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Original Article

Maternal Exposure to Carbon Monoxide in the First Trimester of Pregnancy in the Niger Delta as a causative factor of Minor Pregnancy symptoms and signs

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Abstract

Background: There is paucity of knowledge and information on the association of minor pregnancy symptoms and signs with maternal exposure to CO. **Aim: T**o ascertain the association of chronic maternal exposure to CO in the Niger Delta with minor early pregnancy symptoms and signs. **Material and methods**: It was a cross-sectional study carried out at the Rivers State University Teaching Hospital (RSUTH) in Rivers State, Nigeria. 490 consecutive pregnant women in the first trimester were recruited from the antenatal clinic from January 2021 to January 2022. Their demographic, social and obstetric characteristics were taken. Maternal exhaled CO (ECOC) and carboxyhaemoglobin concentrations (MCOHC) were measured with the aid of a smokerlyzer. Data was analysed, using SPSS version 25.0 (Armonk, NY) software. Ethical approval was obtained from the RSUTH Ethics Committee. **Results:** With respect to ECOC and MCOHC, 335(68.4%) and 461(94.08%), 129(26.3%) and 18(3.67%) and 26(5.3%) and 11(2.2%) out of the 490 patients had mild, moderate and severe exposure to CO respectively. Minor pregnancy symptoms and signs were all associated with maternal exposure to CO with the highest numbers in the mild category of exposure with respect to ECOC and MCOHC. There were statistically significant differences between the proportions of patients who had the symptoms and signs in the mild, moderate and severe exposure categories. For ECOC, headaches - 93(27.8%), 58(45.0%) and 6(23.1%) (X^2=13.66; p<0.001) and sensation of weakness - 33(9.9%), 25(19.4%) and 3(11.5%) (X^2=7.780; p<0.020). With respect to MCOH concentrations, it was statistically significant for dizziness (X^2=5.643; p<0.033) and impaired physical performance (X^2=6.436; p<0.035). The differences were not statistically significant with respect to other symptoms and signs. **Conclusion:** Maternal exposure to Carbon Monoxide in the Niger Delta was associated with minor pregnancy symptoms and signs which were predominant in the mild category of severity of the exposure.

Key words: Key Words: Exposure, Carbon Monoxide, First Trimester, Niger Delta, Minor Pregnancy Symptoms and Signs**.**

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Background

The Niger Delta area in Nigeria is demarcated in the East by longitude 50E to 80E and to the North by latitude 40N to 60N (Figure 1) in the Gulf of Guinea. The region is inhabited by more than 20 million people and is made up of 9 Nigerian States, namely Rivers, Bayelsa, Akwa Ibom, Cross River, Delta, Abia, Edo, Imo and Ondo with the first two States called the 'Core Niger Delta.' The Niger Delta is the industrial hob of Nigeria, harboring most of the upstream and downstream oil related and non-oil related industries that were said to be associated with environmental pollution of the region with different pollutants including carbon monoxide (CO).

Generally, sources of CO pollution in the Delta were domestic sources namely smoking, generators in homes, barbecues, firewood, kerosene, farmland sources - bush and refuse burning, fire outbreaks, road transport related sources - burning of fossil fuels in old vehicles and crude oil and gas industry related sources namely three refineries, oil wells, flow stations, gas flaring, crude oil and condensate spills, vapours from crude and refined oil storage, crude oil processing and transportation facilities, petrochemical plants and gas liquefaction plants. [1]

CO is a product of incomplete combustion of carbonaceous compounds. It is an inorganic colorless, odorless and non-irritating. It is emitted from a source directly into the atmosphere (primary pollutant) and enters into the body primarily through inhalation. There is however also a nominal endogenous production of the gas. CO inhalation is the most common cause of poisoning in the industrialized world. Acute exposure to the gas is associated with multi-organ dysfunction, necessitating admission to intensive care units. [2]

