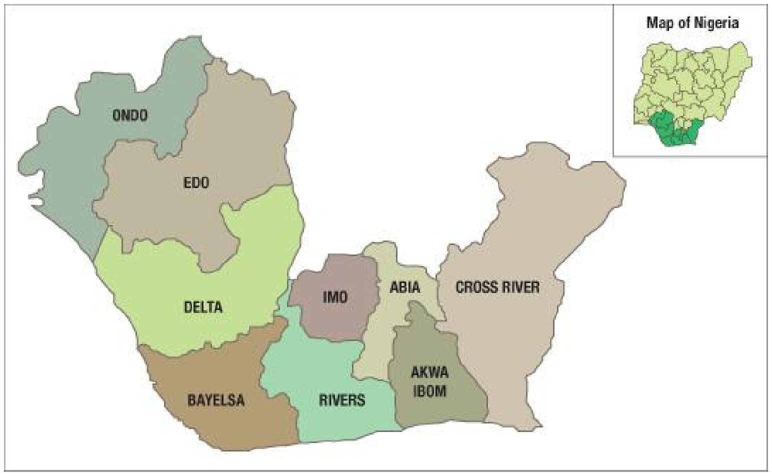
The objective of this study was to assess the impact of gas flare on some cardiopulmonary parameters of residents in gas flaring communities in Niger Delta area of Nigeria and determine the effect of gas flare on blood pressure, pulse rate, respiratory rate and peak expiratory flow rate and determine the effect of duration of exposure to gas flare on these parameters.

2. MATERIALS AND METHODS

2.1 Study Area

The study covered two communities, each in at least five of the Niger Delta states. One gas flaring community (study area) and the other a non-gas flaring community (control) was 35km from the gas station. The two communities in each state are with similar socio- economic and cultural characteristics. The residents of both communities are mainly farmers, traders, students, artisans and civil servants.

State	Study area	Control
Delta	Agbarho-otor/Ughelli	Eku
Akwa Ibom	Ibeno	Ikot Ekpene
Rivers	Oshi	Ahoada
Bayelsa	Immiringi	Ogbia
Edo	Oben	Ekiadolor



Map 1. Map of Niger Delta States

Agbaro-otor is a rural community in Ughelli north local government area and Eku another rural community in Ethiope east local government area both in Delta state. Oben is also a rural community in Orhionwon local government area and Ekiadolor in ovia local government area another rural community both in Edo state. Immiringi and Ogbia are both semi urban town in Ogbia local government area of Bayelsa state. Oshi and Ahoada are both semi urban towns in Ahoada west local government area of Rivers state. Ibeno a rural community in Eket local government area and Ikot Ekpene in Ikot Ekpene local government area both in Akwa Ibom state.

2.2 Study Design

A cross- sectional study that compared some resident exposed to gas flaring with a non-exposed person from other communities. Direct administration of the questionnaire, observation and recording method were used.

2.3 Sampling Technique

This study was carried out using a stratified random sampling technique with a total of 1008 participants. This comprises of five hundred and four (504) in the gas flaring communities and five hundred (504) in the non - gas flaring communities. There are adults and children comprising 564 males and 444 females.

2.4 Selection of Residents

Apparently healthy residents between the ages of 12 to 70 years who verbally consented to participate in the study were randomly selected after a detailed explanation. Close ended questionnaires, covering bio-data and other relevant information were directly administered to participants. These were completed anonymously with reference to age, sex and exposure duration of residents.

2.5 Method of Data Collection

Data collection was carried using closed- ended questionnaire, electronic blood pressure kit spirometric device, peak flow metre, stop watch, weighing scale, to measure blood pressure and pulse rate, for peak flow rate, respiratory rate, and weight respectively.

2.6 Residents Selection Criteria

Inclusion: Apparently healthy adults of either sex aged between 12 – 17 years and adults, male and female of ages 18 - 70 that participated in the study were randomly selected.

Exclusion criteria: Questionnaires were used to exclude Children less than 12 years, tobacco smokers, residents and visitors who have stayed less than one (1) year in the various communities, residents with established respiratory and cardiovascular diseases and those with high body mass index (BMI), residents with positive family history and all known cases of hypertension, diabetes mellitus, dyslipidemia, renal disease, atherosclerosis and contraceptive users.

2.7 Limitation of the Study

It is a population- based study and the use of the questionnaire was necessary to obtain first-hand information from the participants, though this may be subjective as response to the questions depended on the mood of the individual.

However, the questionnaire was relevant with reference to the inclusion/exclusion criteria of this study.

