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Link between Oil Pollution and Adverse Pregnancy Outcomes in the Niger Delta Region of Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author CTK conceptualized the study, designed the study and wrote the first draft of the manuscript. Author ECI co-designed the study, managed part of the literature search and prepared the manuscript for publication. Both authors read and approved the final manuscript.

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ABSTRACT

Oil exploration in the Niger Delta has led to severe environmental pollution. This study investigates the association between exposure to crude oil and adverse pregnancy outcomes.

Study Design: This was a comparative cross-sectional study of the differences in adverse pregnancy outcomes of people living in heavily oil polluted and non-polluted communities

Place and Duration of Study: Kegbara Dere (K-Dere), a rural Community in Ogoniland, Gokana Local Government Area, Rivers State and Obohia community in Ndoki kingdom, Ukwa East LGA of Abia state between June 2022 and Jan 2023.

Methodology: We recruited 900 study participants (450 each from the crude oil impacted and the non-oil polluted communities) using multi-stage random sampling. Questionnaires were used to collect data on socio-demographics and adverse pregnancy history by case definitions using the adapted WHO indirect sisterhood method of maternal mortality estimate. Data was analyzed using

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IBM Statistical Package for Social Sciences (SPSS) version 25. Differences in proportions were compared using Chi Square test. The association between living in an oil polluted community or exposure to crude oil pollutants and adverse pregnancy outcomes was determined using crude odds ratio. Confidence intervals were determined at 95% level and a p-value of less than 0.05 was considered significant.

Results: Pregnant women in the polluted community experienced a significantly higher prevalence of adverse outcomes, including stillbirth, abortion, and birth defects. The risk of experiencing an adverse pregnancy outcome was 30 times higher in the polluted area.

Conclusion: This study suggests a strong link between oil pollution and pregnancy complications. Further research with robust designs is needed to confirm causality. Environmental cleanup and protective measures for pregnant women are crucial in these areas.

Keywords: Crude oil pollution; adverse pregnancy outcome; community; low birth weight; still birth; marine environment; organic compounds.

1. INTRODUCTION

Oil exploration and exploitation has been conducted in the Niger Delta region for several decades [1,2]. Due to the oil exploration and exploitation activities in the region, it is classified as one of the five most severely crude-oil-polluted environment in the world with about 9-13 million barrels of crude oil being spilled over the last five decades [1]. Crude oil spillage, gas flaring and petroleum wastes products from exploration and exploitation activities of the oil industries have been found to contaminate air, soils, sediments, surface and groundwater, marine environment, as well as severely deplete the biodiversity and terrestrial ecosystems of the region [3,4]. Crude oil pollution have been found to contain many pollutants which amongst others include aromatic hydrocarbons (Benzene, Ethylbenzene, toluene, and Xylene), polycyclic aromatic hydrocarbons (PAHs), including volatile organic compounds (VOCs), and heavy metals [5]. Again benzene containing compounds like PAH has been linked to reproductive health consequences such as such as damage to the embryo resulting in birth defects in experimental animals especially the Benzo(a)pyrene, naphthalene and Benzo(a)anthracene groups [6]. Adverse pregnancy outcome will be used to describe a condition in which the fetal wellbeing is jeopardized, or unfavourable [7]. According to WHO, adverse pregnancy outcome is condition in which the pregnancy ends with low birth weight, preterm delivery, stillbirth, or abortion [8]. However in this research adverse pregnancy outcome will also include any form of congenital abnormality noticed at birth or what is termed birth defects. Oil impacted and non-oil impacted community can be assessed using historical spill instances as done in European oil spill impact assessment but also using technical report as the United Nations Environment Programme (UNEP) report of Ogoniland which clearly puts the study community in the realms of heavily impacted and the control as non-impacted community [9-11]. High exposure of humans to polycyclic aromatic hydrocarbon compounds during pregnancy has been shown to increase the risk of adverse pregnancy outcomes including low birth weight, preterm delivery, stillbirth and congenital malformations [6]. This study therefore aimed at investigating the association between adverse pregnancy outcome and living in an oil polluted environment.