The toxic effects of chronic exposure to carbon monoxide vary according to the gestational age at which the poisoning occurs. Chronic exposure to CO during the first two trimesters of pregnancy can produce significant intrauterine growth restriction, [3, 4] presumably due to chronic hypoxia. CO poisoning potentiates oxygen deficiency, and intrauterine growth restriction can be very severe. Other adverse effects include preterm labor, [5] intrauterine fetal death, [6, 7] and sudden infant death. [8] Foetal deaths can occur in the absence of severe maternal symptoms. [9] Maternal exposures to CO during organogenesis is associated with formation of significant congenital abnormalities of the brain,[10] skeletal system, [11] cleft palates, the heart [4, 12] and also behavioral problem during infancy.[13] Maternal exposures during the foetal period are associated with anoxic encephalopathy.[14]

In addition to the severe acute obstetric and non-obstetric complications, chronic maternal exposure to CO in the first trimester of pregnancy also presents with minor pregnancy symptoms and signs namely headaches, impaired physical performance, sensation of weakness, dizziness, sleepiness, visual difficulties, palpitations, nausea, vomiting at MCOH concentrations of 5-20%. We therefore hypothesize that given the abundant sources of CO in the Niger Delta, pregnancy in the region should be associated with minor pregnancy symptoms and signs in the first trimester.

Unfortunately, in contrast to what happens in the developed world of Europe, part of Asia and North America, environmental and human biomonitoring are not practiced in Nigeria except sporadic studies on environmental pollution that are conducted in their areas of interest by multinational companies and also adhoc research projects that are conducted by university research Fellows. [1] Therefore, there was paucity of information on the levels of maternal exhaled CO, MCOHC and foetal carboxyhaemiglibin (fCOHb) at which fetal and maternal complications occur. There was no data on the prevalence and clinical presentations of CO pollution in the Delta. [15] There was also no register of its poisoning. There were guidelines on environmental protection against pollutants in the region but unfortunately, they were not adhered to.

The aim of the study therefore was **t**o ascertain the association of chronic maternal exposure to CO in the Niger Delta with minor early pregnancy symptoms and signs.

Methodology

The study was of cross-sectional design carried out at the Rivers State University Teaching Hospital in Rivers State, which is one of the States in the core Niger Delta area of Nigeria. The study population included all pregnant women attending the antenatal clinics in the first trimester of pregnancy up till 14 weeks from January 2021 to January 2022. Consecutive attendees were counseled about the

research project and informed consents were obtained.

The exclusion criteria were pregnant women with physical disabilities such as deafness and dumbness, critically ill patients, as well as those with a history of ongoing mental illness/retardation

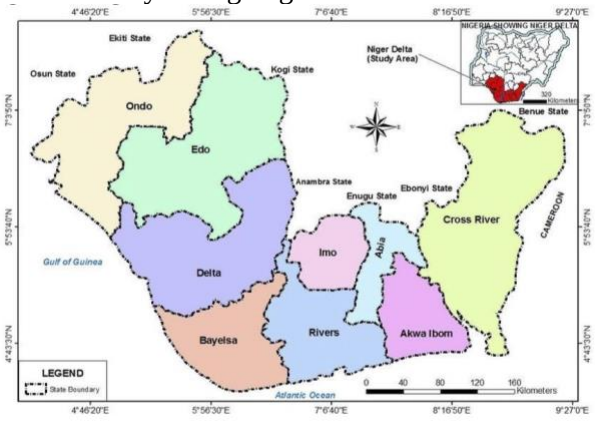

Figure 1: The Niger Delta

(because of the difficulties associated with taking history from the patients) and uncertain date of last menstrual period with no ultrasound estimation of gestational age between 11-14 weeks of gestational age. Demographic, social and obstetric characteristics including age, education, drinking and smoking status, BMI and parity were taken. Breath test was conducted with the aid of a Smokerlyzer (Figure 2) to measure exhaled carbon monoxide concentration for each patient and the prevalence of early pregnancy symptoms and signs in the study population was determined.