3. MATERIALS

Digital device measuring BP in mmHg, Stopwatch, Weighing scale, Laboratory coat, Hand gloves, Face masks, Peak flow metre, questionnaire.

4. METHODS/PROCEDURES

4.1 Measurement of Blood Pressure /Pulse Rate

A device which accesses Blood pressure in mmHg and Heart rate (pulse rate) in beat/minutes for the participants [8].

4.2 Measurement of Respiratory Rate

Participants' respiratory rate was measured while at rest. They were made not to be aware to obtain a reliable count by observing the rise and fall of the participant's chest and count the number of respirations for thirty seconds or one full minute.

4.3 Measurement of Peak Flow Rate

Wright peak flow meter a spirometric device was used to access peak expiratory flow rate in litres/minute for all participants. Three successive readings were taken and the highest of the three was taken as the peak expiratory flow rate of the participants [9,10].

All scales and measures were same through the study.

4.4 Ethical Consideration

Ethical clearance was obtained from school heads, parents and community head where applicable with a view to obtaining informed and valid consent from residents/residents in accordance with [11]. Accordingly the necessary input of the Research and Ethical committee of the College of Health Sciences, of the Delta State University was sought prior to the commencement of the research, registration number RBC/FBMS/DELSU/14/05.

4.5 Statistical Analysis

Data generated were expressed as mean ± SD. The significant difference between the means was determined by student t-test and one-way analysis of variance (ANOVA). SPSS 20 software was used for statistical analysis. A level of P≤.05 was accepted as significant.

5. RESULTS

The results on the impact of gas flaring on various cardiopulmonary parameters as stated as follows:

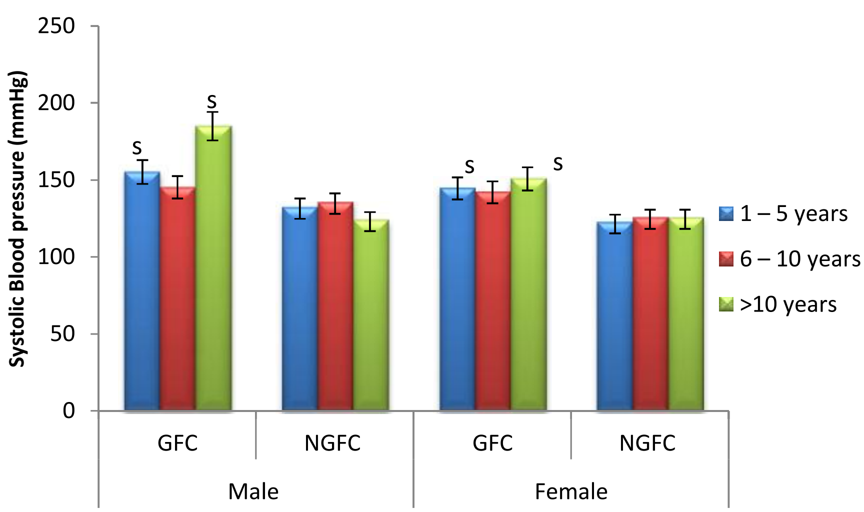


Fig. 1. Effect of gas flaring on systolic blood pressure of adult residents in Edo State

GFC- Gas Flaring community, NGFC- Non Gas Flaring community

Comparing the systolic blood pressure of adult residents residing in non-gas flaring communities, it was observed that gas flare increased the systolic blood pressure with the highest value observed at residents living in gas flaring communities. This Shows an increase in systolic blood pressure in the adult male and female systolic blood pressure with an exposure duration of 1-5 years and >10 years

