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Pollutants Exposure as A Causal Factor of Cardiovascular Diseases Among Meat Roasters in Selected Abattoirs in Obio/Akpor, Rivers State, Nigeria

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ABSTRACT

This study examined the occurrences of CVD among meat roasters in relation to pollutants exposures in abattoirs in Obio/Akpor Local Government Area. Four abattoirs with 50 workers were sampled while air quality parameters were obtained from five points at distances (Om, 20m, 50m, 100m and 200m) in each abattoir. The hand held air quality sampler was used to measure pollutants including ***gases and particulates such as*** NO_2, O_3, SO_2, H_2S, CH_4, ***CO***, $PM_{2.5}$ ***and*** PM_{10} *in parts per million (ppm) and microgram per cubic metre (µg/m³) whereas the electrocardiogram, ECG machine Cardiart 108T (BPL, India) was used to record electrical events in the heart muscle in order to diagnosed manifestations of CVD. The mean concentration of pollutants measured were* O_3 ***(0.43)***, SO_2***(0.31)***, H_2S ***(0.17)***, CH_4***(0.15), CO (0.64)***, $PM_{2.5}$***(2.26) and*** PM_{10}***(8.88). The Pearson Product Moment Correlation and Analysis of Variance statistical tools were employed in the analyses and*** *the coefficient* $r = .616$, $r^2 = .379$ *revealed that 38% of CVD occurrence among meat roasters is due to pollutant concentration exposure. On the other, pollutant concentration across the area do not vary significantly as revealed by the ANOVA result* ($F= 2.3941$, $P<0.05$) *with 74% of CVD occurrence observed among workers between the ages of 21-40 years of age. The study concluded that abattoirs are localized source of air pollution releasing pollutants, which contributes significantly to CVD occurrence. Thus, air quality monitoring, constant environmental management and evaluation of abattoirs, use of personal preventive/precautionary approach including going for constant medical check-up, adherence to medical advice, use of personal protective equipment and reduction in duration of exposure were highly recommended.*

Keywords
Cardiovascular diseases, Good hygiene practices.

Introduction

The continuous drive to increase meat production for the protein needs of the ever-increasing world population has some pollution problems connected with it. According to Akinro et al. [1], pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP). For hygienic reasons, abattoirs use large amount of water in processing operations; this produces large amount of wastewater. The major environmental problem associated with this" abattoir wastewater is the large amount of suspended solids and liquid waste as well as odour generation which interfere with the enjoyment of life and property. Thus, it is a recognized source of localized air pollution which produces odorous compounds like Sulphides, Mercaptans, Amines, Organic acids etc. [2]. Pollution of air as a result of man's activity has been a feature of the urban environment for centuries, probably since the introduction of fire as a means of heating and cooking. Urban air pollution increased rapidly with the use of wood and later coal for domestic heating and, later again, for industrial processes. Pollution arising from the latter was regarded for many years as a necessary or unavoidable evil, the inevitable price of provision of work for the population [3]. Human activities which lead to pollution of the environment and a disruption of ecosystem functionality contribute impurities in the form of industrial, domestic, and agricultural wastes to the environment. In many parts of the world, human activities impact negatively on the environment and biodiversity. Some of the consequences of man-made pollution include transmission of diseases by water borne pathogens, eutrophication of natural water bodies, accumulation of toxic or recalcitrant chemicals in the soil, destabilization of ecological balance and negative effects on human health [4-8].

Abattoir are one of the industries which release appreciable amounts of odorous organic and inorganic air pollutants compounds, such as hydrogen sulfide (HoS), methanethiol (MT), dimethylesulfide (DMS), during heating of animal tissues. In addition, the primary air pollutants found in most urban areas through the operations of abattoir activities, such as burning of bones and skin with tyres are styrene and 1,3- but adienes while the use of woods or coal, lead to the emission of smoke and gases like carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbons, and particulate matter to the atmosphere, causing air pollution [9,10]. These pollutants are dispersed throughout the world's atmosphere in concentrations high enough to gradually cause serious health problems [9]. Evidence exists that exposure to air pollutants irritate eyes and cause inflammation of the respiratory tract, suppress the immune system and increase susceptibility to infection. Other health problems that can result from long-term exposure to toxic air pollutants are cancer, chronic obstructive pulmonary disease, asthma, respiratory infections, and cardiovascular disease. The American Heart Association (AHA) published its first scientific statement regarding air pollution and cardiovascular disease (CVD) in 2004 and after which several other epidemiological studies of varied design that significantly add to the overall weight of evidence that exposure to air pollutants at present day levels contributes to cardiovascular morbidity and mortality has been reported [11]. By 2005, the total number of cardiovascular disease (CVD) deaths (mainly coronary heart disease, stroke, and rheumatic heart disease) had increased globally to 17.5 million from 14.4 million in 1990. Of these, 7.6 million were attributed to coronary heart disease and 5.7 million to stroke. More than 80 percent of the deaths occurred in low and middle income countries [12]. By 2030, researchers project that non- communicable diseases will account for more than three-quarters of deaths worldwide; CVD alone will be responsible for more deaths in low income countries than infectious diseases (including -HIV/AIDS, tuberculosis, andmalaria), maternal and perinatal conditions, and nutritional disorders combined [13]. Thus, CVD is today the largest single contributor to global mortality and will continue to dominate mortality trends in the future [12]. Meanwhile, most cardiovascular disease is said to occur in middle and old age whereas comparatively little occurs in young people suggesting that the proportion of persons in the age range 45-65 years dying of cardiovascular disease is high. Arising from the foregoing, the focus of this study is to examine exposure and risk reduction strategy for CVD occurrence in specific population of meat roasters as a significant section of the abattoir operations particularly in Obio/Akpor.