Figure 2: Smokerlyzer

Smokerlyzer) has been used to measure the concentration of CO in expired air especially in smokers. [16] It displays CO in part per million (ppm), MCOHC, which is synonymous with the concentration of oxygen that is displaced by CO (% COHb) and fCOHC which, is synonymous with the percentage of oxygen that is displaced by CO in foetal circulation (% FCOHb). It only directly measures the exhaled CO concentration while MCOHC and FCOHC are calculations based on clinical evidence. CO ppm - %COHb calculation was taken from Jarvis M et al (1986). [17] COHb = 0.63 + 0.16(EC50**),** where (EC50) is the concentration of CO in ppm that is expired after inhalation. [16] COppm - %FCOHb calculation was taken from Gomez C. et al (2005). [18] The conversion values were shown in table 1 which came with the smokerlyzer.

Although women in the core Niger Delta almost do not smoke, they are perpetually exposed to CO because of the presence of several sources of the gas in the Delta. We therefore hypothesised that they were likely to be affected by the gas just as women who smoke were. The smokerlyzer was therefore used to measure the concentration of exhaled CO in the women.

The severity of maternal exposure to CO was assessed, using the data from Table 1(a and b).

***Green zone*:** This is where a mother really needs to be! It means she does not exhale more than 3 ppm of CO in her breath and that corresponds to less than 2% carbon monoxide (CO) in her blood.

***Gray zone*:** Having a reading in this zone would indicate a light smoker or a non-smoker breathing in poor air quality or passive smoke.

***Red zone*:** Having a reading in this zone indicates that the person may well be a regular smoker with higher levels of CO in the blood; in the present study, we have extrapolated that to significant environmental pollution since almost all the study population does not smoke

Determination of the sample size

The outcome measures in the study were the prevalence of different degrees of severity of maternal exposure to CO and the prevalence of early pregnancy symptoms and signs associated with

different degrees of severity of exposure. Therefore, the sample size was calculated using the sample size formula for a cross-sectional study with a categorical outcome.

$n = Z\alpha/22\ P\ (1\text{-}P) / d^2$ where

$Z\alpha/22$ = Standard normal deviate at 95% confidence interval =1.96.
P - Expected proportion in population based on previous studies. Since there were no figures in the past for the assessed parameters in the study, 50% was used in the calculation of the sample size.
d = Absolute error or precision=0.05.

Therefore,
$N = 1.962 \times 0.5(1\text{-}0.5)/0.052 = 3.8416 \times 0.5 \times 0.5/0.0025 = 384.16$

The required number of patients for the study was therefore 384.16. Giving allowance for attrition rate of 10%, the final sample size for the study was $10/100 \times 384 + 384 = 422.56$. Therefore, the number of patients to be recruited for the study was 423. We were however able to recruit 490 patients.

Statistical analysis

Data was collected on a special pretested proforma and then transferred into an excel file where they were cleaned and fed into SPSS version 25.0 (Armonk, NY) software for analysis. Simple proportions were used in the descriptive analysis. Quantitative data were summarized and presented as mean and standard deviation while qualitative data were presented as numbers and percentages. Comparison of related variables was conducted, using the Chi-square (X^2) and the P-values. When the P-value was less than 0.05, the differences between the variables were said to be statistically significant. When an expected count was lower than 5 in a cell, Fisher Exact test was used.

Ethical consideration

The study was carried out in compliance with the international ethical guidelines for biomedical research involving human subjects. Ethical approval was obtained from the RSUTH ethics committee. Verbal consents were obtained from all the women that were enrolled in the study. All the information that was collected from individual patients was available for clinical use and for the research purposes. Privacy rules were maintained and confidentiality was observed at all levels of dealing with patients' data

Results

Demographic, Obstetric and General Characteristics

Four hundred and ninety (490) pregnant women were recruited for the study from 11-13^{+6} weeks of pregnancy (Table 1). Findings were as shown in table 2 and figure 3. The mean gestational age at booking among study population ± SD = 12.251±1 weeks. The median age was 13 weeks; range = 11 – 13^{+6} weeks. Median gravidity of the study population = Gravida 1; Range = Gravida 1 – 8. Median parity of study population = Para 1; Range = 0 – 5.