2. MATERIALS AND METHODS

2.1 Study Design

This research employed comparative cross-sectional study design of the differences in adverse pregnancy outcomes of people living in heavily oil polluted and non-polluted communities

2.2 Setting

The study areas was conducted in Kegbara Dere (K-Dere), a rural Community Ogoniland, Gokana Local Government Area, Rivers State and Obohia community in Ndoki kingdom, Ukwa East LGA of Abia state between June 2022 and January 2023.

2.3 Eligibility Criteria

2.3.1 Eligibility for recruiting human participants from crude oil polluted community (exposed group)

2.3.1.1 Inclusion

i. Adults (18yrs and above) member of a household, who resides in the community for at least 5years and who gave informed consent.

ii. Those knowledgeable with their immediate and extended family history (more likely to remember those who had suffered from adverse pregnancy outcomes).

2.3.1.2 Exclusion

i. Those too ill to participate in the study.
ii. Those who may not respond for their families or who have no knowledge of every member of their family).

2.3.2 Eligibility for recruiting human participants from non-crude oil polluted community (Controlled group)

2.3.2.1 Inclusion

i. Adults (18yrs and above) member of a household, who resides in the community for at least 5years and who gave informed consent.
ii. Those knowledgeable with their immediate and extended family history.

2.3.2.2 Exclusion

i. Those too ill to participate in the study.
ii. Those who may not respond for their household.

2.4 Variables

According to WHO, adverse pregnancy outcome is condition in which the pregnancy ends with low birth weight, preterm delivery, stillbirth, or abortion [8]. However in this research adverse pregnancy outcome will also include any form of congenital abnormality noticed at birth or what is termed birth defects. Low birth weight are composed of infants who are mostly born too small ie infant weight is usually smaller than normal, Preterm infants are those born too early than expected date of delivery, regardless of birth weight [12], Stillbirth or fetal death is defined as a baby born with no signs of life after a given threshold or late fetal death in utero [13]. Abortion or Spontaneous abortion or miscarriage is the loss of pregnancy naturally before twenty eight weeks (7 months) of gestation [14-16]. Birth defects are structural changes present at birth that can affect almost any part or parts of the body (e.g., heart, brain, foot). They may affect how the body looks, works, or both [17]. Cleft lip and cleft palate are openings or splits in the upper lip, the roof of the mouth (palate) or both [18-22]. Congenital Heart Defect is detected in the first week of life and characterized by murmur or noise in the heart beats, cyanosis or blueness of the newborn and dyspnea or tiredness or inability of the baby to suck breast [23]. Limb anomalies were described as children who walked on the sides and/or tops of their feet before treatment [24] Neural tube defects were described as openings on the back, usually occurring with weakness of the legs, uncontrolled urination or defaecation and abnormal sensation [25].

2.5 Sampling Technique

Participants to the study were recruited using multistage random sampling. Each of the community was divided into 4 cluster areas based on the four cardinal points standing at the middle. From each of the areas, 114 households were randomly selected and one adult per household was selected for the study making a total of 456 participants. In each of the area, the researcher stood at the middle of the community and divided the area into 4 cardinal points, then spun a coin and whichever direction the head points sampling is commenced recruiting alternate households until 29 households/adults was recruited. This was performed in the four directions going anticlockwise, until complete sample size was achieved.

2.6 Data Sources/Measurement

This study was carried out using a pretested, validated and semi-structured questionnaire. The questionnaire was content validated by three research experts in the field of Environmental health and epidemiology. The questionnaire comprises of two sections. The first section was used to obtain information on socio-demographic characteristics like age, sex, address, marital status, and educational level. The second section was used to extract adverse pregnancy history by case definitions using the method adopted and adapted from the WHO indirect sisterhood method of maternal mortality estimate in a rural community [26].

2.7 Study Procedure

Eight research assistants (four in each of the community) was trained on the data collection tool. The four research assistants were community health workers and members of the communities for ease of data collection. Case definitions for various adverse pregnancy outcomes were developed and verbal autopsy method used to administer the questionnaire to heads of households. Pictorial evidence of the various types of adverse pregnancy outcomes was attached to the various segments of the questionnaire to aid understanding of the different types (see appendix 1). Heads of households or adult in the house responded to information on adverse pregnancy occurrence in the immediate and extended family for the last 10 years. The study questionnaires were administered to the study participants by the researcher and the four trained research assistants in each community after successful community entry activities and consent by the study participants.