Materials and Methods

The study area lies along the Bonny River, an eastern distributaries of the Niger approximately between latitude 4° 42' and 4° 47' N and Longitude 6° 55' and 7° 08' E. A total of twelve (12) operational and sizeable abattoirs were identified within the area at Ogbogoro, Rumuokparali, Choba, Alakahia, Rumuokoro, Eneka, Rukpokwu, Ruuosi, Eliozu, Rumuokwurushi, Elelenwo and Oginigba, whereas five representing 30% of the totalwere randomly selected for this study through the balloting method in alignment with Kpolovie as shown in Table 1. The air quality parameters investigated at the selected abattoirs include both gases such as carbon monoxide, Sulphur dioxide, Hydrogen Sulphide, Methane, Nitrogen Oxide, Ozone, and Volatile Organic Compounds (VOCs) and particulates. Air quality samples were obtained from five different points (Om, 20m, 50m, 100m, 200m) within each sampled location for spatial coverage and to avoid a point specific measurement in corroboration with [14] cited in Weli, Kpang and Adegoke [15] and then averaged to obtain the mean. Both the gases and particulates were all measured with the aid of a hand held air quality samplerin parts per million (ppm) and microgram per cubic metre ($\mu g/m^3$) respectively and later converted to milligram per cubic metre (mg/m^3) as per the equation:

$$Y\ mg/m^3 = (X\ ppm)(\text{molecular weight})/24.45 \ldots\ldots\ldots \text{eqn} \qquad (1)$$

Also the electrocardiogram, ECG machine *Cardiart 108T* (BPL, India) a graphic time based record of electrical events in the heart muscle was employed in diagnosing manifestations of ischemic heart disease, i.e., myocardial infarction of the sampled population from the different abattoirs so as to establish whether or not there is direct link between air pollutants and cardiovascular diseases in the study area. This was done by placing electrodes (small, plastic patches) at certain locations on the chest, arms, and legs of the sampled abattoir workers and subsequently connected to an ECG machine by lead wires and the electrical activity of the heart of the sampled populations measured and printed out for the physician's information and further interpretation. The electrocardiographic graph of the sampled populations obtained through the use of electrocardiogram machine at the University of Port Harcourt Teaching Hospital were further analyzed using the 'Minnesota code' for purpose of assessment of cardiovascular health of the sampled populations. The framework for reporting electrocardiographic findings was based on the ECG scheme of classification provided below.

Table 1: ECG Classification Scheme.

Item	Aspect Analyzed
1	Q - wave amplitude
2	Axis Deviation -QRS-Complex
3	High amplitude R waves
4	ST-segment depression
5	T-wave negativity
6	AV conduction defect
7	Ventricular conduction defect
8	Arrhythmias
9	Low QRS amplitude
10	ST segment elevation

Similarly, the Pearson Product Moment Correlation statistic (PPMC) and Analysis of Variance (ANOVA) were employed to analyze the data in order to validate or invalidate whether a correlation exist between Cardiovascular diseases and pollutant concentration and also to establish whether the occurrence of CVD among meat roasters in the area vary significantly or not and to also verify variation in the concentration of pollutants across the study area (if any). The mathematical expressions of the formulae are shown in equation (2) and (3).

$$\mathbf{r} = \frac{\mathbf{n}(\sum \mathbf{xy}) - (\sum \mathbf{x})(\sum \mathbf{y})}{\sqrt{[\mathbf{n}\sum \mathbf{x}^2 - (\sum \mathbf{x})^2][\mathbf{n}\sum \mathbf{y}^2 - (\sum \mathbf{y})^2]}} \tag{2}$$

Where,

- r = Pearson Coefficient
- n= number of the pairs of the stock
- $\sum xy$ = sum of products of the paired stocks
- $\sum x$ = sum of the x scores
- $\sum y$= sum of the y scores
- $\sum x^2$ = sum of the squared x scores
- $\sum y^2$ = sum of the squared y scores

Table 2: Sample size for the study.

S/ No	Location	No of workers	Sample Size	Percentage	Area Coverage (Sq.m)
1	Elelenwo	30	9	18	2052
2	Rumuokoro	25	8	16	1551
3	Rukpokwu	15	5	10	559
4	Trans-Amadi	94	28	56	661.5
5	Total	164	50	100	

Table 3: Pollutants Concentration at the Sampled Abattoirs.

