

Duration and Gender Variations of Gas Flaring and Crude Oil Contamination Exposures on Blood Pressure in Delta State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

As adverse effects and health implications of human exposures to petroleum products (crude oil) remains an issue of public concern, interests on the different adverse effects on various body system has grown in recent years. Current study investigated the duration and age dependent effect of exposure of the cardiovascular system (CVS) to gas flaring and crude oil contamination in selected communities of Delta State, southern Nigeria. Two Hundred and Forty (240) subjects, who were exposed to gas flaring and crude oil contamination were ethically recruited from Agbarho [Ughelli North Local government Area (LGA)] and Bomadi (Bomadi LGA) in Delta State, Nigeria. One hundred and twenty (120) non-exposed individuals were also recruited (control) from Abraka, a non-gas flaring community in Ethiope East LGA of the same state. Thereafter, subjects were matched by gender, age, and duration of stay (exposure) to gas flaring and oil contamination in

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selected towns. In any case, cardiovascular parameters [systolic blood pressure (SBP), diastolic blood pressure (DBP)] were measured, while obtaining their pulse and mean arterial pressures (PP and MAP respectively) from measured variables. After statistical analysis (using the student t-test), study observed (at $p < .05$) a statistically significant increase in SBP and MAP for subjects above 10 years and 6 – 10 years of gas flaring exposure (Experimental groups) compared to those who had been exposed for just 1 – 5 years (Control). Study also observed a statistically significant increase in SBP and DBP (of females) for crude contamination exposed subjects for ages greater than 5 years compared to control. A duration-dependent exposure of subjects to increased SBP and DBP, following exposure to gas flaring and crude oil contamination was thus established. Apparently, exposed males showed an increase in average values of PP, MAP, SBP and DBP than the female counterparts. Study therefore ascertained findings from previous studies relating to cardiovascular changes on gas flaring and crude oil exposed humans; confirming gas flaring and oil contamination as potent elicitors of hypertension. Thus, environmental pollutants may act as markers for the screening and identification of CVS high-risk population, prior to actual diagnosis, intervention and prognosis of hypertension. We recommend periodic epidemiological assessment of environmental pollutants as a factor for indexing municipal risk of hypertensive individuals.

Keywords: Cardiovascular system; duration; gender; gas flaring.

1. INTRODUCTION

As the world grows warmer from time to time, global elites have continued to intensify efforts at combating the excesses of industrial wastes and human disposals on the environment [1].

This has prompted scientific researches and predictions that more people will get sick or die from cardiovascular diseases (CVDs), due not only to hotter days but more importantly to warmer nights (giving CVD sufferers less relief) [2]. More frequent and intense heat waves will further contribute to this trend; at the same time, there will be some decreases in the number of cold-related deaths. Diseases such as hypertension have also now been projected to widen their range as industries grow, and perpetuate myriads of toxic chemical disposition on the ecosystem. Other non-CVDs may spread similarly, including dengue fever, yellow fever, and encephalitis. Scientists also project rising incidence of allergies and respiratory diseases as warmer air grows more charged with pollutants, mold spores, and pollens [3].

Pollution, which is the contamination of Earth's environment with materials that interfere with human health, quality of life, or the natural functioning of the ecosystems (living organisms and their physical surroundings) in relation to the body's "*Internal milieu*" (internal environment) is known to result from natural causes such as volcanic eruptions, with most probably caused by human and industrial activities [4].

In recent times, air pollution has been globally associated with the development of several health problems, including heart disease, high blood pressure, stroke, lung cancer, as well as chronic and acute respiratory ailments like asthma, bronchitis, etc [5]. A More recent study has revealed that many chemical pollutants are able to mimic sex hormones in humans, and interfere with their body's reproductive and developmental functions. These substances are known as endocrine disrupters [6], and have been associated with several mortalities and morbidities, posing enormous health and economic consequences that reflects on increased loss of productivity, reduced labor efficiency in low to middle income nations [7].

In the Niger-Delta region of Nigeria, gas production and allied industrial activities like oil drilling and local refineries are growing. As such, gas flaring and industrial waste disposal have grown preponderantly, with over 130 reported flaring sites identified [8]. This makes Nigeria one of the highest emitters of greenhouse gases in Africa [9]. Constant exposure to hazardous chemicals as these, with accompanying deleterious health implications is likely to be more in humans that reside close to these refineries and gas flaring sites [10].