2.8 Sample Size Determination

The sample size was calculated using the formula for comparative study [27]. A retrospective cohort study done in facilities located in an oil polluted area and non-oil polluted area in Rivers State found the proportion of preterm birth and adverse pregnancy outcome to be 16% , and 7.7% respectively [28]. The sample size was then calculated using these proportions:

$$n = \frac{[2\,(Z\alpha+Z\beta)^2 \text{ X } P(1-P)]}{(P^0 - P^1)^2}$$

Where

n = Minimum sample size for each group or community

$Z\alpha$ = Standard normal deviate at 5% significant for two sided comparison = 1.96

$Z\beta$ = Standard normal deviate at Power 80% for two sided comparison = 0.84

P_o = Proportion of preterm birth in non-crude oil polluted environment in the reference study = 7.7% (0.077)

P_1 = Proportion of preterm birth in crude oil polluted environment in the reference study = 16% (0.16)

P = Mean of the two proportions- $(Po + P_1) / 2 = (0.77 + 0.16) /2 = 0.1185$

$(Po - P_1)^2 = (0.077 - 0.16)^2 = 0.006889$

$(Z\alpha + Z\beta)^2 = (1.96 + 0.84)^2 = 7.84$

1-P = (1- 0.1185) = 0.8815

Therefore inserting the figures above in this equation

$n = [2 \times (Z\alpha+ Z\beta)^2 \times P(1 - P)] / (Po - P_1)^2$

$n = [2 \times 7.84 \times 0.1185 \times (0.8815)] / 0.006889$

$n = [2(0.81894876)] / 0.006889$

n = 235.755

Assuming a non-response rate of 10%, = 23.755

n, becomes = 259.54

Applying design effect of 1.72

The minimum sample size was 446.4

However this was approximated to 450 persons/households per community Hence, a minimum of 450 adults members of a household from crude oil polluted community and 450 adults members of a household from non-crude oil polluted community was selected in the study, making a total of 900 participants.

2.9 Data Analysis

Data was analyzed using IBM Statistical Package for Social Sciences (SPSS) version 25. Categorical variables were expressed as frequencies and proportions. Differences in proportions were compared using Chi Square statistics. The association between living in an oil polluted community or exposure to crude oil pollutants and adverse pregnancy outcomes was investigated by crude odds ratio. Confidence intervals were determined at 95% level and a p-value of less than 0.05 was considered significant.

3. RESULTS AND DISCUSSION

This comparative cross sectional study had 900 human participants, consisting of 450 residents of heavily polluted community and 450 residents and non-oil polluted community.

Table 1a shows the socio-demographic characteristics of the study participants The socio-demographic characteristics of the two communities (study and control) were basically comparable and differences observed were not statistically significant. Majority of the respondents have respectively lived in the community for more than five years (96.6%, 96.4%), were between 40 to 44 years of age (17.6%, 18.0%), married (76.4%, 76.2%), Christians (96.7%, 96.2%), had secondary level of education (38.7%, 38.4%) and engaged in farming activities (45.8%, 45.8%). Majority also earns below thirty-thousand-naira national minimum wage (72.2%, 66.4%). Majority of the respondents neither smoke (92.0%, 92.2%) nor use alcohol (76.2%, 75.1%).