Locations	Distance (m)	NO_2 mg/m^3	O_3 mg/m^3	SO_2 mg/m^3	H_2S mg/m^3	CH_4 mg/m^3	CO mg/m^3	$PM_{2.5}$ ug/m^3	PM_{10} ug/m^3
Trans-Amadi	0	0	0.20	1.57	0.14	0.26	0.23	5.1	15.4
	20	0	0	0	0.14	0.20	0.92	3.1	11.6
	50	0	0	1.05	0	0.13	0.23	2.3	8.0
	100	0	1.77	0	0	0	0	2.2	9.4
	200	0	0	0.97	0.28	0.13	0.11	2.3	8.2
	Mean	0	0.39	0.72	0.11	0.14	0.30	3.0	10.52
Rumuokoro	0	0	0.39	0	0	0.20	1.60	2.7	8.3
	20	0	0.20	0	0.42	0.26	0.57	2.2	10.5
	50	0	0.0	0	0	0.39	1.03	2.4	7.0
	100	0	0.59	0.52	0.14	0	0.22	2.1	8.7
	200	0.19	0.79	0.79	0.56	0	0.46	2.4	9.4
	Mean	0.04	0.39	0.26	0.22	0.17	0.77	2.36	8.78
Rukpokwu	0	0	0	0.52	0	0.07	0	2.5	7.6
	20	0.19	0.39	0	0	0	0.34	2.0	9.2
	50	0	0	0.26	0	0	0	1.9	6.8
	100	0	0.59	0	0	0	0.11	2.2	7.3
	200	0	0.39	0.52	0.14	0	0.11	1.8	8.0
	Mean	0.04	0.27	0.26	0.03	0.14	0.56	2.08	7.78
Elelenwo	0	0	0.59	0.26	0.29	0.13	1.37	3.0	8.4
	20	0	0	0.79	0	0.20	0.46	2.0	12.6
	50	0	0.39	0	0.14	0.33	0.80	2.5	6.2
	100	0	0.78	0	0	0	0	1.8	8.0
	200	0	0.39	0.52	0.42	0.07	0.57	2.0	9.2
	Mean	0	0.43	0.31	0.17	0.15	0.64	2.26	8.88

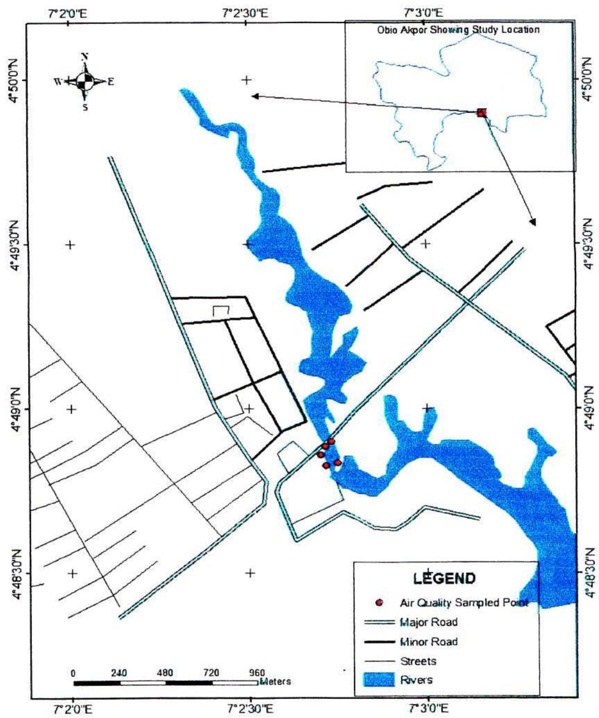

Figure 1: Air Quality Sampled Points at Trans-Amadi Abattoir.

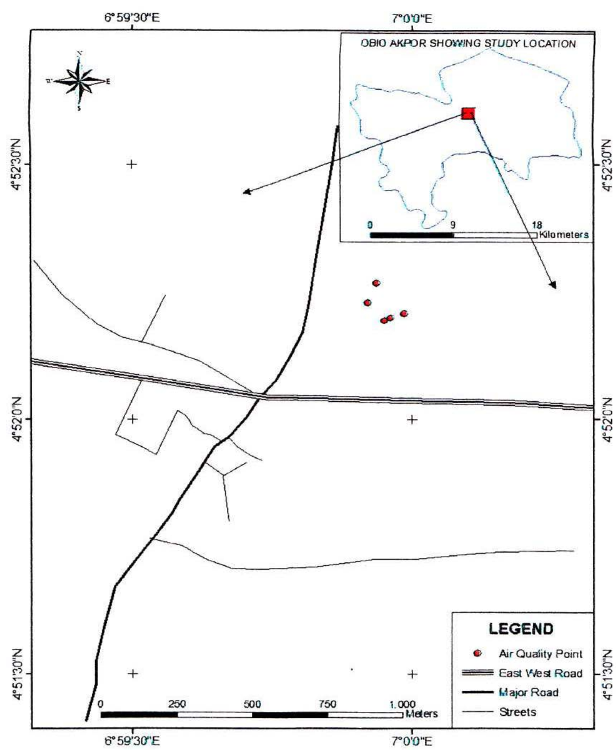

Figure 2: Air Quality Sampled Points at Rumuokoro Abattoir.