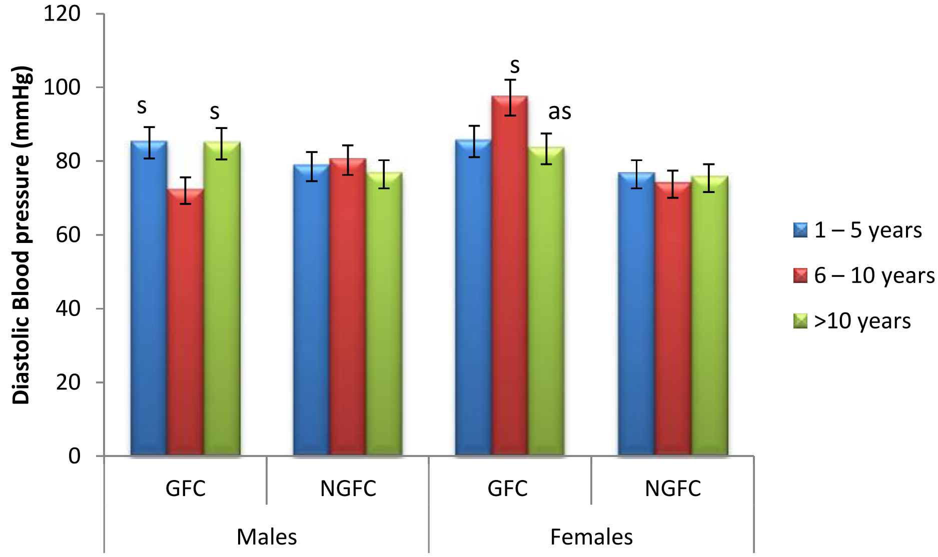


Fig. 2. Effect of gas flaring on diastolic blood pressure of adult residents in Akwa Ibom State

Values are represented as mean Standard error of mean
a: P<.05 when compared to 6 – 10 years s: P<.05 when compared with NGFC
Diastolic blood pressure of adult residents in gas flaring communities was compared with those of non-gas flaring communities. There was a significant increase in DBP of adult males with exposure duration (1-5 years and above 10 years) and a significant increase also in adult females of 6-10 years and above 10 years exposure duration

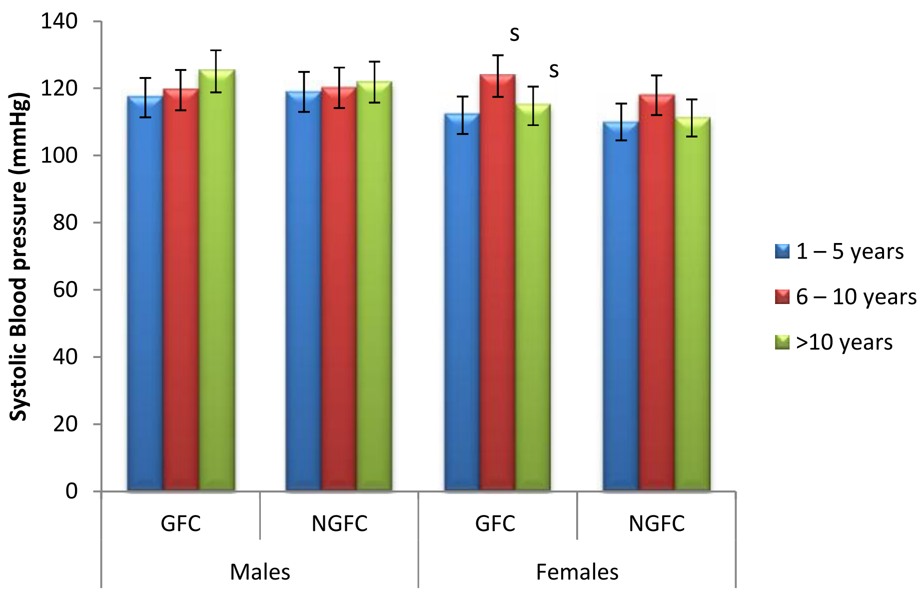


Fig. 3. Effect of gas flaring on systolic blood pressure of children residents in Rivers State

Values are represented as mean Standard error of mean
s: P<.05 when compared with NGFC
Systolic blood pressure of children living in gas flaring communities was compared with those of non-gas flaring communities result shows that Systolic blood pressure increases minimally for all residents with an increase in the years of exposure and significantly in female children of 6-10 years and 10 years and above