Table 1: Derivation of the % COHb and % fCOHb from CO ppm on the basis of clinical evidence. [16]

a			b	
CO ppm	% COHb		CO ppm	% FCOHb
30	5.43		20+	5.66
29	5.27			
28	5.11		19	5.58
27	4.95			
26	4.79		18	5.09
25	4.63			
24	4.47		17	4.81
23	4.31			
22	4.15		16	4.53
21	3.99			
20	3.83	Red zone	15	4.25
19	3.67			
18	3.51		14	3.96
17	3.35		13	3.69
16	3.19		12	3.40
15	3.03		11	3.11
14	2.87		10	2.83
13	2.71		9	2.55
12	2.55		8	2.26
11	2.39		7	1.98
10	2.23		6	1.70
9	2.07		5	1.42
8	1.91	Gray zone	4	1.13
7	1.75			
6	1.59		3	0.85
5	1.43			
4	1.27	Green zone	2	0.57
3	1.11			
2	0.95		1	0.28
1	0.79			

Measures of Severity of Maternal Exposure to Carbon Monoxide

They were as follows: the mean and median values of maternal exhaled CO and MCOH concentration and the 3 degrees of severity of exposure to CO as shown in table and figure 3. The mean value of maternal exhaled CO which was 3.25 ± 2.51 parts per

Table 2: Demographic, obstetric and general characteristics of the patients.

Demographic obstetric and general characteristics		Frequency (n) **N=490**	Percentage (%)
Maternal age, Years	20 – 24 years	24	4.9
	25 – 29 years	133	27.1
	30 – 34 years	215	43.9
	35 – 39 years	103	21.0
	40 – 44 years	11	2.2
	≥45 years	4	0.8
Education	secondary	73	14.90
	tertiary	417	85.10
Smoking	no	487	99.39
	yes	3	0.61
Alcohol	No	372	75.9
	Yes	118	24.1
Gravida	G1	246	50.2
	G2	108	22.0
	G3	88	18.0
	>G3	48	9.8
Parity	Para 0	230	46.9
	Para 1	128	26.1
	Para 2 – 4	128	26.1
	≥ Para 5	4	0.8
BMI	18.5–24.9 (Normal weight)	101	20.60
	25.0–29.9 (Overweight)	212	43.30
	30.0–34.9 (Class I Obesity)	107	21.84
	35.0–39.9 (Class II Obesity)	51	10.61
	≥40.0) (Class III Obesity)	18	3.67
Marital Status	Married	490	100
	Not married	0	0

million (ppm) while the median value was 3.00 ppm; Range = 1 – 19 ppm. The mean value of maternal COHb concentration ± SD = 1.15±0.40%; Median = 1.11%; Range = 0.79 – 3.67%.

Relationship Between Different Degrees of Exposure to CO (Exhaled CO Concentrations) and the Occurrence of Early Pregnancy Symptoms and Signs

The findings were as shown in table 4.

Assessment of the association of minor pregnancy symptoms and signs with the three degrees of severity of maternal COH concentrations was also carried out. The findings were as shown in table 5.