The pollutants concentration measured at each distances in the selected abattoirs including the pollutant concentration for each pollutants investigated is shown in Table 3. It is obvious from the table that the pollutants present at the abattoirs include gases and particulates such as NO_2, O_3, SO_2, H_2S, CH_4, CO, $PM_{2.5}$ and PM_{10}.

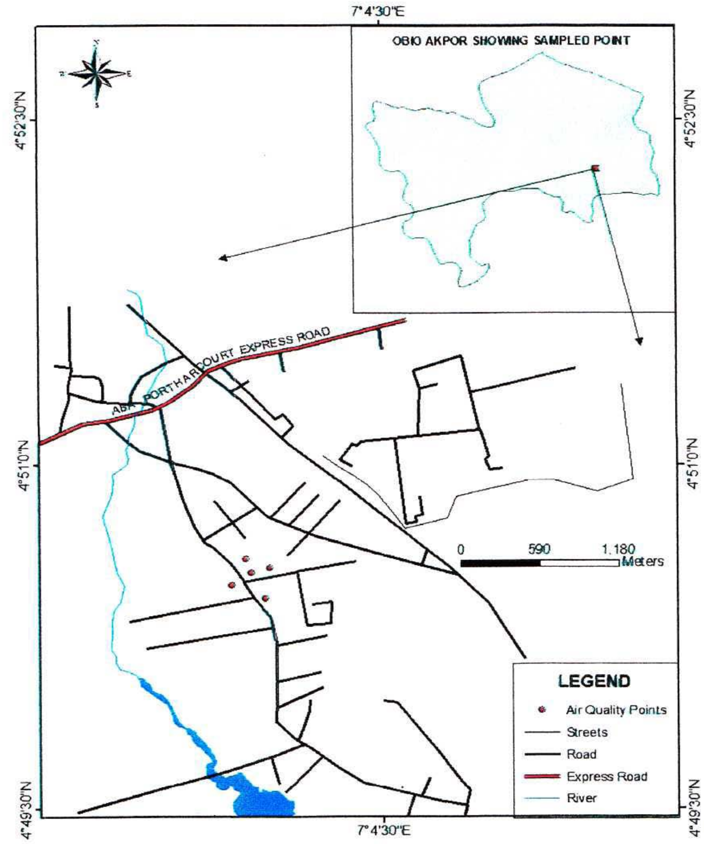

Figure 3: Air Quality Sampled Points at Elelenwo Abattoir.

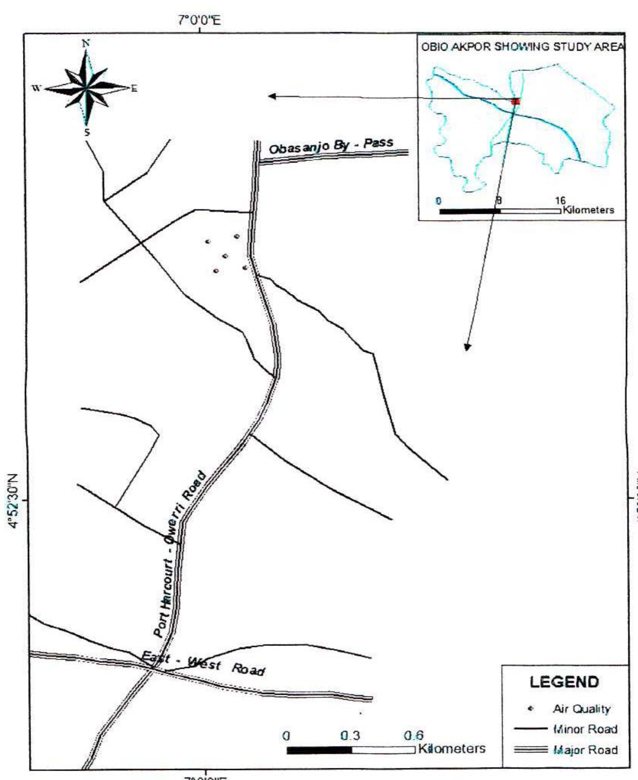

Figure 4: Air Quality Sampled Points at Rukpokwu Abattoir.