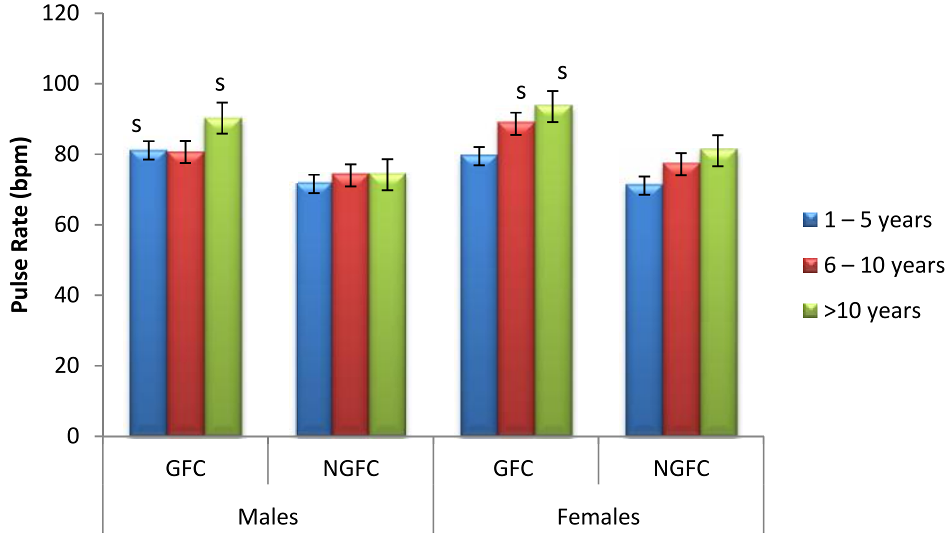


Fig. 4. Effect of gas flaring on pulse rate of adult residents in Rivers State

Values are represented as mean Standard error of mean

s: P<.05 when compared with NGFC

The changes in pulse rate of adult residents due to gas flare were determined and the pulse rate of residents in gas flaring and non-gas flaring (communities) was compared result shows significant increase in PR of adult male and female residents (with 1-5 years, >10 years and 6-10 years, >10 years) exposure duration respectively

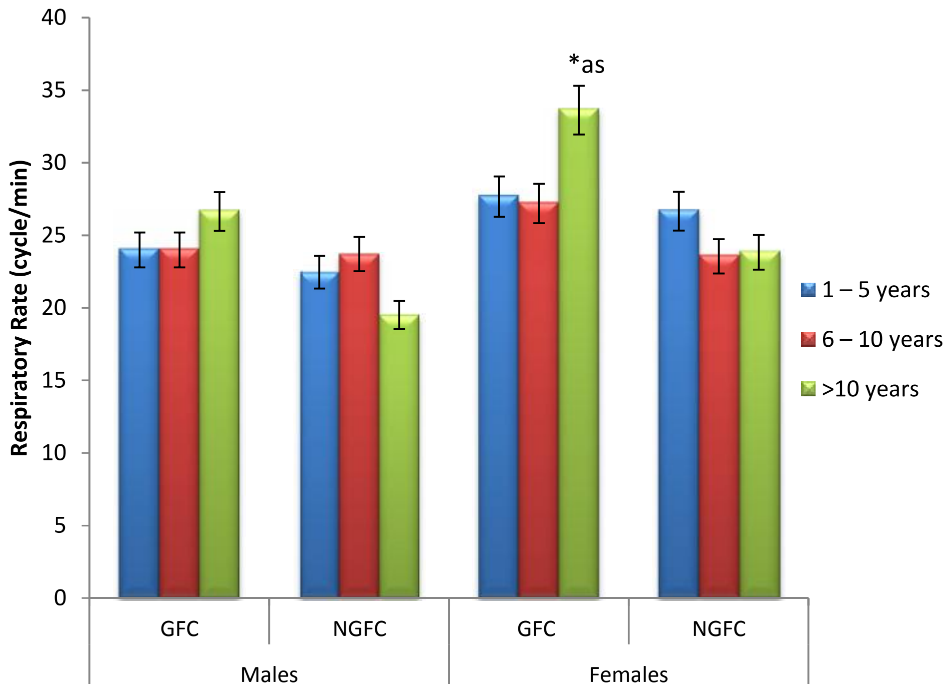


Fig. 5. Effect of gas flaring on respiratory rate of adult residents in Akwa Ibom State

Values are represented as mean Standard error of mean

**: P<.05 when compared to 1 – 5 years a: P<.05 when compared to 6 – 10 years s: P<.05 when compared with NGFC*

Comparing the respiratory rate of residents in gas flaring and non gas flaring communities, there was a significant increase in the respiratory rate of adult females in gas flaring communities with exposure duration above 10 years when compared to those in non-gas flaring communities