Recently, a meta-Analysis of epidemiological studies has established a positive correlation between cardiovascular risk and exposure to such several environmental pollutants [11]. Toxicological findings have also posited that inflammatory dose of particulate matter (PM) is likely to cause an increase in plasma fibrinogen

and blood viscosity, plus altering systemic and local inflammatory events [12]. These attenuations in blood coagulability and endothelial dysfunction have also recently been associated with health implications of human exposures to gas flaring [13]. Specifically, in chronic doses, acute exposure to these PM in high concentrations reportedly increases the risk of cardiovascular disorder [14]. Currently, researchers are of the opinion that the prevalence of hypertension and other cardiovascular risk factors are significantly higher in urban than rural communities [15].

In the light of this, current study was devised and designed to examine the durational and gender based changes in selected cardiovascular parameters of humans exposed to gas flaring and crude oil contamination activities in selected communities in Delta State, Nigeria. Specifically, study determined the comparative effects of gas flaring and crude oil contamination on systolic and diastolic blood pressures, as well as pulse and mean arterial pressures of resident male and females with time (Duration of exposure) [7, 10 & 14]. Study also ascertained the duration-dependent effects of exposures to gas flaring and crude oil contamination on systolic and diastolic blood pressures of samples subjects. Lastly, study assessed the comparative change that accompanies the impact of gas flaring and oil contamination on SBP, DBP and MAP.

2. MATERIALS AND METHODS

2.1 Scope of Study

Study was designed to be non-invasive. It examined in humans, the comparative changes in cardiovascular parameters due to gender and duration of exposure to gas flaring and oil contamination in selected flaring and contamination sites across Delta State, Nigeria. The study was exclusively designed to encompass communities in the state where gas flaring and/or refining activities are rampant. With Abraka (Non-gas flaring community) targeted for non-exposed subjects (control), Bomadi and Agbarho communities were targeted gas-flaring sites for exposed humans.

2.2 Study Design

Study adopted the cross sectional research type of design and compared selected cardiovascular parameters by gender and duration of exposure, for residents of gas flaring and oil contaminated

communities with those of non-flaring and non-oil-contaminated areas.

2.3 Study Location

Three different communities each with similar social-economic and cultural characteristic features, from three different local government areas (LGA) of Delta State, Nigeria were chosen for the study. Bomadi, a rural community in Bomadi LGA of the state was chosen. Bomadi reportedly covers an area of 129 km², with a population density of about 918.6 / km². The community is about 118, 500 populated and represented crude oil contaminated communities in this study. Agbarho, yet another gas flaring community was also selected from Ugheli North LGA of the state. The community is estimated to have 170,000 people in an 818 km² area of land. Abraka, a non-gas-flaring, non-oil-contaminated community was selected as control. Abraka is a rural community in Ethiope East LGA of Delta State, and is 276,000 populated.

2.4 Selection Criteria

For participants to be qualified for selection, several factors were considered in the course of this study; most importantly were; age (duration of stay and / or exposure to gas flaring and oil contamination at target towns), gender, physical fitness, non-disability and exceptions to use of heavy drugs.

2.5 Eligibility / Inclusion Criteria

Subjects who reside in the study area for more than two consecutive years, who were within the age brackets of 18-45 years were selected for this study. Selected subjects were also ascertained to be free from any cardio-pulmonary ailment.

2.6 Exclusion Criteria

Structured questionnaires and interview were used to exclude residents less than 18 years, and those who were above 45 years; also excluded were residents and/or visitors who have lived less than 2 years in various target communities. Subjects who smoke, consume alcohol, and suffer from disorders like diabetes mellitus, hyperlipidaemia, peripheral vascular disease, renal disease, and chronic ailments like sickle cell and asthma were also exempted.

2.7 Sample Size

Three hundred and sixty (360) subjects were drawn from three LGAs of Delta State. The sample size of eligible adults was calculated based on the assumed prevalence of hypertension of 18% as earlier reported [16].

2.8 Statistical Analysis

Results obtained from the study were expressed as Mean \pm SEM (Standard Error of Mean). With P-value of less than 0.05 ($p < 0.05$) considered to be statistically significant, a one-way analysis

of variance (ANOVA) was used to determine the mean differences for variables between groups.