It is revealed from Table 3 that NO_2 was only found at Rumuokoro and Rukpokwu abattoirs measuring 0.19 mg/m^3 at 200m and 20m respectively. The minimum concentration of the gases ranged between 0.11mg/m^3-1.77mg/m^3 whereas the particulates ranged between 1.8ug/m^3- 15.4ug/m^3 and both measurements had the least at Rukpokwu and the highest at Trans-Amadi. Similarly, it is evidently clear from the table that the pollutants concentration recorded at Trans-Amadi abattoir ranged between 0.13mg/m^3 -1.77mg/m^3 for gases and 2.2ug/m^3- 15.4ug/m^3 for particulates with O_3 recording 1.77mg/m^3 as the highest and 0.13mg/m^3 for CH_4 as the lowest whereas $PM_{2.5}$ measured between 2.2ug/m^3-5.1ug/m^3 and PM_{10} was seen to fluctuate between 8mg/m^3-15.4mg/m^3. On the other hand, H_2S was observed as the pollutant with the least concentration at Rumuokoro (0.14mg/m^3) and CO as the highest with 1.60mg/m^3 while at RukpowuCH_4recorded the least concentration (0.07mg/m^3) and O_3 as the highest with 0.59mg/m^3. It was also observed from Table 2 that at Elelenwo CH_4 measurement was the least similar to the situation at Rukpokwu (0.07 mg/m^3) while CO was the highest with 1.37 mg/m^3. Conversely, $PM_{2.5}$ recorded it least measurement as 2.1ug/m^3 and PM_{10} recorded 10.50ug/m^3 as the highest at Rumuokoro whereas at Rukpokwu $PM_{2.5}$ fluctuate between 1.8ug/m^3 and 2.5ug/m^3 and PM_{10} (6.8ug/m^3 and 9.2 ug/m^3) but at Elelenwo $PM_{2.5}$ ranged between 1.8ug/m^3 and 3.0ug/m^3 while PM_{10} reading was found to be between 6.2ug/m^3 and 9.2ug/m^3.

The mean concentration of pollutants at the sampled locations is clearly displayed in Table 3, it was observed that 0.72 mg/m^3 for at the Trans- Amadi abattoir was the highest compared to its concentration at other sampled stations. At Rumuokoro CO has the highest mean concentration of 0.77 mg/m^3 while O_3, SO_2 and H_2S measures 0.39 mg/m^3, 0.26 mg/m^3 and 0.22 mg/m^3 respectively. On the other hand, CO was observed as the highest mean concentration at both Rukpokwu and Elelenwo abattoirs recording 0.56 mg/m^3 and 0.64mg/m^3 respectively. Although, particulates were observed to have significant mean concentrations at all the sampled abattoirs, PM_{10} measuring 10.52 ug/m^3 was actually the most significant at Trans-Amadi and the least mean concentration of the same category of particulates was recorded at Elelenwo measuring 6.2ug/m^3 while the least mean concentration of $PM_{2.5}$ was observed at Elelenwo with the value 2.26ug/m^3 whereas Trans-Amadi and Rukpokwu has the highest mean concentrations of the same particulate with 3.0ug/m^3 at each of the respective locations. Although, CO is a weak greenhouse gas, it has severe influence on the climate which is beyond its own direct effects. The presence of CO in the atmosphere affects concentrations of other greenhouse gases including carbon dioxide, methane and tropospheric ozone by reacting with the hydroxyl radical (OH) to form a much stronger, greenhouse gas CO_2. These particles have the capacity to penetrate sensitive tissue through diverse

Table 4: Exposure Assessment and Risk Reduction Strategy for CVD.

Duration of Workers Exposure to Pollutants							
Location	2 Hrs	4 Hrs	6 Hrs	8 Hrs	10 Hrs	Total	%
Trans-Amadi	2	3	7	10	6	28	56
Rumuokoro	0	1	1	4	2	8	16
Rukpokwu	0	0	0	4	1	5	10
Elelenwo	0	2	1	4	2	9	18
Total	2	6	9	22	11	50	100
Percentage (%)	4	12	18	44	22	100	

Common Symptoms of CVD						
Location	**Breathlessness**	**Cough**	**Chest Pain**	**Dizziness**	**Total**	**%**
Trans-Amadi	4	5	. 14	5	28	56
Rumuokoro	1	2	4	1	8	16
Rukpokwu	1	1	2	1	5	10
Elelenwo	1	2	5	1	9	18
Total	7	10	25	8	50	100
Percentage (%)	14	20	50	16	100	

Frequency of Hospital Visitation based on Symptoms of CVD						
Location	**Very often**	**Often**	**Occasionally**	**Never**	**Total**	**%**
Trans-Amadi	3	2	5	18	28	56
Rumuokoro	-	-	2	6	8	16
Rukpokwu	-	-	1	4	5	10
Elelenwo	-	1	3	5	9	18
Total	3	3	11	33	50	100
Percentage (%)	6	6	22	66	100	

Risk Reduction Strategies						
Location	**Constant medical check up**	**Using PPE**	**Government Policy**	**Taking Time Off**	**Change of life style**	**Total**
Trans-Amadi	4	8	3	10	3	28
Rumuokoro	1	2	-	4	1	8
Rukpokwu	-	3	L	1	-	5
Elelenwo	1	4	1 '	1	2	9
Total	6	17	5	16	6	50
Percentage (%)	12	34	10	32	12	100

pathways such as ingestion, inhalation or dermal contact and causing significant damages and may eventually lead to death in most cases. According to Zhang, Dang, Zheng, & Yi [16], the inhalation of the gas at higher concentrations may cause severe respiratory illness and diseases aggravating to heart disease. In a related development, particulates matter are another set of air pollutants with frustrating consequences due to their ability to penetrate deep into the lungs and blood streams unfiltered, causing permanent DNA mutations, cardiac attacks and subsequently death [17]. The presence of these gases and particulates at the abattoirs is an indication that the health of workers in the area is at cardiovascular risk in corroboration with studies with document linkages between health effects and atmospheric pollution leading to serious health effects ranging from respiratory related diseases to chronic diseases that could lead to high mortality [18,19].