Table 1a. Social demographic characteristics of the study population

Variable	K-Dere n=450	Obohia n=450	X^2(p-value)
Duration in the community (years)			
≤5 years	14(3.1)	16(3.6)	0.138(0.710)
>5 years	436(96.9)	434(96.4)	
Age group (years)			
18-23	6(1.3)	4(0.9)	3.904(0.918)
24-29	16(3.6)	15(3.3)	
30-34	37(8.2)	27(6.0)	
35-39	66(14.7)	58(12.9)	
40-44	79(17.6)	81(18.0)	
45-49	75(16.7)	75(16.7)	
50-54	44(9.8)	46(10.2)	
55-59	37(8.2)	38(8.4)	
60-64	31(6.9)	37(8.2)	
≥65	59(13.1)	69(15.3)	
Marital status			
Single	65(14.4)	67(14.9)	0.143(0.986)
Married	344(76.4)	343(76.2)	
Divorced/Separated	5(1.1)	4(0.9)	
Widow	36(8.0)	36(8.0)	
Religion			
Christian	435(96.7)	433(96.2)	2.747(0.432)
Islam	3(0.7)	4(0.9)	
Traditional	8(1.8)	12(2.7)	
Others	4(0.9)	1(0.2)	
Education			
None	94(20.9)	97(21.6)	0.068(0.995))
Primary	112(24.9)	110(24.4)1	
Secondary	174(38.7)	173(38.4)	
Tertiary	70(15.6)	70(14.5)	
Occupation			
Civil/Public service	41(9.1)	50(11.1)	4.758(0.575)
Company worker	13(2.9)	10(2.2)	
Farming	206(45.8)	206(45.8)	
Fishing	31(6.9)	38(8.4)	
Trading	58(12.9)	64(14.2)	
Artisan	6(1.3)	3(0.7)	
Others	95(21.1))	79(17.6)	

Table 1b. Social demographic characteristics of the study population (continuation)

Variable	K-Dere n=450	Obohia n=450	X^2(p-value)
Income (Naira)			
<30000	324(72.0)	299(66.4)	3.260(0.071)
≥30000	126(28.0)	151(33.6)	
Tobacco use			
Yes	36(8.0)	35(7.8)	0.015(0.902)
No	414(92.0)	415(92.2)	
Alcohol intake			
Yes	107(23.8)	112(24.9)	0.151(0.698)
No	343(76.2)	338(75.1)	

The prevalence of various adverse pregnancy outcomes found at study and control communities are LBW (18.9%, 0.7%; p value <0.001), PTB (20.2%, 0.2%; p value <0.001), stillbirth (17.8%, 0.2%; p value <0.001), Abortion (22.9%, 1.1%; p value< 0.001), cleft lip (4.2%, 0.2%; p value 0.001), congenital heart defect (5.1%, 0.4%; p value 0.001), congenital talipes (1.1%, 0.00%; p value <0.025), Neural tube defect (1.6%, 0.2%, p value< 0.033), hydrocephalus (6.0%, 0.2%, p value< 0.001) The differences in the proportion of the various adverse pregnancy outcomes observed in both study and control communities were statistically significant. Also when all the adverse pregnancy outcomes were pulled together, the overall prevalence was 35.8%, 1.8%; p value 0.001 with OR 30.8(C. I. 14.9- 63.6). This difference was also statistically significant (Table 2).

There was an association between living in an oil polluted community and rate of adverse pregnancy outcomes. This association was statistically significant (OR 30.8, 95% C.I. 14.9-63.6) (Table 3).

3.1 Discussion

This study showed that, there is a significant association between living in K-Dere and having adverse pregnancy outcome. People who live at K-Dere are about thirty times more at risk of reporting adverse outcome of pregnancy like low birth weight, preterm birth, stillbirth, or any of the congenital birth defects than those living at Obohia. This result showed that exposure to crude oil pollution puts residents at more risk of having adverse pregnancy outcome than those who are not. This is in line with a systematic

Table 2. Prevalence of adverse pregnancy outcomes reported in K- Dere and Obohia communities

Variable	K-Dere n=450	Obohia n=450	X^2(p-value)	OR(95% C.I)
Low birth weight				
Yes	85(18.9)	3(0.7)	84.690(<0.001)	
No	365(81.1)	447(99.3)		
Preterm birth				
Yes	91(20.2)	1(0.2)	98.068(<0.001)	
No	359(79.8)	449(99.8)		
Still birth				
Yes	80(17.8)	1(0.2)	84.670(<0.001)	
No	370(82.2)	449(99.8)		
Abortion				
Yes	103(22.9)	5(1.1)	101.052(<0.001)	
No	347(77.1)	445(98.9)		
Cleft Lip				
Yes	19(4.2)	1(0.2)	16.568(<0.001)	
No	431(95.8)	449(99.8)		
Congenital heart defect				
Yes	23(5.1)	2(0.4)	18.144(<0.001)	
No	427(94.9)	448(99.6)		
Congenital Talipes				
Yes	5(1.1)	0(0.0)	5.028(0.025)	
No	445(98.9)	450(100.0)		
Neural Tube defect				
Yes	7(1.6)	1(0.2)	4.540(0.033)	
No	443(98.4)	449(99.8)		
Hydrocephaly				
Yes	27(6.0)	1(0.2)	24.918(<0.001)	
No	423(94.0)	449(99.8)		
Prevalence of Adverse Pregnancy Outcome				
Yes	161(35.8)	8(1.8)	170.538(<0.001)	30.8(14.9-63.6)
No	289(64.2)	442(98.2)		

