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Comparative Study Assessing Birth Outcomes in Health Facilities within the Highly Crude Oil Refining Eleme Community of Rivers State and the Non-Oil Refining Ubakala-Umuahia in Abia State

[1]Ike Martha Ifeoma, [2]Aseminaso Tubonemi O., [3]Iyaye David & [4]Dagogo-Brown Igirigi Deinabobo

[I,2,3]Africa Centre of Excellence Public Health and Toxicological Research, University of Port Harcourt, Nigeria
[4]Department of Medical/Surgical Nursing Faculty of Nursing Sciences, Federal University, Otuoke, Nigeria
*CorrespondingAuthor:*AseminasoTubonemiO. **aseminaso_omineokuma@uniport.edu.ng**

Abstract

Constant exposure to outdoor air pollution by populations within crude oil refineries in Southern part of Nigeria has continued to attract research interests due to its health implications. This study investigated birth outcomes in health facilities within the highly crude oil refining Eleme community of Rivers State and the non-oil refining Ubakala-Umuahia in Abia State. A retrospective comparative cohort design based on obstetric/midwifery records of birth was used for this study. This design required the review of the records over a five-year period (2015-2020). The cohorts involved a population exposed to ambient air pollution from the Port Harcourt petroleum refinery source and a non-exposed population residing at Ubakala-Umuahia (about 100km away from the Port Harcourt refinery). A total sample size of 412 was used for the study. In Eleme, a total of 206 birth records were systematically selected (Interval: every 18th record) from 2015-2020. In Ubakala-umuahia PHC, a total of 206 birth records. The results showed that birth risk was two times higher in the exposed group than in the non-exposed group ($p = 0.012$); between the exposed and non-exposed groups, there was a significant difference in birth weight ($p = 0.018$) and congenital abnormalities ($p = 0.004$). When compared to the non-exposed group, participants in the exposed group had 89% higher risk of low birth weight and a 6 times higher chance of congenital abnormalities. The study recommended that government and other stake holders should encourage off-shore fossil fuel refining, and public health policy makers and governments should regulate the emission of particulate matter which is incriminated as a major cause of air pollution.

Keywords: air pollution, birth outcomes, crude oil refining, health facilities

Introduction

Air pollution due to fossil fuel exploration poses the largest environmental risk to human populations globally (World Health Organization [WHO], 2017). About three million deaths worldwide are associated every year with exposure to outdoor air pollution (Yakubu, 2018). The insatiable global demand for fossile fuel has predominantly increased crude oil exploration and refining. Fumes emited from gas flaring during crude oil refining tends to emit air pollutants at higher concentrations than those found in cities with traffic-related air pollution (Wylie et al., 2014). The air pollutants usually found and routinely measured near crude oil refineries include particulate matter (PM or soot), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxides (SO_2) (Liu et al., 2019). Due the inhalable size of these air pollutants, human populations residing near crude oil refineries are perhaps at risk of polluatant inhalation (Kim, et al., 2019). This could also pose extra risk especially to pregnant women and their foetuses in perspective of the physiologcal peculiarities of pregnancy. More so, environmental risks that could result in adverse birth outcomes are fundamental concerns for public health and midwifery (Gray et al., 2014).

The WHO had proposed guidelines on maximum limits for several outdoor air pollutants (Kim, et al., 2019). The WHO recommended 10 µg/m^{3}for particulate matter (PM), 40 µg/m^3 for Nitrogen dioxide (NO_2), 20 µg/m^3 for Sulphur dioxides (SO_2) and 10 µg/m^3 for Carbon monoxide (CO) (WHO, 2018). The WHO recommended the metioned ambient air pollutants at very low concentrations due to their possible health risks. Particulate matter when inhaled is known to cause lung disease and breathing difficulties (Guo et al., 2018). Nitrogen dioxide (NO_2) is known to cause bronchitis (Petit et al., 2017). Carbon monoxide (CO) is known to cause breathing challenges, poor blood oxygenation and death (Rose et al., 2017). Sulphur dioxide (SO_2) is known to cause eye irritation, coughing, and cardiac dysfunction (Shepherd et al., 2015). Additionally, SO_2 poisons rain water as it is the major component of acid rain (WHO, 2018). About ninety-one percent of premature deaths in developing countires are related to ambient air pollution (WHO, 2018). In addition, ninety-nine percent of deaths during pregnancy occur in developing countries (Girum & Wasie, 2017). This would suggest that pregnant women are among the most vulnerable groups within the human population in developing countries, and would benefit from health promotion and air quality initiatives.