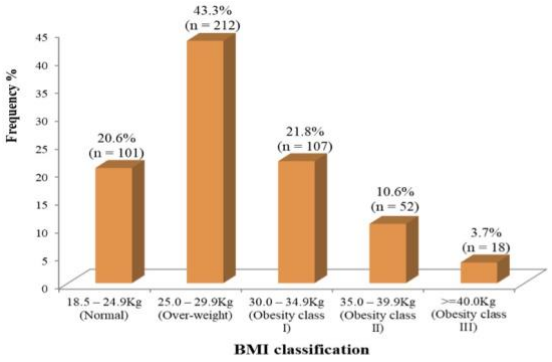

Figure 3: BMI classification of patients

Table 3: Degrees of Severity of Exposures to CO (N = 490)

Types of exposure to CO	Severity of impact	Values	Frequency	Percentages %
Exhaled CO concentration, (ppm).	Mild	1-3	335	68.37
	Moderate	4-6	129	26.33
	Severe	> 6	26	5.31
MCOH (%)	Mild	0.78 to 1.59	461	94.08
	Moderate	1.75 to 2.23	18	3.6
	Severe	> 2.23	11	2.2

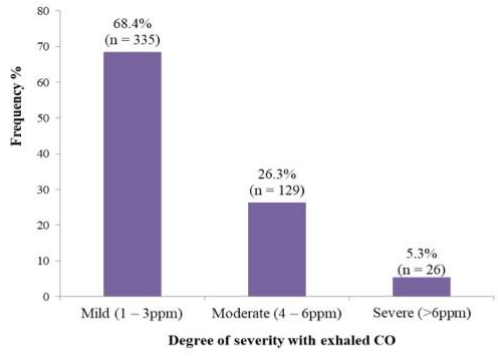

Figure 3: Degrees of severity of exposure to CO based on the concentrations of exhaled CO

Table 4: Relationship between different degrees of exposure to CO (exhaled CO concentrations) and the occurrence of early pregnancy symptoms and signs

Variables	Degrees of severity of exhaled CO (ppm)					
	Mild (1 – 3) n (%)	Moderate (4 – 6) n (%)	Severe (>6) n (%)	Total n (%)	Chi Square	p-value
Headaches						
Yes	93(59.2) /(27.76)	58 (36.9) /(45.0)	6 (3.8) /(23.1)	157(100.0) /(32.0)	13.667	0.001*
No	242 (72.67) /(72.24)	71 (21.32) /55.0)	20 (6.0) /(76.9)	333(100.0) /(68.0)		
Sensation of weakness						
Yes	33 (54.1) / (9.9)	25 (41.0) / (19.4)	3 (4.9) / (11.5)	61 (100.0) /(12.4)	7.780	0.020*
No	302 (70.4) /(90.1)	104 (24.2) / (80.6)	23 (5.4) / (88.5)	429 100.0) /(87.6)		
Dizziness						
Yes	24 (55.8) /(7.2)	16 (37.2) /(12.4)	3 (7.0) /(11.5)	43 (100.0)	3.455	0.178
No	311 (59.6) / (92.8)	113 (25.3) /(87.6)	23 (5.1) /(88.5)	447 100.0)		
Sleeplessness						
Yes	34 (69.4) / (10.1)	15 (30.6) /(11.6)	0 (0.0) /(0.0)	49 (100.0)	3.277	0.194
No	301 (68.3) /(89.9)	114 (25.9) /(88.4)	26 (5.9) /(100.0)	441 100.0)		
Impaired physical performance						
Yes	27 (81.8) /(8.1)	3 (9.1) /(2.3)	3 (9.1) /(11.5)	33 (100.0)	5.884 F	0.053
No	308 (67.4) /(91.9	126 (27.6) /(97.7)	23 (5.0) /(88.5)	457(100.0)		
Visual disturbances						
Yes	4 (100.0) /(1.2)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	4 (100.0)	1.273 F	0.662
No	331 (68.1) /(98.8)	129 (26.5) /(100.0)	26 (5.3) /(100.0)	486 100.0)		
Palpitation						
Yes	14 (70.0) /(4.2)	6 (30.0) /(4.7)	0 (0.0) /(0.0)	20 (100.0)	1.221	0.543
No	321 (68.3) /(95.8)	123 (26.2) /(95.3)	26 (5.5) /(100.0)	470 (100.0)		
Nausea						
Yes	137 (69.5) /(40.9)	49 (24.9) /(38.0)	11 (5.6) /(42.3)	197(100.0)	0.379	0.827
No	198 (67.6) /(59.1)	80 (27.3) /(62.1)	15 (5.1) /(57.7)	293(100.0)		
Vomiting						
Yes	128 (68.1) /(38.2)	46 (24.5) /(35.7)	14 (7.4) /(53.8)	188 100.0)	3.038	0.219
No	207 (68.5) /(61.8)	83 (27.5) /(64.3)	12 (4.0) /(46.2)	302(100.0)		
Bp category						
<90/60mmHg	4 (80.0) /(1.19)	1 (20.0) /(0.8)	0 (0.0) /(0.0)	5 (100.0)		
90/60-139/89mmHg	312 (67.4) /(93.1)	125 (27.0) /(96.9)	26 (5.6) /(100.0)	463(100.0)	3.167 F	0.733
140/90 -159/100mm	13 (81.2) /(3.9)	3 (18.8) /(2.3)	0 (0.0) /(0.0)	16 (100.0)		
160/110mmHg	6 (100.0) /(1.8)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	6 (100.0)		
Pulse Rate						
60 - 100	318 (68.1) /(94.9)	123 (26.3)/ (95.3)	26 (5.6) /(100.0)	467(100.0)	1.390	0.499
>100	17 (73.9) /(5.1)	6 (26.1) /(4.7)	0 (0.0) /(0.0)	23 (100.0)		