The data on duration of workers exposure to pollutants at each of the sampled locations, common symptoms of CVD and frequency of hospital visitation based on perceived symptoms of CVD is reported Table 4. It is indicated that only 12% of the total respondents visit the hospital often based on perceived cardiovascular disease symptoms. Also, it was found that 22% of the workers occasionally approach the health facility whereas 66% of the workers said they have never visited the hospital irrespective of whatever may be the case. Again, they also assumed that they are always physically fit to do their job so there wasn't any reason to visit the hospital in the absence of any visual evidence of ailment which to a great extent can be actually classified as acting based on ignorance. Table 4 also shows the common symptoms of cardiovascular diseases among abattoir workers in the study area and reveals that 14% of the workers have symptoms of breathlessness while 20% of the respondents have the symptom of cough. The table shows that the most prevalent CVD symptom in the area is chest pain as 50% of the workers admitted having cough almost on regular basis. Another symptom observed among the abattoir workers linked to CVD is dizziness and this was based on the response of 16% of the workers in the study area. It was also noted from Table 4 that 4% of the workers spend only 2 hours at the abattoir and thus are exposed to the pollutants within the specified period. Among the sampled population it was clear that 12% are exposed to the pollutants for 4 hours, another 18% of the populations are exposed to the pollutants for 6 hours whereas 44% representing almost half of the target population are exposed to these pollutants for 8 hours while 22% accounts for those who are exposed for 10 hours. Table 4 equally revealed that the respondents position in relation to the risk reduction strategies for CVD occurrences among abattoir workers in the area. In the opinion of 12% of the respondents, constant medical checkup/adhering to medical advice was the risk reduction option while 34% opted for use of personal protective equipment as a better strategy. The table also indicates that 10% of the people believed that the most considerable strategy that will yield positive result is through policy intervention by government whereas taking time off and change of lifestyle recorded 32%and 12% respectively. The World Health Organization (WHO) reported that air pollution was responsible for 3.7 million deaths in 2012, representing 6.7% of total deaths worldwide, and was the cause of 16% of lung cancer deaths, 11% of chronic obstructive pulmonary disease-related death, 29% of heart disease and stroke, and approximately 13% of deaths due to respiratory infection which strongly shows that air pollution is an important public health issue, causing cardiovascular and pulmonary diseases worldwide and therefore of major concern to governments and health organizations [14,20]. The pulmonary effects of air pollution containing $PM_{2.5}$ and PM_{10} include increased respiratory symptoms, decreased lung function, and increased incidence of chronic cough, bronchitis, and conjunctivitis. This study reveals the presence of particulate matter (PM) in substantial quantities within the vicinity of abattoir whereas PM like other components of the air is associated with the most severe air pollution induced health effects since it may contain toxic substances and transports them into the respiratory tract. The effect of PM on the body can depend on PM size, which is related to its aerodynamic diameter (AD) ranging from 2.5 to 10 μm, and are deposited in the nasal cavities and upper airways and may penetrate the lung alveoli and enter into the bloodstream, thereby exerting adverse health effects such as increased respiratory symptoms, decreased lung function, and increased incidence of chronic cough, bronchitis, and conjunctivitis [21-23]. Similarly, The relationship between exposure to both $PM_{2.5}$ and PM_{10} air pollutant concentrations have been reported to have a marked and close association with adverse health effect, such as heart disease, stroke, blood pressure, and cardiovascular diseases [24-26]. Although air pollution is of global health concerns, the ambient PM composition and size are considered the most important indicator of the adverse health effect of air pollution after both short-term exposure to an elevated concentration of pollutants or after long-term exposure [27,28]. Although air pollution is reported as serious issue of public health concern by WHO, United States Global Change Research Program, USGRP, Kelishadi & Poursafa on account of its severe health and environmental threat such as Chronic Obstructive Pulmonary Disease (COPD), cough, shortness of breath, wheezing, asthma, respiratory disease, and high rates of hospitalization on short-term exposure and chronic asthma, pulmonary insufficiency, cardiovascular diseases, and cardiovascular mortality, mental and perinatal dysfunction, leading to infant mortality or chronic disease in adult age as long term effect. It is surprising to note that 66% of the respondents in this study never visited the hospitals for any reason linked to symptom (s) from their occupational engagement which could either be seen as an act of ignorance and raises serious concern as the cumulative effect at the long run may be disastrous.

Table 5: Occurrence of CVD in the population of different age groups.