Pregnancy is percieved as a period when the mother and her fetus is most vulnerable to chemical catastrophe (Harville et al., 2017). It is often a unique life changing period for both mother and foetus. Several physical, physiological and emotional changes occur during pregnancy as the pregnant woman interacts with her environment. For example, there is a twenty percent increase in oxygen consumption needed to fuel a fifteen percent increase in body metabolism during pregnancy (Soma-pillay et al., 2016). This has drawn the attention of researchers towards examining the pregnant woman's environment for possible impact of air pollution on birth outcomes and the newborn.

Newborn birth outcomes is an important midwifery and obstetric concern (Abbey et al., 2017). Adverse newborn birth events is one of the leading causes of birth related mortality and morbidity globally (Khan et al., 2019). About seven percent of newborns in developed countries and sixteen percent in developing countries would have low birth weight at the point of birth (Lamichhane et al., 2015). Between five and eighteen percent of newborns would have preterm birth (Seabrook et al., 2018). In addition, newborn deaths make up thirty-seven percent of all births in developing countries (Oghenetega et al., 2020). In scrutiny of the fore mentioned, Tran et al (2020) reported that adverse birth outcomes was assosciated with residential proximity to crude oil and gas refineries. Furthermore, other studies on the association between the air quality and birth outcomes have shown significant associations (Smith et al., 2020; Liu et al., 2019). Nonetheless, most of the published studies on the subject were conducted in USA and China. Against this background more studies are required to confirm the finding across other continents such as Africa and crude oil refining countries such as Nigeria.

Nigeria is a developing country with one of the fastest growing crude oil producing economies in West Africa (Yakubu, 2018). It is the second largest crude oil producer in Africa (Oghenetega et al., 2020). Most of Nigeria's crude oil deposits are located within the Niger Delta region of south-southern Nigeria, mainly Rivers and Bayelsa States (Ede & Edokpa, 2015). More so, Rivers State holds one of Nigeria's important crude oil refineries known as the Eleme Refinery located in Eleme community. Additionally, Eleme is home to a teeming human population which includes pregnant women. Moreover, Rivers State was reported to have a 2% prevalence of negative birth outcomes (especially birth defects) between 2011 and 2014 (Abbey et al., 2017). The authors demonstrated that the 2%

prevalence was significantly higher than the prevalence in other south-southern states with no functional crude oil refinery such as Cross River (0.42%) and Akwa Ibom State (0.40%). They further reported that the prevalence was higher than 0.40% found in nearby south-eastern states of Nigeria. It is however not clear whether the higher prevalence of adverse birth outcomes is related to the crude oil refining within parts of Rivers State. It would hence be reasonable to examine birth outcomes in locations of poor air quality such as near crude oil refineries in comparison to non-oil refining locations. This comparative study seeks to assess birth outcomes in health facilities within the highly crude oil refining Eleme community of Rivers State and the non-oil refining Ubakala-Umuahia in Abia State.

Research Questions/Hypotheses

1. What are the birth outcomes in exposed pregnancies in facilities near Eleme refinery in the study?
2. What are the birth outcomes in unexposed pregnancies at facilities in Ubakala-Umuahia in the study?
3. What is the difference in birth outcomes between exposed and unexposed groups?

Hypotheses

The following hypotheses were tested

1. There is no significant difference in maternal birth outcomes between exposed and unexposed groups in the study.
2. There is no significant difference in newborn birth outcomes between exposed and unexposed groups in the stud.

Theoretical Review

This study was anchored on Nightingale's Environmental Theory (1969). Florence Nightingale proposed the Nightingale Environmental theory between 1860 and 1969 (Fitzpatrick & McCarthy, 2014). She noted that nursing is an act of utilizing initiative to configure environmental forces towards assisting a patient to recovery from illness and maintaining health (Alligood, 2017). She further noted that extrinsic factors related to an individual's environment affect life processes, growth and development (Smith, 2019). The environmental theory postulated that for one to maintain health or recover from illness, there is a need for pure fresh air, pure fresh water, effective drainage, direct sunlight and cleanliness (Alligood, 2017). The theory predicts that any deficiency in one or more of the fore mentioned factors will lead to limited function of life maintaining processes, hence diminish human health (Smith , 2019).

Respiration is a basic human need. In line with the fore mentioned, air is of vital importance to humans. According to Nightingale's environmental theory, the air within the immediate surroundings of an individual will need to be free of pollutants. In addition, it should be warm enough to provide comfort to the individual who breaths. If this air is not fresh, then the individual stands a chance of falling to disease caused by such impurities or pollutants in the air.