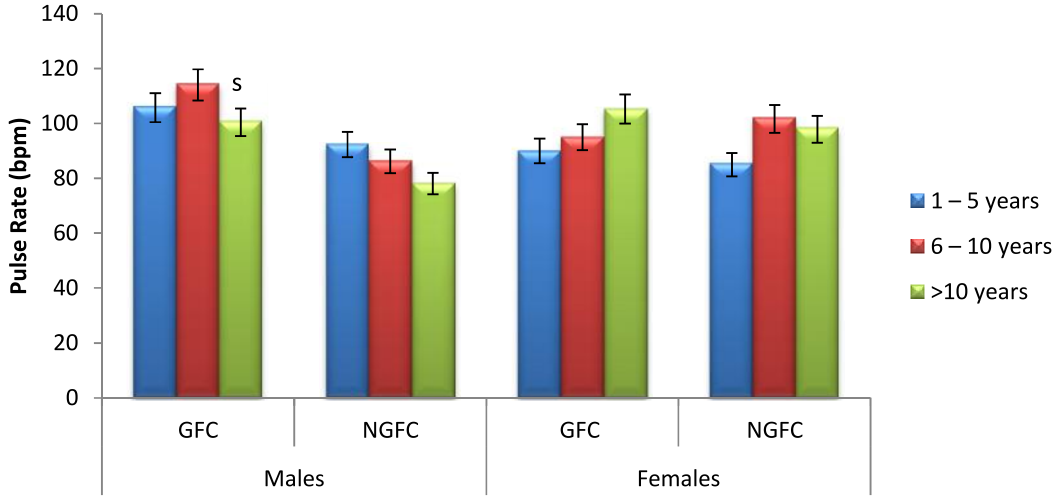


Fig. 6. Effect of gas flaring on pulse rate of children residents in Bayelsa State

Values are represented as mean Standard error of mean, s: P<.05 when compared with NGFC
Comparing the pulse rate of residents in gas flaring and non-gas flaring communities, there was a significant increase in pulse rate of the male children in gas flaring communities with exposure duration above 10years when compared to non-gas flaring communities

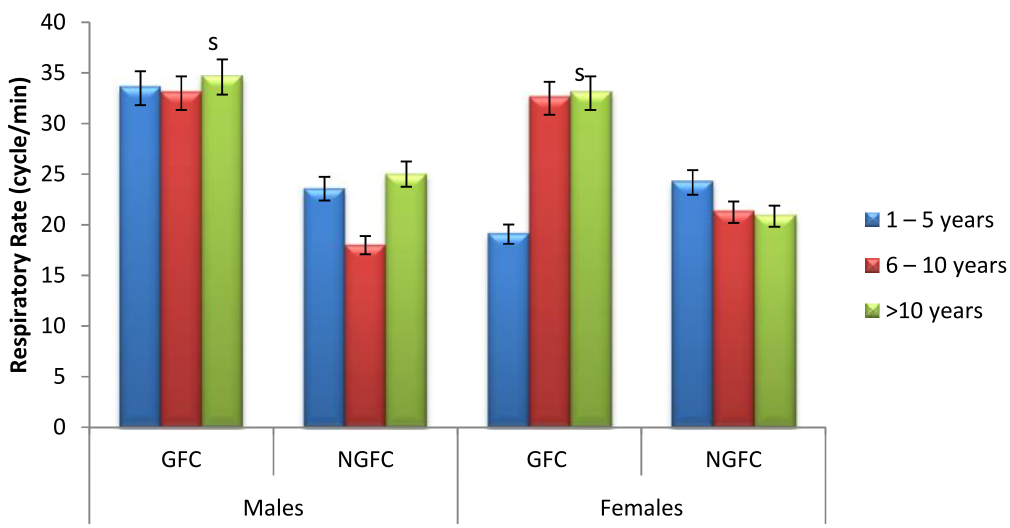


Fig. 7. Effect of gas flaring on respiratory rate of children residents in Delta State

Values are represented as mean Standard error of mean
s: P<.05 when compared with NGFC
Comparing the respiratory rate of residents in gas flaring and non-gas flaring communities, gas flares generally increase the RR for all residents in GFC with a significant increase in the RR of male and female children of exposure duration above 10 years

6. DISCUSSION

The present study evaluated the impact of gas flare on some cardiopulmonary parameters of humans residing in gas flaring communities in some states of the Niger Delta. The cardiopulmonary parameters studied include Blood pressure, pulse rate, respiratory rate, and peak expiratory flow rate. The above parameters of residents in gas flaring communities in Edo, Rivers, Akwa Ibom, Bayelsa and Delta states were compared with those in non-gas flaring communities.