3. RESULTS

The figures below (Figs. 1-10) show graphical representation of results.

4. DISCUSSION

One of the most controversial cardiovascular diseases is hypertension. Hypertension, or elevated blood pressure, develops when the body's blood vessels narrow, causing

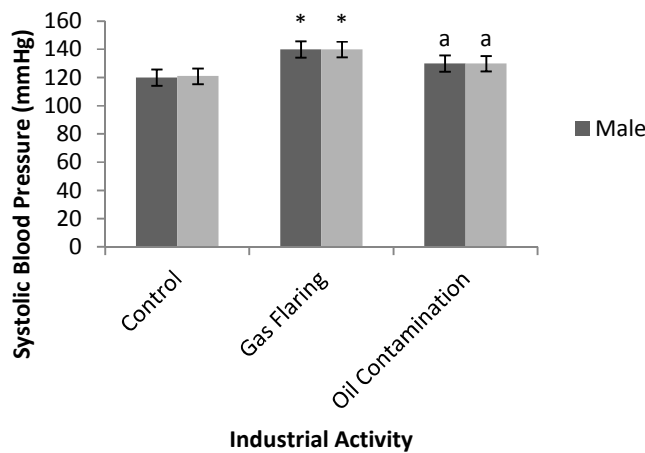


Fig. 1. Comparative effect of gas flaring and oil contamination on Systolic Blood Pressure (SBP)

*: significant at $p < .05$ as compared to control; ^a: significant at $p < .05$ upon comparison between gas flaring and oil contamination exposed subjects

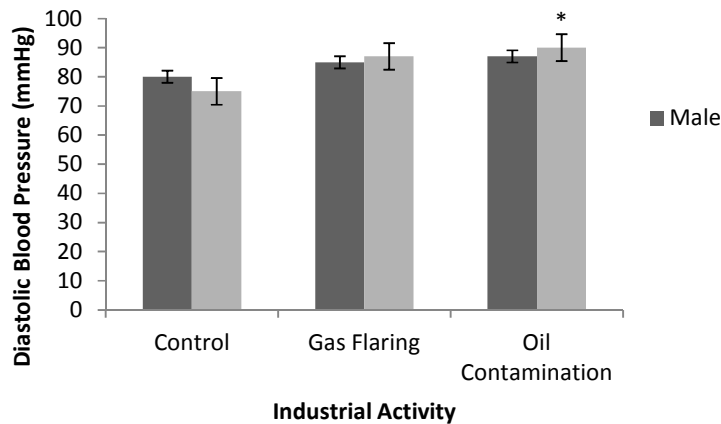


Fig. 2. Comparative effect of gas flaring and oil contamination on Diastolic Blood Pressure (DBP)

*: significant at $p < .05$ as compared to control

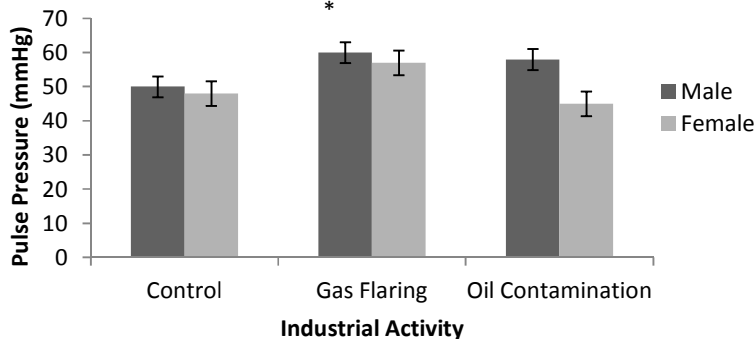


Fig. 3. Comparative effect of gas flaring and oil contamination on Pulse Pressure (PP)
 *: significant at $p < .05$ as compared to control