*Statistically significant ($p<0.05$). *F* – Fisher's exact

Table 5: Relationship between symptoms and maternal COHb levels among patients

Variables	Degrees of severity of exhaled CO (ppm)					
	Mild (1 – 3) n (%)	Moderate (4 – 6) n (%)	Severe (>6) n (%)	Total n (%)	Chi Square	p-value
Headaches						
Yes	145 (92.4) /(31,7)	9 (5.7) /(42.9)	3(1.9) /(27.3)	157 (100)	1.327	0.532
No	313 (94.0) /(68.3)	12 (3.6) (57.1)	8 (2.4) /(72.7)	333(100)		
Sensation of weakness						
Yes	58 (95.1) /((12.7)	0 (0.0) /(0.0)	3 (4.9) /27.3	61 (100)	5.349 F	0.053
No	400 (93.2) /(87.3)	21 (4.9) /(100.0)	8 (1.9) /(72.7)	429(100)		
Dizziness						
Yes	40 (93.0) /(8.7)	0 (0.0) /(0.0)	3 (7.0) /(27.3)	43 (100) /(8.8%)	5.643 F	0.033*
No	418 (93.5) /(91.3)	21 (4.7) /(100.0)	8 (1.8) /(72.7)	447(100) /(91.2%)		
Sleeplessness						
Yes	49 (100.0) /(10.7)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	49 (100)	2.744 F	0.207
No	409 (92.7) /(89.3)	21 (4.8) /(100.0)	11 (2.5) /(100.0)	441(100)		
Impaired physical performance						
Yes	30 (90.9) /(6.6)	0 (0.0) /(0.0)	3 (9.1) /(27.3)	33 (100) /(6.7%)	6.436 F	0.035*
No	428 (93.7) /(93.4)	21 (4.6) /(100.0)	8 (1.8) /(72.7)	457(100) /(93.3%)		
Visual disturbances						
Yes	4 (100.0) /(0.9)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	4 (100)	1.124 F	1.000
No	454 (93.4) /(99.1)	21 (4.3) /(100.0)	11 (2.3) /(100.0)	486(100)		
Palpitation						
Yes	20 (100.0) /(4.4)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	20 (100)	0.187	1.000
No	438 (93.2) /(95.6)	21 (4.5) /(100.0)	11 (2.3) /(100.0)	470(100)		
Nausea						
Yes	183 (92.9) /(40.0)	3 (1.5) /(14.3)	11 (5.6) /(100.0)	197(100)	23.383	0.0001*
No	275 (93.9) /(60.0)	18 (6.1) /(85.7)	0 (0.0) /(0.0)	293(100)		
Vomiting						
Yes	171 (91.0) /(37.3)	6 (3.2) /(28.6)	11 (5.9) /(100.0)	188(100)	18.728	0.0001*
No	287 (95.0) /(62.7)	15 (5.0) /(71.4)	0 (0.0) /(0.0)	302 (100)		
Bp category						
<90/60mmHg	5 (100.0) /(1.1)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	5 (100.0)		
90/60-139/89mmHg	431 (93.1) /(94.1)	21 (4.5) /(100.0)	11 (2.4) /(100.0)	463(100.0)	1.531 F	1.000
140/90 - 159/100mm	16 (100.0) /(3.5)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	16 (100.0)		
160/110mmHg	6 (100.0) /(1.3)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	6 (100.0)		
Pulse Rate						
60 - 100	435 (93.1) /(95.0)	21 (4.5) /(100.0)	11 (2.4) /(100.0)	467(100.0)	0.345	0.774
>100	23(100.0) /(5.0)	0 (0.0) /(0.0)	0 (0.0) /(0.0)	23 (100.0)		