Table 3. Association between exposure to crude oil pollution and prevalence of adverse pregnancy outcomes

Variable	Adverse preg outcome	No adverse preg outcome	X^2(p-value)	OR(95% C.I)
Exposure				
Exposed	161(35.8)	289(64.2)	170.538(<0.001)	30.8(14.9-63.6)
Non exposed	8(1.8)	442(98.2)		

review that looked at the relationship between gas flare-ups, oil spills, and unfavorable pregnancy outcomes over a 20-year period in Nigeria. It found that both of these factors may increase the risk of unfavorable pregnancy outcomes for expectant mothers, such as abortion, hypertensive disorders of pregnancy that can result in low birth weight, preterm birth, stillbirth, and other congenital birth defects [29]. This systematic review as a pooled evidence shows that crude oil pollution contains endocrine disruptors which are capable of causing damage to the growing fetus. Additionally, in a prospective cohort study examining the effects of maternal exposure to oil pollution in the Nigerian Niger Delta region, pregnant women were tracked from conception to delivery: Women in high exposure areas experienced a higher incidence of preterm birth following premature rupture of the membrane (PROM) than women in areas with low exposure to oil pollution. Even after adjusting for confounding variables, women in high exposure areas still showed a higher risk of early rupture of the membranes and preterm delivery as compared to women in low exposure areas to oil pollution [30]. This suggests once more that exposure to oil pollution is a factor in the unfavorable outcomes of pregnancy. Similar to this, throughout the period of 1990 to 2003, records from two sizable hospitals in Port Harcourt, Rivers state, Nigeria, were analyzed as part of a retrospective study to determine the frequency of congenital abnormalities: more congenital defects were identified in the initial hospital, with the majority being deformities of the skeletal and central neurological systems. On the other hand, lower frequency of congenital abnormalities were observed in the second hospital with that of the skeletal and central nervous systems leading to an inverted sequence of progression [31]. Combining the two Port Harcourt hospitals yields an incidence which is comparable to the results of another study conducted in the states of Cross River and Akwa Ibom, which found instances of deformity of the skeletal system having the highest percentage of anomalies and additional abnormalities related to the central nervous system following [32]. Since both investigations were conducted in the same oil-bearing region and hospital base, the results were comparable and also to current study. A retrospective study of congenital malformations among newborns admitted in the neonatal unit of a tertiary hospital in Enugu, South-East Nigeria between 2007 and 2011, found a high prevalence of congenital anomalies of various types. The majority of congenital abnormalities observed in these neonates were surgical birth defects, including dysmorphism associated with various congenital malformations, cleft lip and palate, neural tube defects, limb abnormalities, omphalocele, umbilical hernias, and ano-rectal malformations. Neural tube abnormalities may occur on their own or in conjunction with other issues [33]. The high prevalence shown here might result from the study's exclusive focus on neonates hospitalized for surgical repairs, rather than the full hospital birth registry or live births. As a referral center, patients may have come from the oil-polluted Niger Delta region as well as other states. In general, the frequency of unfavorable pregnancy outcomes linked to exposure to PAH or TPH can vary depending on the precise kind and degree of exposure, in addition to other human and environmental factors. To safeguard the health of expectant mothers and their unborn children, it is crucial to reduce exposure to PAH and TPH as much as possible in the interim. Pregnancy outcomes may also suffer from exposure to total petroleum hydrocarbons (TPH), albeit the frequency of these effects may vary depending on a number of variables. TPH is a complex blend of several organic chemicals that are present in petroleum products and crude oil. Exposure can happen as a result of petroleum derivative-containing consumer goods, environmental contamination, or occupational exposure. TPH exposure during pregnancy has been linked to an increased risk of unfavorable outcomes, including low birth weight, preterm birth, and birth abnormalities, according to studies [34-36]. However, the kind and degree of TPH exposure can affect the prevalence of unfavorable pregnancy outcomes**.