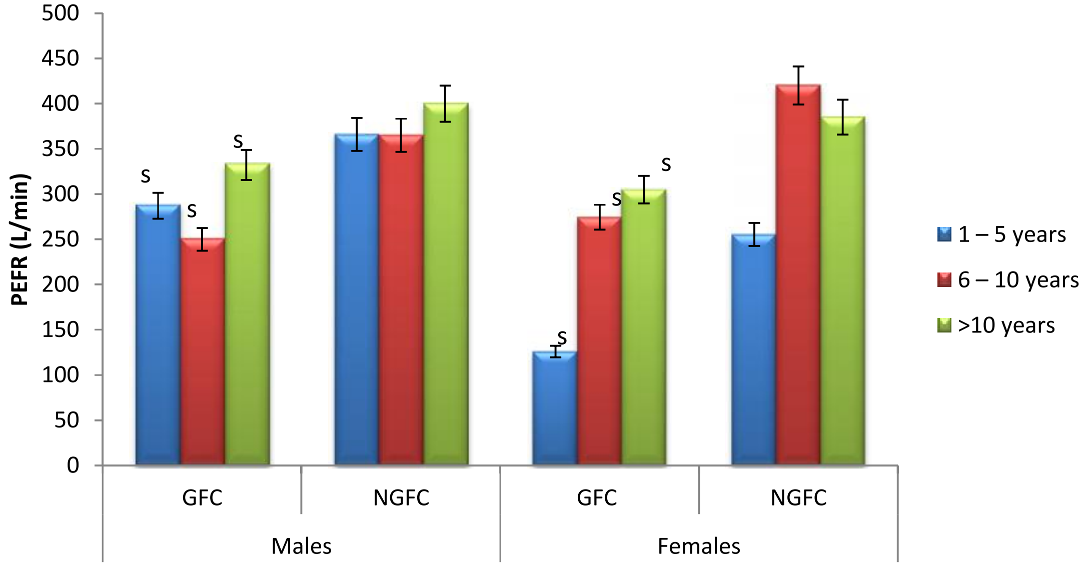


Fig. 8. Effect of gas flaring on peak expiratory flow rate of children residents in Delta State

Values are represented as mean Standard error of mean

**: P<.05 when compared to 0 – 5 years a: P<.05 when compared to 6 – 10 years s: P<.05 when compared with NGFC*

In comparing the peak expiratory flow rate of residents in gas flaring communities and non-gas flaring communities, there was a significant decrease in PEFR of male and female children in GFC irrespective of the duration of exposure when compared to non-gas flaring communities

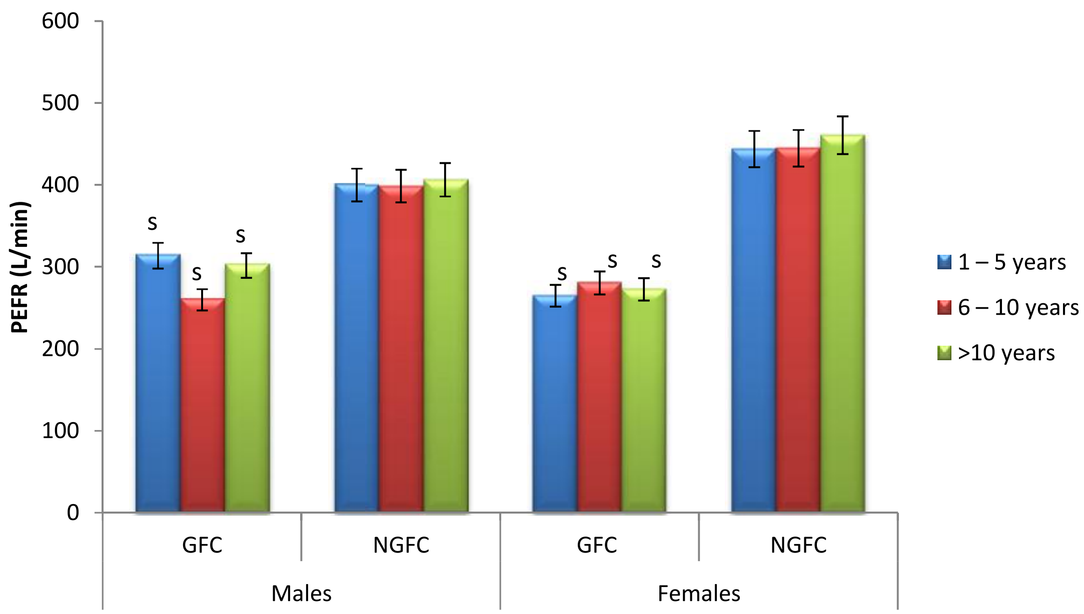


Fig. 9. Effect of gas flaring on peak expiratory flow rate of adult residents in Delta State

Values are represented as mean Standard error of mean

**: P<.05 when compared to 0 – 5 years a: P<.05 when compared to 6 – 10 years s: P<.05 when compared with NGFC*

Comparing the peak expiratory flow rate of adult residents in gas flaring communities, there was a significant decrease in PEFR of male and female adults in GFC irrespective of the duration of exposure when compared to non-gas flaring communities

Likewise, the study also found the result of gas flare on the duration of exposure of residents. This was indicated by a residency period of 1-5years, 6-10years and greater than 10years duration of exposure in the gas flaring and non-gas flaring communities. All the residents, children and adults, males and females have different resident's duration of exposure to gas flare. The study also determined the effect of gas flare on males and females. This was carried out by comparing the cardiopulmonary parameters of male residents in gas flaring communities and non-gas flaring communities in the various states.