Methodology

A retrospective comparative cohort design based on obstetric/midwifery records of birth was used for this study. This design required the review of the records over a five-year period (2015-2020). The cohorts involved a population exposed to ambient air pollution from the Port Harcourt petroleum refinery source and a non-exposed population residing at Ubakala-Umuahia (about 100km away from the Port Harcourt refinery).

The target population for the study was a total of as 6,159 recorded births in the three model facilities in Eleme and Ubakala-Umuahia PHC (3,903 in Eleme and 2,256 in Ubakala-Umuahia) covering a period of 6 years (2015-2020).

Birth records in the named Health facilities are obstetric/midwifery notes on activities and events that happened during childbirth and first six weeks of follow up. Information on background maternal characteristics, gestation at birth, spontaneity of labor, mode of birth, birth complications, and morbidity are documented on the birth records.

A total sample size of 412 was used for the study. The sample size for the study was calculated using Cochran (1977) sample size formula for studies involving proportion, mathematically stated as: $n_s = \{[Z_{1-\alpha/2}^2 \times P(1-P)] \div d^2\}$; Where n_s = minimum sample size; $Z_{1-\alpha/2}$ = Type 1 error at $p < 5\%$ = 1.96; P = Prevalence of first parity preterm birth in among mothers in southern Nigeria = 16% (Zini & Omo-aghoja, 2019); d = Precision = 0.05 (Charan & Biswas, 2013). A minimum sample size of 206 birth records was computed for each of the exposed and non-exposed (comparison) groups of the study. Total sample size = 412 which is double of the minimum sample size for each arm. A sample size of 206 birth records represented approximately 5.2% of birth records in Eleme. Additionally, a sample size of 206 birth records represented approximately 9.1% of birth records in Ubakala-Umuahia PHC.

Systematic sampling technique was utilized to select birth records for the study. The point of random origin "4" was generated by throwing a dice. The sampling interval was determined by dividing the total number of records in each of the facilities (3,903 in Eleme and 2,256 in Town) by 206 thus having systematic intervals of 18 and 10 for Eleme and Ubakala-Umuahia PHCs respectively. Birth records were selected from births conducted from January 2015 to December 2020. In Eleme, a total of 206 birth records were systematically selected (Interval: every 18th record) from 2015-2020, in Ubakala-USmuahia PHC, a total of 206 birth records.

The inclusion criteria for enrollment of birth records included:

1. Singleton birth
2. Case notes from 2015-2020
3. Maternal age between 15 and 49 years

The criteria for excluding birth records from the study included:

1. Caesarean section
2. Referral to a secondary health facility for further obstetric care
3. Incomplete demographic information

Data collection took place between 1stFebruary and 31th May 2021. Systematically selected birth records were scrutinized for birth outcomes parameters in the most recent birth. Data was extracted using the data extraction sheet. The outcomes of the data extractedinclude duration of pregnancy, birth status, birth weight, and birth defect.

Ethical considerations

This study was approved by the Institutional Review Board of the University of Port Harcourt (Approval ID: UPH/CEREMAD/REC/MM75/018). Administrative permission was obtained from The Primary Health Care Management Board for Rivers and Abia States. Participant's birth records were de-identified and kept anonymous throughout the period of data collection. All collected data was protected and used only for the approved academic purpose.

Characteristics of Participants
Table 1
Background characteristics of participants **N = 412**

Category	Exposed group (Eleme, n = 206)		Non-exposed group (Ubakala, n = 206)		χ^2	p
	Mean (SD)	f (%)	Mean (SD)	f (%)		
Maternal Age					4.02	0.134
16-25 years		22 (10.7)		28 (13.6)		
26-35 years		115 (55.8)		127 (61.6)		
36-45 years		69 (33.5)		51 (24.8)		
Mean	32.8 (6.3)		31.6 (5.9)			
Parity Status					3.58†	0.058
Primigravida		54 (26.2)		38 (18.4)		
Multigravida		152(73.8)		168 (81.6)		
Occupation					7.97	0.093
Unemployed		57 (27.7)		49 (23.8)		
Farmer		96 (46.6)		87 (42.2)		
Civil servant		11 (5.3)		23 (11.2)		
Trader		19 (9.2)		29 (14.1)		
Factory worker		23(11.2)		18 (8.7)		

† Fisher exact test, SD = standard deviation, f = frequency, % = percent; $p < 0.05$ = significant

Table 1 showed that participants in the exposed group and the non-exposed group were similar in many characteristics such as maternal age, parity status, and occupation (p > 0.05).

Research Question 1: What are the birth outcomes in exposed pregnancies in facilities near Eleme refinery?