** In a cross-sectional study on abortion and infertility conducted in the US after the Gulf oil spill, there was a very slight increase in the incidence of abortion for everyone exposed to the oil leak. The study was conducted in Southeast Louisiana. However, the great majority of women who were in close proximity to the oil spill stated that they postponed getting pregnant due to worries about possible negative outcomes. This could be the cause of the study sample's marginally elevated chance of abortion [37]. Comparable results were seen in a Chinese case-control study investigating the relationship between maternal serum PAH concentrations and low birth weight (LBW): A logistic regression analysis revealed a positive correlation between LBW and the PAH component acenaphthene in the mothers' peripheral blood [38]. Once more, evidence demonstrates that some PAH constituents are detrimental to fetal development. A cohort study was done in China to see if prenatal exposure to PAHs was associated with poor birth outcomes. Lower birth weight has been associated with pregnant exposure to some PAHs [39]. This conclusion may be related to the fact that exposure to polycyclic aromatic hydrocarbons (PAHs) has been linked to several health risks, including carcinogenicity, endocrine disruption, and damage to the reproductive and developmental systems. The developing fetus is also known to be more susceptible to the toxicological effects of PAHs because of its immaturity in terms of physiology, its inadequate immune response, and its incapacity to efficiently detoxify hazardous compounds [39]. Similarly, early gestational exposure to carcinogenic PAHs may affect fetal growth, leading to low birth weight. This was demonstrated by the results of a longitudinal study carried out in the heavily oil-polluted city of Teplice, Czech Republic, to investigate the relationship between maternal exposure to polycyclic aromatic hydrocarbons in fine particles and low birth weight/intrauterine growth retardation (IUGR) [40]. This again shows the effect of oil pollution on occurrence of adverse pregnancy outcome. Once more, a large population-based case-control study conducted in the USA among mothers of infants without major birth defects as part of the National Birth Defects Prevention Study found that maternal occupational exposure to polycyclic aromatic hydrocarbons was associated with an increased risk of small-for-gestational-age or low birth weight babies [41] This shows that women in their reproductive age who work in environments contaminated with oil pollution stand at an increased risk of unfavourable pregnancy outcome. A time-series study was conducted in Ahvaz, Iran, to determine the relationship between air pollution and stillbirth, premature delivery, and spontaneous abortion. The Environmental Protection Agency and the Khuzestan Province Meteorology Office provided information on air pollution, including NO, CO, NO2, PM10, SO2, and O3, and meteorological data, respectively. Ahvaz Imam Khomeini Hospital provided information on spontaneous abortion, preterm delivery, and stillbirth. The relationship between air pollution and the frequency of abortions, premature deliveries, and stillbirths was examined using a quasi-Poisson distributed lag model that took trend, seasonality, temperature, relative humidity, weekdays, and holidays into account. The study's findings demonstrate a robust relationship between each 10-unit increase in SO2 and spontaneous abortion at lags of 0 to 9 days. There was a substantial correlation between each 10-unit increase in CO and NO2 and preterm delivery in lag 0. Furthermore, there is a statistically significant correlation (p value<0.05) between preterm delivery and every 10-unit increase in CO, PM10, and NO [42]. This study reinforces the idea that pregnant women who are exposed to polluted air, particularly from petroleum products, may have a higher chance of stillbirth and other unfavorable pregnancy outcomes. Therefore high exposure to oil pollution increased the risk of stillbirth and infant mortality in women. In addition, 43 papers—including 8 animal studies and 35 human studies—that examined the effects of air pollution exposure on stillbirth and spontaneous abortion during pregnancy were reviewed in a systematic review: These studies collectively suggest that there may be a higher risk of stillbirth and spontaneous abortion when individuals are exposed to air pollutants such cooking smoke, particulate matter, and carbon monoxide (CO). Concerns for stillbirth may arise from third-trimester exposure to PM2.5 and PM10. Pregnancy-related exposure to PM10 has been associated with a higher risk of spontaneous abortion. Exposure to CO in the first trimester has been associated with a higher risk of spontaneous abortion, but exposure to CO in the third trimester has been associated with a higher risk of stillbirth. It was abundantly evident from the data that cooking smoke raised the risk of stillbirths. Several additional pollutants, such as NO2 and SO2, had conflicting or insufficient evidence [43].