6.1 Gas Flaring and Blood Pressure

It was observed that gas flares increased systolic Blood pressure (SBP) of male and female children with an increase in the years of exposure as shown in Figs. 1 and 3. Data also shows that the systolic blood pressure of both male and female adults increased after exposure to gas flare and this was duration dependent and a similar trend was observed across the states as shown in Figs. 1 and 3.

On diastolic blood pressure (DBP), it was shown that gas flaring increased the mean diastolic blood pressure of male and female residents compared to control. The increase in diastolic blood pressure was significant in adult male and female with longer duration of exposure as shown in Fig. 2.

From the results obtained there was a statistically significant increase in systolic and diastolic blood pressure of the residents in the gas flaring communities when compared with the non- gas flaring communities (control) (P<.05). This finding agrees with [12] who reported a significant increase in SBP and DBP among residents with prolonged exposure to gas flare in Imo state south- eastern Nigeria. The finding also agrees with [13] who noted an increase in SBP and DBP among solid waste workers in Port Harcourt south- eastern Nigeria that was exposed to particulate matter, Carbon monoxide and other chemicals emitted from solid waste that is also components of a gas flare. The finding from the study is also in consonant with earlier reports [14] that healthy residents exposed to the particulate matter had an increase in systolic blood pressure.

An earlier study has shown a link between environmental pollution and the ontogeny of cardiovascular disorders (CVD) [15]. The statistically significant increase in SBP and DBP and by extension hypertension among residents of gas flaring communities in the Niger Delta may be ascribed to the fact that Gas flaring affects sleep-wake cycle [16]. The Sleep loss is linked with high a prevalence of Hypertension [17]. Sleeploss lead significant rise in serum norepinephrine and sympathetic activity, venous endothelial dysfunction and hypertension [18]. Sleeploss lowered plasma angiotensin II concentrations, raised renal sympathetic nerve activity and probably increase in blood pressure [16]. Modesty and coworkers have shown that for every hour of extra daylight experienced, the mean nighttime systolic blood pressure rose by 0.63mm Hg [19].

Gas flaring causes an increase in temperature [20]. An increase in temperature can lead to persistent and chronic dehydration among residents of gas flaring communities. Dehydration occasioned by the persistent heat causes reduced blood volume, an increase in blood viscosity, and increase in blood pressure. And this is further aggravated by the poor water available in the Region [12]. Also, it has been reported that exposure to particulate matter has been linked with blood pressure and the underlying physiological mechanism for this linkage with air pollution led to increased cardiovascular risk could include distorted circadian rhythms of renal sodium handling and blood pressure [21]. Another possible reason for the increase in blood pressure is the heavy metal like Zn present in Nigerian crude oil and waters in gas flaring communities [22,12,23]. High blood pressure can also raise serum uric acid (SUA) through elevated serum lactate levels. Hypertension initially produces renal microvascular disorders with local tissue hypoxia, as shown an increase in serum lactate. The lactate lowers tubular secretion of uric acid, causing increased serum levels. Intra-renal ischaemia can also add to a generation of the uric acid through xanthine oxidase. It is also probable that metabolic changes (hyperinsulinemia) activity may produce changes in renal sodium handling, culminating in increased arterial pressure, decreased renal blood flow and lower uric acid secretion. This will subsequently increase purine oxidation, resulting in increased generation of reactive oxygen species (ROS), subsequent vascular injury, and reduced nitric oxide [24]. The rise in hypertension of the exposed individuals could also be ascribed to the effect of gas flare on the kidneys. Chronic dehydration has also been linked with prolonged exposure to oil and gas flares because of its effect on the kidney. Renal perfusion and persistent dehydration have also been reported to cause elevated urea level [25].

Furthermore, gas flaring has been linked with noise pollution from blazing fire, vehicular, human traffic as well as from movement of heavy duty machinery. Noise pollution could contribute significantly to cardiovascular disease and hearing loss, sleep disturbance, reduced productivity, impaired teaching and learning, absenteeism, increased drug use, and accidents [26]. Noise sensitivity has a correlation with hypertension and increased cardiopulmonary morbidity and mortality [27].