Table 2
Birth outcomes in exposed pregnancies between 2015 and 2020**N = 206**

Categories	**f**	**%**
Gestation		
Preterm (< 37 weeks)	27	13.1
Term (37 – 40 weeks)	179	86.9
Birth status		
Live birth	194	94.2
Still birth	12	5.8
Birth weight		
Low Birth Weight (< 2.5 kg)	34	16.5
Normal Birth Weight (≥ 2.5 kg)	172	83.5
Congenital abnormality		
Present	13	6.3
Not –present	193	93.7

f = frequency, % = percent

Table 2 revealed that the participants in the exposed group had approximately 13% of preterm babies, 5% of stillbirths, 16% low birth weight babies, and 6% congenital abnormalities.

Question 2: What are the birth outcomes in non-exposed pregnancies at facilities in Ubakala-Umuahia?

Table 3
Birth outcomes in non-exposed pregnancies between 2015 and 2020**N = 206**

Categories	f	%
Gestation		
Preterm (< 37 weeks)	12	5.8
Term (37 – 40 weeks)	194	94.2
Birth status		
Live birth	199	96.6
Still birth	7	3.4
Birth weight		
Low Birth Weight (< 2.5 kg)	18	8.7
Normal Birth Weight (≥ 2.5 kg)	188	91.3
Congenital abnormality		
Present	2	1.0
Not –present	204	99.0

f = frequency, % = percent

Table 3 revealed that the participants in the non-exposed group had about 5% of preterm babies, 3% of stillbirths, 8% of low birth weight babies, and 1% of congenital abnormalities.

Research Question 3: what is the difference in birth outcomes between exposed and unexposed groups?

Research question 3 was answered by testing the following hypotheses “There is no significant difference in maternal birth outcomes between exposed and unexposed groups” and “There is no significant difference in newborn birth outcomes between exposed and unexposed groups”.

Hypothesis 1

Ho: There is no significant difference in maternal birth outcomes between exposed and unexposed groups.

Table 4
Comparison of maternal birth outcomes between exposed and non-exposed pregnancies between 2015 and 2020 **N = 412**

Categories	**Exposed (Eleme) n = 206**	**Non-exposed (Ubakala) n = 206**	**fisher**	**RR(95%CI)**	**p**
	f	**f**			
Gestation			6.37	2.25 (1.17 – 4.31)	0.012*
Preterm (< 37 weeks)	27	12			
Term (37 – 40 weeks)	179	194			
Birthstatus			1.38	1.71 (0.68 – 4.26)	0.240
Still birth	12	7			
Live birth	194	199			

* Significant difference between groups, f = frequency, RR = Relative Risk, p < 0.05 = significant

Table 4 demonstrated that there was a significant difference in duration of pregnancy (gestation) between participants in the exposed and non-exposed groups ($p = 0.012$). The risk of having preterm birth was two times more in the exposed group compared to the non-exposed group.

Hypothesis 2
Ho: There is no significant difference in newborn birth outcomes between exposed and unexposed groups.

Table 5
Comparison of infant birth outcomes between exposed and non-exposed pregnancies between 2015 and 2020 **N = 412**

Categories	**Exposed (Eleme) n = 206**	**Non-exposed (Ubakala) n = 206)**	**fisher**	**RR(95%CI)**	**p**
	F	**f**			
Birth weight			5.63	1.89 (1.10 – 3.23)	0.018*
Low Birth Weight (< 2.5 kg)	34	18			
Normal Birth Weight (≥ 2.5 kg)	172	188			
Congenital abnormality			8.37	6.50 (1.49 – 28.44)	0.004*
Present	13	2			
Not -present	193	204			

* Significant difference between groups, f = frequency, RR = Relative Risk, $p < 0.05$ = significant

Table 4.5 showed that there was a significant difference in birth weight ($p = 0.018$) and congenital abnormality ($p = 0.004$) between the exposed group and non-exposed groups. Participants in the exposed group had about 89% increased risk of having low birth weight, and about 6 times the risk for congenital abnormality compared to participants in the non-exposed group.

Discussion

This study found that the exposed group had roughly 13% preterm births, 5% stillbirths, 16% low birth weight newborns, and 6% congenital abnormalities. The findings of this study did not support an Iranian study which found a prevalence of 0.57% for low birth weight and 3.8% for preterm birth (Sarizadeh et al., 2020). The dissimilarity in findings could be linked to the dismimilarity in years from which data was drawn. The Iraninan study utilized data from 10 years (2008 – 2018), whereas the present study utilized data from 6 years (2015 – 2020). Based on the logic that 10 years provides a larger data diversity compared to a 6 years, the dissimilarity in findings was expected. Additionally, the Iraninan study utilized data from a referal tertiary centre, but this study draw data from primary health care facilities. Based on the argument that referal centres have more advanced medical technology compared to the primary level centres, the dissimilarity in findings was expected. In contrast, this finding corroborates a Chinese study that found the prevalence of preterm births to be 14.5% (Liu et al, 2018). The similarity in findings could be linked to the similarities in the area of study.