Sampled Locations	Age in years					Total CVD Occurrence
	11- 20	21- 30	31-40	41- 50	>50	
Trans –Amadi	3	7	10	3	2	25
Rumuokoro	0	4	1	1	0	6
Rukpokwu	0	2	2	0	0	4
Elelenwo	0	3	2	1	1	7
Total	3	16	15	5	3	42

The occurrence of CVD in the population of different age groups in the study area is shown in Table 5 whereas 89.28% of CVD occurrence was observed among the workers in Trans-Amadi abattoirs while 75% occurrence was the case among Rumuokoro abattoirs. On the other hand, the presence of CVD manifested in 80% of the workers sampled in Rukpokwu abattoir whereas in Elelenwo CVD presence was evidently seen in 77.77% of the workers. A careful look at the table reveals that 59% of CVD occurrence among the workers in the area is reported in Trans-Amadi while Rumuokoro accounts for 14% of the CVD presence among the studied population. The table further shows that 10% of CVD occurrence among workers in the area is recorded in Rukpokwu while 17% of the total occurrence of CVD among the sampled workers is domiciled in Elelenwo abattoir. With regards to specific populations of the abattoir workers, 7% of the CVD occurrence among the workers were found within the age bracket of 11-20 whereas 38% of the reported cases of occurrence of CVD manifested among those in age group 21 -30 years. Also 36% of the occurrence was found among the workers who are between 31-40 years while those in age bracket 41- 50 and >50 manifested presence of CVD in the proportion of 12% and 7% respectively. It is reported in the table that 74% of CVD manifestation is predominantly among the youths between 21-40 years implying that the economic viable population is facing severe cardiovascular threat due to abattoir emitted pollutants.

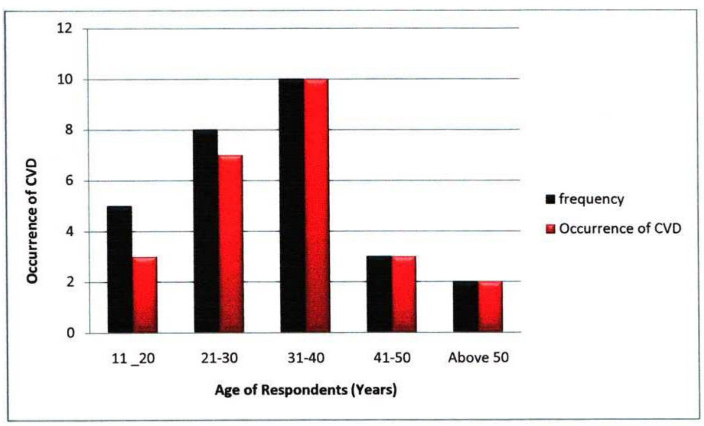

Figure 5: CVD Occurrence in the age groups at Trans-Amadi Abattoir.

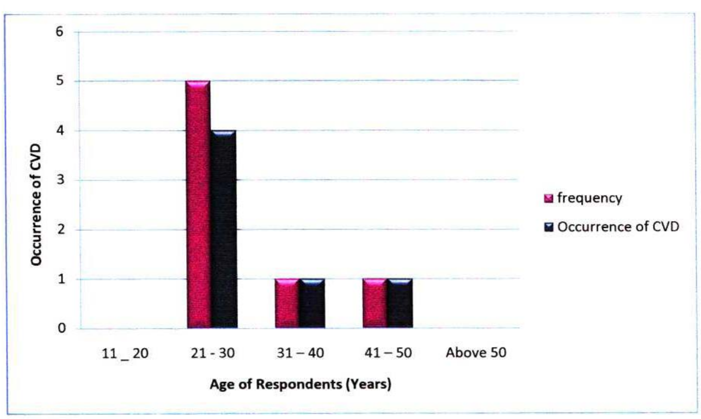

Figure 6: CVD Occurrence in the different age group at Rumuokoro.

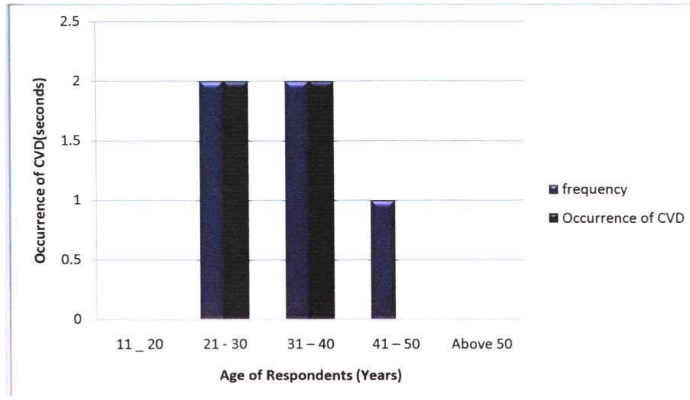

Figure 7: CVD Occurrence in different age Group at Rukpokwu Abattoir.