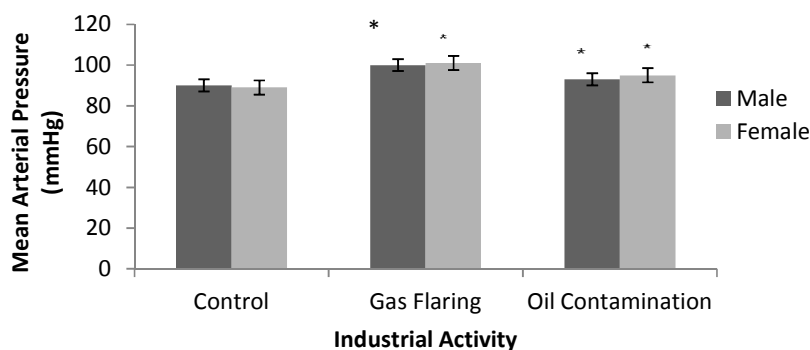


Fig. 4. Comparative effect of gas flaring and oil contamination on Mean Arterial Pressure (MAP)
 *: significant at $p < .05$ as compared to control

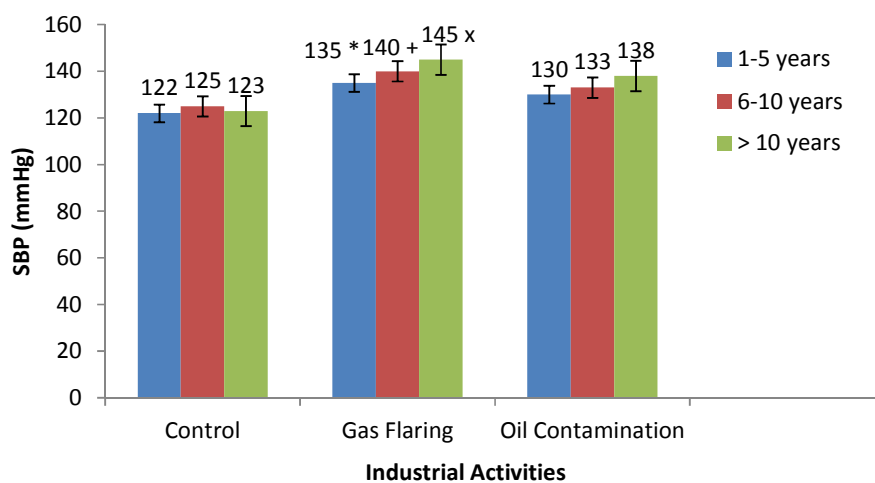


Fig. 5. Durational effect of gas flaring and oil contamination on Systolic Blood Pressure (SBP) of male subjects

*: significant at $p < .05$ as compared to 1-5 years exposed subjects (control); +: significant at $p < .05$ as compared to 6-10 years exposed subjects; x: significant at $p < .05$ as compared to > 10 years exposed subjects

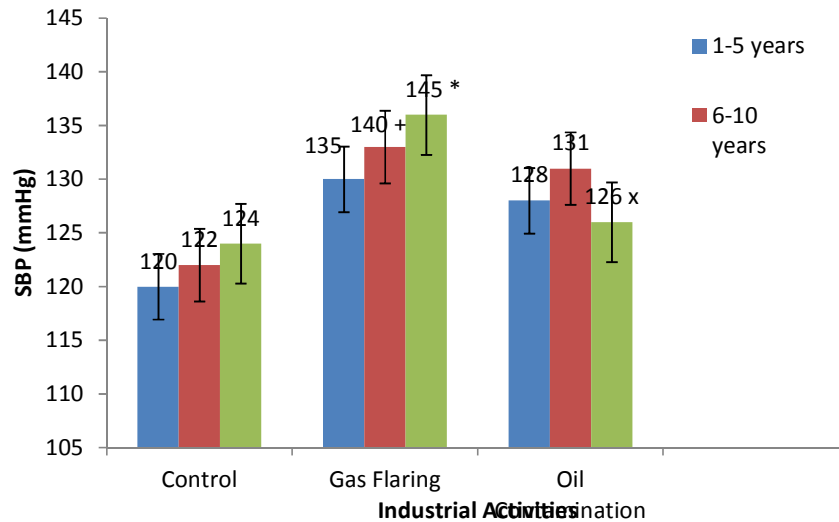


Fig. 6. Durational effect of gas flaring and oil contamination on Systolic Blood Pressure (SBP) of female subjects

⁺: significant at $p < .05$ as compared to 1-5 years exposed subjects (control); ^{*}: significant at $p < .05$ as compared to 6-10 years exposed subjects; ^x: significant at $p < .05$ as compared to > 10 years exposed subjects