*Statistically significant ($p<0.05$) F– Fisher's exact

Discussion

The mean age of the study population ± SD was 31.57 ± 4.49 years; median age = 32 years and age range = 21 – 50 years. Majority of the patients were in the age category 25-34 years–348 (71.02%) out of the total 490 patients, followed by 103 (21.02%) at 35-39 years of age, indicating that most women had their children in the normal reproductive age limits. [19]

The study was prompted by the popular believe that the core Niger Delta area of Nigeria was plagued with environmental pollution. The sustained impact of maternal and fetal exposure to CO was measured by the mean and median concentrations of ECOC, which were 3.25 ± 2.51 parts per million (ppm), and 3.00 ppm respectively and of MCOHC which were 1.15±0.40% and 1.11 %, respectively. Another measure were the 3 degrees of severity of exposure to CO which were

mild (1-3 ppm and 0.78 to 1.59%), moderate (4-6 ppm and 1.75 to 2.23%) and severe (more than 6 ppm and > 2.23 %) for ECOC and MCOH respectively in each degree of severity. The classification was adapted from the hitherto attained norms that came with the instrument Smokerlyzer Bedmont and was based on previous studies. [15, 16]

There were similar tendencies in the proportion of patients that had mild, moderate and severe exposure to CO as measured by the ECOC and MCOH with the highest number of patients in the mild exposure category followed by those in the moderate exposure and then the least number in the severe exposure. [20, 21] With respect to ECOC, the figures were 335(68.37%), 129(26.33%) and 26(5.31%) for mild, moderate and severe exposure respectively. The corresponding values for MCOHC were 461(94.08%), 18(3.67%) and 11(2.20%) for mild, moderate and severe exposures respectively.

The relationships between different degrees of exposure to CO with respect to ECOC and the occurrence of minor early pregnancy symptoms and signs were established. Out of the 490 Study population, 157 (32%) patients had headache while 333 (68%) did not. 93(27.8%), 58(45.0%) and 6(23.1%) out of the 335, 129 and 26 patients that had mild, moderate and severe exposure to CO respectively had headache. There were differences between the proportions of patients that had headaches in each of the three degrees of severity of the exposure and the differences were statistically significant (X^2=13.66; p<0.001). The majority of the affected patients 93(59.2%) belong to the mild category of exposure to CO. The same was applicable to the number of patients who had sensation of weakness. 61(12.4%) of them had it while 429(87.6%) did not. 33(9.9%), 25(19.4%) and 3(11.5%) out of the total that had mild, moderate and severe exposure to CO respectively developed sensation of weakness. The differences between the proportions of patients that had sensation of weakness in each of the three degrees of severity of exposure were statistically significant (X^2=7.780; p<0.020). The majority of the affected patients 33 (54.1%) belong to the mild category of exposure to CO.