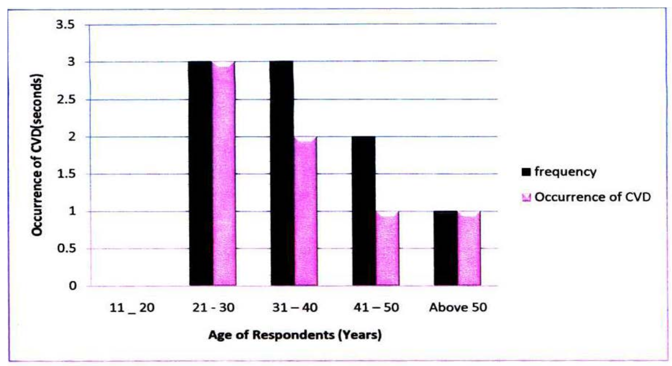

Figure 8: CVD Occurrence in different age group at Elelenwo Abattoir.

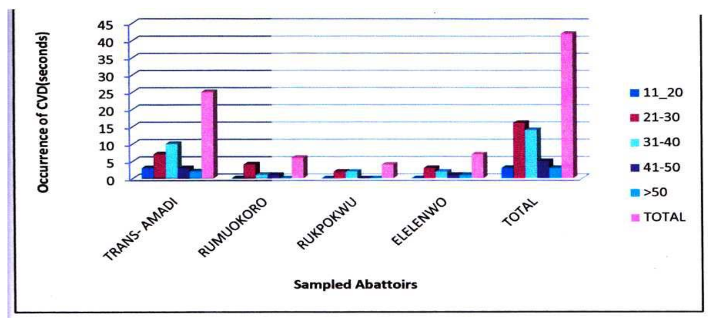

Figure 9: CVD Occurrence in different population across the area.

Table 6: Cardiovascular Disease Occurrence and Pollutant Concentrations.

R	R-Square	Pollutants	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
			B	Std. Error	Beta		
.616	.379	(Constant)	4.635	9.810		.473	.646
		NO_2	-22.369	39.885	-.151	-.561	.005
		O_3	-2.859	6.209	-.141	-.460	.006
		SO_2	8.014	7.143	.422	1.122	.002
		H_2S	-6.607	13.809	-.132	-.478	.006
		CH_4	-5.229	26.882	-.075	-.195	.008
		CO	-1.027	6.525	-.056	-.157	.087
		$PM_{2.5}$	-1.521	4.623	-.127	-.329	.007
		PM_{10}	1.101	1.323	.276	.832	.004

Table 7: ANOVA[a].

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1540.622	8	192.5	2.3941	0.0145[b]
	Residual	884.378	11	80.398		
	Total	2425.000	19			

The model summary of the Pearson Product Moment Correlation presented in Table 6 above indicates that for pollutant concentration r = .616, r^2 = .379 implying that 38% of the occurrence of cardio-vascular Diseases among the workers is attributable to pollutant concentration. This result is a clear indication that 62% of CVD manifestations among meat roasters in the abattoirs can be explained by other factors which may include, physiological differences, frequency of visits to the area, the degree and concentration of the atmospheric pollutants, the meteorological conditions of the abattoir which determines to a large extent the level of atmospheric loading of the pollutants which supports the findings of a growing body of epidemiological and clinical evidence which has over the last decade, led to a heightened concern about the potential deleterious effects of ambient air pollution on health and its relation to heart disease and stroke. The environmental air pollutants identified in this study which includes carbon monoxide; oxides of nitrogen, sulfur dioxide, ozone, lead, and particulate matter ($PM_{2.5}$, PM_{10}) are associated with increased hospitalization and congestive heart failure, frequent arrhythmias, or both in consonance with Tawari & Abowel [29], who opined that air pollution in modern day particularly when there are no effective control measures has raised cause for global environmental concern as high levels of pollutants such as SO_2, NO_2, CO and Particulate matter released via various anthropogenic sources have significant harmful effects on the environment and human health.

On the other hand, the ANOVA revealed at (F= 2.3941, P>0.05) as shown in Table 7 that the pollutant concentration in the area do not vary significantly while the standardized coefficients of the model predicting the occurrence of cardiovascular diseases in relation to the pollutants reported in the table is expressed in equation 2.

$$CVD = 4.635-22.369_{NO2}–2.859_{O3}+8.014_{SO2}-6.607_{H2S}-5.229_{CH4}-1.027_{CO}-1.521PM_{2.5}+1.101_{PM10}$$

Conclusion and Recommendations

Several studies of varied design which have significantly add to the overall weight of evidence that exposure to air pollutants at present-day levels contributes to cardiovascular morbidity and mortality been published. However, there is no particular attention to the operations of abattoirs as a source of localized air pollution where wastes that can produce odours which interfere with the enjoyment of life and property are generated. The investigation revealed that pollutants such as SO_2, NO_2, CO, H_2S, $PM_{2.5}$ and PM_{10} with substantial impact of environmental exposures on the burden of cardiovascular disease at the population-level are associated with abattoir activities. Consequently, the study recommends setting/monitoring of air quality objectives and standards and environmental management and evaluation of abattoirs by government. Use of personal preventive/precautionary approach including going for constant medical check-up, adhering to medical advice, use of personal protective equipment were also recommended.

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