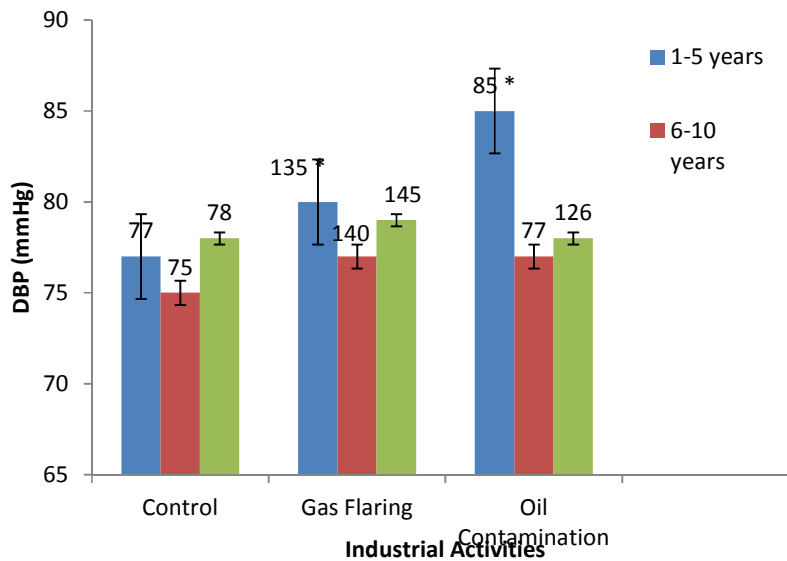


Fig. 7. Durational effect of gas flaring and oil contamination on Diastolic Blood Pressure (DBP) of male subjects

⁺: significant at $p < .05$ as compared to 1-5 years exposed subjects (control)

the heart to pump harder than normal to push blood through the narrowed openings [15]. It has been argued that hypertension that remains untreated may cause heart enlargement and thickening of the heart muscle. Also, Blood pressure (BP) as an important predictor of cardio-vascular events has been recognized in recent times to be traditionally importance to

systolic BP, especially in older adults [16]. Blood pressure may be steady (Mean Arterial Pressure -MAP) or pulsatile (Pulse Arterial Pressure – PAP). This study examined the changes in selected cardiovascular parameters of subjects residing in gas flaring and crude oil contaminated communities of Delta State, Nigeria.

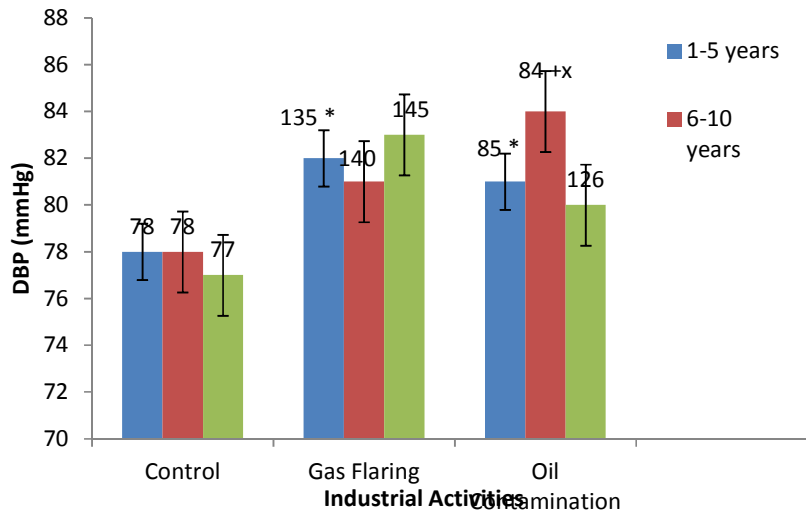


Fig. 8. Durational effect of gas flaring and oil contamination on Diastolic Blood Pressure (DBP) of female subjects

: significant at $p < .05$ as compared to 1-5 years exposed subjects (control); ++: significant at $p < .05$ as compared to 6-10 years exposed subjects; +: significant at $p < .05$ as compared to > 10 years exposed subjects