In both cases (headaches and feeling of weakness), the severity of exposure to CO seemed not to predict the number of patients that will develop symptoms and signs. However, patients with moderate exposure were more prone to developing minor pregnancy symptoms than those who had mild and severe exposure. Regarding the association of other minor pregnancy symptoms and signs namely dizziness, sleeplessness, impaired physical performance, visual disturbances, palpitation, nausea and vomiting, blood pressure and heart rates problems, although there were differences between the proportions of patients that had them in each of the three degrees of severity of exposure, they were not statistically significant. Generally, although early pregnancy symptoms and signs were associated with CO inhalation, the numbers of affected patients did not depend on the severity of the exposure. The highest number and the proportion of the patients affected were in the mild category of exposure

Generally, there was paucity of information on the actual concentrations of exhaled CO that were associated with early pregnancy symptoms and signs. What were available were the ambient concentrations of CO in parts per million (ppm) of air that were associated with the symptoms and signs. The levels were 35 to 1600 ppm, which were associated with headache and all the other symptoms and signs of pregnancy at various lengths of exposure to the gas. [22, 23]

The association of minor pregnancy symptoms and signs with the three degrees of severity of maternal exposure to CO with respect to MCOHC was also carried out**.** Generally, it was believed that the early pregnancy symptoms and signs especially headache manifest when MCOHC is 5-20%. [24, 25] There was however, paucity of information on the association of each of the symptoms and signs with MCOHC levels

Out of the 490 Study population, 43(8.8%) patients had dizziness while 447(91.2%) did not. 40(8.7%), 0(0%) and 3(27.3%) out of the 458, 21 and 11 patients that had mild, moderate and severe exposure to CO respectively had dizziness. There were differences between the proportions of the patients that had dizziness in each of the three degrees of severity of the exposure and the differences were statistically significant (X^2=5.643; p<0.033). The majority of the affected patients 40 (93.0%) belong to the mild category of exposure.

The same was applicable to the number of patients who had impaired physical performance. 33 (6.7%) of them had it while 457 (93.3%) did not. 30 (6.6%), 0 (0.0%) and 3 (27.3%) out of the 458, 21

and 11 patients that had mild, moderate and severe exposure to CO respectively developed impaired physical performance. The differences between the proportions of patients that had impaired physical performance in each of the three degrees of severity of exposure were statistically significant (X^2=6.436; p<0.035). The majority of the affected patients 39 (90.9%) belong to the mild category of exposure to CO.

Regarding the association of other minor pregnancy symptoms namely dizziness, sleeplessness, Impaired physical performance, visual disturbances, palpitation, nausea and vomiting, blood pressure and pulse problems, although there were differences between the proportions and numbers of patients that had them in each of the three degrees of severity of exposure, they were not statistically significant. In terms of actual numbers and proportions of the affected patients, it was obviously vivid that the majority of the affected patients belong to the mild category of exposure to CO.

Conclusion

Different degrees of exposure to CO were associated with minor pregnancy symptoms and signs but contrary to expectations, the development of minor pregnancy symptoms and signs did not depend on the severity of exposure to CO with respect to maternal ECOC and MCOHC. The majority of the affected patients belong to the mild category of exposure. However, the differences in the occurrence of headache and feeling of weakness among the three degrees of severity of exposure as measured by ECOC were statistically significant. The same was applicable to the occurrence of dizziness and impaired physical performance in the MCOHC group.

Recommendations

The enormous sources of air pollution (with CO included) in the Niger Delta area of Nigeria and their implications for maternal fetal health underscore the urgent need for air quality monitoring in the region and Nigeria at large and also the need for medical bio-monitoring of pregnant women in the region.

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