On the one hand, the Chinese study drew its sample from Ningbo which is a highly industrialized area that drives on fossil fuel and has high particulate matter (PM) pollution. On the other hand, the exposed group in this study is drawn from Eleme which is a fossil fuel refining area with high levels of particulate matter pollution above WHO recommendation. Based on the identified similarity in the area of study, similar results in birth outcomes were expected. Furthermore, this study corroborates an American study which found a prevalence of 14.1% for preterm births, but a lower prevalence of 10.1% for low birth weight births (Cushing et al., 2020). The dissimilarity in findings could be linked to sample size utilized for the study. Where the American study utilized 23,487 birth records, this present study utilized 206 birth records from the exposed area. The wide gap between sample sizes explains finding more low birth weight cases in Cushing et al., (2020).

This study also found that the non-exposed group had roughly 5% of preterm births, 3% of stillbirths, 8% of low birth weight newborns, and 1% of congenital abnormalities. The findings of this study is lower than that reported in an American study which found a prevalence of 10.5% for preterm births and 10.3% for low birth weight births (Cushing et al., 2020). The dissimilarity in findings could be linked to genetic differences between the USA population and the Nigerian population sampled. Defranco et al (2016) noted that some genetic differences influence birth outcomes between non-Hispanic black, non-Hispanic white and Hispanic people. The American study sampled a mix of Hispanic and Caucasian participants which is quite different from the completely African population sampled in this study. The findings of this study was lower than figures reported in another American study which found a prevalence of 8.4%, 14.1%, and 0.4% for preterm birth, low birth weight and stillbirths (Whitworth et al., 2017). The dissimilarity in fndings could be linked to the idea that the non-exposed group in the American study were sampled from an area about 16 km from the pollution source. Extrapolating that to this study, that location will fall into our exposed group criteria. This study sampled from a location not less than 100 km from the source of pollution, hence dissimilarities in findings were expected.

Concerning maternal birth outcomes, this study found a significant difference in pregnancy duration (gestation) between exposed and non-exposed participants ($p = 0.012$). The risk of preterm birth was two times as likely in the exposed group than in the non-exposed group. Regarding infant birth outcomes, this study discovered a significant difference in birth weight ($p = 0.018$) and congenital abnormalities ($p = 0.004$) between the exposed and non-exposed groups. When compared to the non-exposed group, participants in the exposed group had an 89% higher risk for low birth weight and a 6 folds higher risk for congenital abnormalities. This finding corroborates a yet another American study which reported thatexposure to Particulate Matter (soot) greater than WHO recommended levels within 10km from ambient air pollution source did increase the risk of preterm birth by 19% ($p = <0.001$) (Defranco et al., 2016). The similarity in findings could be linked to the design utilized in the study. Both this present study and the American utilized a retrospective cohort study design. Based on this, results were expected to be similar. More so, it may be vital to state here that the estimated risk in the American study was lower than was found in this study. This could be linked to dissimilarities in sampling methodology. This study utilized systematic selection of records, whereas the American study utilized a simple random selection. Compared to systematic sampling, simple random selection is more robust at minimizing systematic bias (Polit & Beck, 2020). The findings of this study was in line with an American study which reported that There were significant associations between women residing within 5km to Gas wells and low birth weight ($p = < 0.001$). The similarity in findings could be linked to thestatistical method utilized for hypotheses testing (Cushing et al., 2020). Both this present study and the American study utilized the chi square based non-parametric statistical tool for test of hypotheses. In contrast to parametric statstical hypotheses testing tool, the non-parametric statistical tools are not very sensitive to very small changes in parameter values.

Conclusion

In conclusion, the risk for adverse birth outcomes was 2 folds for preterm birth, 2 folds for low birth weight, and 6 folds for congenital abnormalities higher in the exposed group compared to the non-exposed group.

Recommendations

The following recommendations were made:

1. More studies on the toxicological effect of air pollution on birth outcomes, using a prospective design is called for by researchers.
2. The government and other stake holders should encourage off-shore fossil fuel refining
3. Public health policy makers and governments should regulate the emission of Particulate Matter which is incriminated as a major cause of air pollution. Any pollution taxes paid by emitters should be repurposed for community upgrade and resettlement further away from pollution source.
4. The government should be proactive at promulgating policies that are geared towards the reduction of Particulate Matter emissions.

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