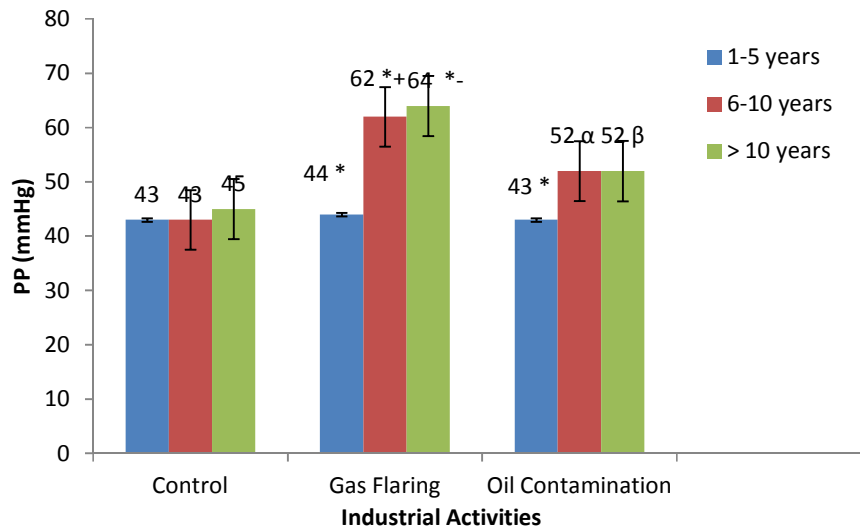


Fig. 9. Durational effect of gas flaring and oil contamination on Pulse Pressure (PP) of male subjects

: significant at $p < .05$ as compared to 1-5 years exposed subjects (control);+: significant at $p < .05$ as compared to 6-10 years exposed subjects; *-: significant at $p < .05$ as compared to > 10 years exposed subjects; α =significant at $p < .05$ when compared to subjects exposed to gas flaring for 6-10 years; β =significant at $p < .05$ when compared to subjects exposed to gas flaring for >10 years

Following data collection and careful observation from current study, results showed a statistically significant increase in the levels of systolic blood pressure (SBP), Diastolic blood pressure (DBP), and mean arterial pressure (MAP) of gas flaring

and oil contamination exposed participants. This observation was in agreement with the report of Joffer et al. (2009), who reported an increased risk of hypertension in prolonged exposure to gas flaring (Figs.1 - 4).

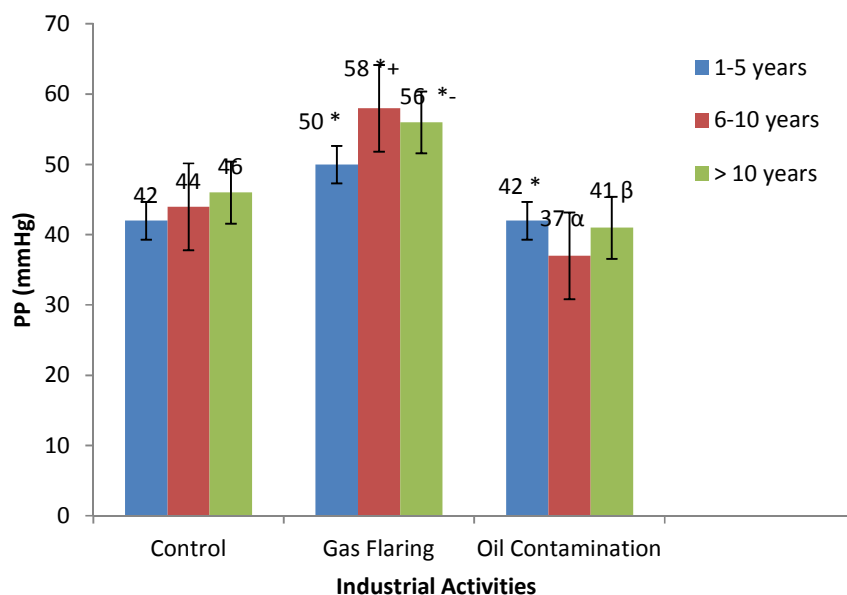


Fig. 10. Durational effect of gas flaring and oil contamination on Pulse Pressure (PP) of female subjects

+: significant at $p < .05$ as compared to 1-5 years exposed subjects (control); *: significant at $p < .05$ as compared to 6-10 years exposed subjects; α=significant at $p < .05$ when compared to subjects exposed to gas flaring for 6-10 years; β=significant at $p < .05$ when compared to subjects exposed to gas flaring for >10 years

Again from current study, a statistically significant increase was observed for Mean Arterial Pressure (MAP) of participants following durational exposures to gas flaring and oil contamination. Theoretically, MAP implicates in humans, the continuously regulated pressure, necessary to maintain end organ-tissue perfusion, and is required for adequate cellular oxygenation. By this, tissue oxygenation is improved with increased MAP, with detrimental changes induced by gas flaring and crude oil contamination to restrict the effect(s) on vascular tissues.