6.2 Gas Flaring and Pulse Rate

There was a significant increase in pulse rate of children in gas flaring communities compared with non-gas flaring communities. The increase in pulse rate was significant in both male and female children in gas flaring communities. Similarly, there was a significant increase in pulse rate of both male and female adults in gas flaring communities when compared with children in non-gas flaring communities as shown in Fig. 4. The statistically significant increases in pulse rate as observed in this study has further strengthened earlier report by [13] who observed a significant increase in pulse rate (index of heart rate) among solid waste workers. This may be attributed to a possible physiologic haemodynamic instability resulting from exposure to chemicals present in a gas flare. The inhaled particulate matter decreases the blood oxygen tension (PO2) that the body responds by increasing the heart rate in order to sustain adequate oxygen delivery to tissues which was observed as an increase in pulse rate. This is similar to the findings of [28] who reported that sharp particulate matter exposure is ha the capacity of increasing Heart Rate. However, this result does not support earlier reports by [28-31] that noted a decrease in heart rate variability with residents exposed to concentrated air pollution, concentrated coarse air pollution particles, concentrated ambient coarse particles and coarse particulate matter respectively.

6.3 Gas Flaring and Respiratory Rate

There was a statistically significant increase in the respiratory rate of male and female children as well as those of adult males and female residents in gas flaring communities when compared with those of non-gas flaring communities especially in those with longer duration of exposure as shown in figure 5 (females). Arising from the result, this observation agrees with the outcome of the panel study by [32] who reported an increase in breath rate among participants exposed to particulate matter in the Beijing Olympic and noted fast breath rate as an indicator of poor air quality. Findings from this present study, however, disagree with that of [13] who noted no changes in the respiratory rate among residents in the various duration exposed groups.

6.4 Gas Flaring and Peak Expiratory Flow Rate

There was a significant decrease in *PEFR* of children living in gas flaring communities when compared with those in non-gas flaring communities. There was also a significant decrease in *PEFR* in adult residents in gas flaring communities when compared with those in non -gas flaring communities especially in those with longer duration of exposure. These observations were seen in Figs. 8 and 9. A common trend in this parameter is a decrease in *PEFR* for most residents irrespective of sex and age. This finding is in agreement with [33-36] that reported lower mean *PEFR* values among people living around oil and the gas flaring environment when compared with national and international values.

The exposure- dependent decrease in peak expiratory flow rate (*PEFR*) shown in the test groups when compared with the control may be ascribed to the direct inhalation of a large and progressively accumulating volume of obnoxious gaseous chemicals and particulate matter deposits in the lungs related inflammatory changes, as well as physically impeding the normal lung function [37]. There is reasonably strong evidence that people in Niger Delta area are exposed to potentially dangerous chemicals in the environment. The increase in such pollutants as nitrogen oxides, sulphur oxide and ozone exposures along with other air pollutants from oil and gas exploration activities are significant contributors to chronic obstructive pulmonary diseases (COPD).

Moreso, findings so far has shown that gas flaring impacts negatively on the lung function of children and adults of gas flaring communities by reducing their mean peak flow rates and the severity of impact on peak flow rate worsens with longer exposure to gas flaring hence a marked reduction in peak expiratory flow rate of impacted residents.

6.5 Duration of Exposure to Gas Flares and Cardiopulmonary Parameters

It was observed that the changes in cardiopulmonary parameters were duration dependent. The subject for this study were not patients, but are residents (inhabitants) of those areas with a different residency period (exposure duration- 1-5 years-blue, 6-10 years- red and 10 years and above-green as depicted in the bar chart).

The blood pressure, systolic and diastolic for children (males and females) and for the adult (males and females) was statistically increased (P<.05) for residents with prolonged duration of exposure to gas flare as shown in Figs. 1 and 3. This observation is in consonant with [12] that prolonged exposure to gas oil and gas flare ups the risk for hypertension.

Data shows that gas flare increases pulse rate of male and female children and adult residents. These changes are statistically significant (P<.05) especially in residents with prolonged duration of exposure as seen in Fig. 4.

As regards the pulmonary parameters respiratory rate and *PEFR*, data shows an increase in the mean respiratory rate of residents and a decrease in mean *PEFR* of residents with an increase in duration of exposure as shown in figures 4, 5, 7, 8 and 9. The statistically significant decrease in *PEFR* found among the residents with prolonged exposure to gas flares agrees with an earlier report by [38,36] that noted reduction in lung function among residents with longer duration in an environment highly polluted with particulate matter and a decrease in lung function with residents exposed to prolong gas flare in Delta state south - south Nigeria respectively.

7. CONCLUSION

The study revealed that gas flare increase blood pressure, pulse rate (resting heart rate) and respiratory rate of children and adult residents in gas flaring communities in the Niger Delta area. Gas flare reduces the mean peak expiratory flow rate of residents in the gas flaring communities and the change in cardiopulmonary parameters is duration dependent as prolonged duration of exposure affected the changes markedly. The study has shown that gender variation impacted on cardiopulmonary parameters of residents in gas flaring communities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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