In this study, Fig. 5 explains the durational effect of gas flaring and oil contamination on systolic blood pressure (SBP) of sampled males. From the figure, it is observed that there was a duration-dependent exposure effect on SBP, causing increased SBP in males than females exposed to gas flaring and oil contamination activities. This increase was incremental for 1 – 5 years of exposure, through 6 – 10 years to > 10 exposure durations; and was apparently significant at $p < .05$ when compared to resident males in control group for respective duration. For Figs. 9, 10 however, pulse pressure was observed to return a statistically significant higher

value in subjects exposed to gas flaring in a duration-dependent manner upon comparison with males exposed to oil contamination activity. Theoretically, two major factors could be traced to this effect as seen in pulse pressure; stroke volume output and total dispensability of pressure. It could be suggested that the observed significant increase in pulse pressure caused by gas flaring could have influenced stroke volume and/or compliance of arterial wall [17]. Gatzka et al. 2008 were able to show that the increase in pulse pressure in subjects with coronary heart diseases was closely associated with an increase in echocardiographically measured aortic stiffness.

Again, comparison of the effect of gas flaring and oil contamination activity on systolic blood pressure (SBP) of female participants (Fig. 6 was similar, but distinct from those of males in Fig. 5. here, SBP of resident female subject in gas flaring and oil contaminated communities were higher in values than those of females in control group (non-flaring and non-oil contaminated communities). It was also observed that SBP of female subjects in gas flaring and oil contaminated communities was duration-dependent, increasing as such with increased

period of stay in sampled communities. This posed a statistically significant increase (at $p < .05$) with comparison of subjects who had stayed for 6 – 10 years to those of control despite this higher SBP value in SBP of exposed females. Findings from Patience et al. (2004) showed increased risk of hypertension due to increased SBP for exposed females as against that of males. However, investigations from this study showed that gas flaring caused more negative impacts on systolic and pulse pressures of males than crude oil contamination effects when compared (Fig. 5). All of these findings were duration dependent, contradicting reports from Patience et al. (2004). Furthermore, the less negative impact of gas flaring on MAP compared to the more negative impact of crude oil contamination could imply that gas flaring has a potent cardio-toxic effect on cardiovascular parameters.

Also seen result of this study was the prevalence of blood pressure variables (SBP, DBP, PP and MAP) that appear higher in males than in females (Figs. 7, 8), comparing male to be of higher mean values than females [18]. This increased BP in males than females may be physiologically traceable to the influence of and differences in sex hormones across gender. For instance, androgen levels in men with cardiovascular and other chronic ailments have been linked with chronic disease, and may exacerbate cardiovascular diseases in men [19,20]. Thus, men tend to have higher blood pressure than women upon comparison.

5. CONCLUSION

Current study established a duration-dependent exposure effect of gas flaring and crude oil contamination on cardiovascular variables across gender. Outcome from the study implicated environmental pollutants useful tools for the diagnosis and screening of high-risk pollution related effects on exposed subjects prior to identification of hypertension. This will thus be useful in targeting appropriate intervention for prognosis, whilst affirming gas flare and crude oil contamination effects on cardiovascular parameters.

6. RECOMMENDATIONS

To help curtail the excesses and hypertension-causing tendencies of oil and gas exploration activities to exposed humans within the neighbourhood, we recommend a routine

cardiovascular health programs and check-ups through governments and civil society groups. Current study should also be extended to other parts of the Niger-Delta regions of Nigeria where oil exploration ventures is rapid.

CONSENT

Informed and written Consent was also obtained from participants, seeking their opinion and informed approval before actual investigation. Subjects who gave consent (in writing) were selected for the study.

ETHICAL APPROVAL

Before the commencement of study, ethical approval was obtained from the research and ethics committee of the Faculty of basic medical Sciences, Delta State, University, Abraka, Delta State.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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