A time series analysis on congenital malformations was carried out in Hefei, China (2013–2016) to determine the correlations between exposure to air pollution and birth defects: The study found a strong correlation between birth defect risk and exposure to PM2.5, PM10, SO2, NO2, and O3. Maternal exposure to PM2.5 and SO2 was found to significantly increase the risk of birth defects from the fourth to the thirteenth week of pregnancy; the effect peaked in the seventh or eighth week for PM2.5 and the seventh week for SO2. For PM10, NO2, and O3, the fourth to fourteenth, fourth to twelfth, and twenty-sixth to thirty-fifth weeks of gestattion, respectively, were the favorably significant exposure periods. The strongest correlations for PM10, NO2, and O3 were observed in the seventh, ninth, and seventh weeks of gestation respectively [44]. The findings of this study demonstrate that pregnant women are more likely to experience birth defects when exposed to air pollution, especially particulate matter that contains PAHs. A case-control research on congenital abnormalities among live babies in a high environmental risk area in southern Italy found a correlation between exposure to oil pollution and congenital heart disease (CHD) [45]. There may be a connection between pollution exposure and the onset of congenital heart disease (CHD), according to a case-control study on congenital malformations among live newborns in a high environmental risk area of southern Italy. The study found an association between exposure to oil pollution and CHD. It is crucial to remember that while a case-control study may show a relationship between two variables, it is unable to prove a cause and effect relationship. In order to ascertain whether there are additional factors that could be contributing to the development of CHD, as well as to explore the possible mechanisms that underlie the connection, more research is required. In addition, it's critical to account for and control for any confounding variables in the analysis, such as smoking, maternal age, and other environmental factors that may have an impact on the development of CHD. In order to avoid potential harmful health effects, this study emphasizes the necessity of continuous monitoring and management of environmental pollution, especially in locations with high risk of exposure like in K- Dere. Similarly, the neurodevelopment of infants, children, and young adults is affected by a variety of pollutants, including particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, xylenes (BTEX), heavy metals (arsenic and manganese), and endocrine disrupting chemicals (EDCs). It is reasonable to conclude that young children who are frequently exposed to these pollutants are especially high-risk individuals for chronic neurological diseases and congenital malformations [46].

In the Nigerian Niger Delta, a retrospective cohort study was conducted on abortion, stillbirth, and infant mortality. After accounting for potential confounders, neonatal death was the only outcome that continued to show a significant correlation with high exposure. There was no connection found between high amounts of oil pollution and abortion in this study [47]. This conclusion could be explained by the ease with which forgetfulness-related recollection bias can develop in retrospective research. Furthermore, there might not be a substantial enough variation in the pollution levels between the two areas to affect gestation in a different way. In a cross-sectional study involving pairs of mothers and newborns from four hospitals in four different cities in China, the concentrations of polycyclic aromatic hydrocarbons (PAHs) in Chinese pregnant women and their newborns were measured, and the relationship between levels of PAHs and infant birth weight was examined. The bulk of PAHs found in mother serum and three PAHs evaluated in cord blood showed a negative, albeit non-statistically significant, correlation with birth weight [48] Given that the significance may rise with bigger sample sizes, this finding might be the result of lower sample sizes. On the other hand, the following information about the relationship between birth weight and perinatal exposure to polycyclic aromatic hydrocarbons was found in a meta-analysis that included 11 Chinese studies: Prenatal PAH exposure and birth weight did not significantly associated with one another [49]. This conclusion could be explained by the small number of studies that are included in the analysis in addition to the tribal distinctions between Chinese and other races.

4. CONCLUSION

Considering adverse pregnancy outcomes, the result of this study showed that mothers who resided at K-Dere in Rivers state have significantly higher prevalence of adverse pregnancy outcome compared to those who lived at Obohia community in Abia state. This cut across the prevalence of low birth weight, preterm birth, stillbirth, abortion, cleft lip, congenital heart defect, congenital talipes, neural tube defect and hydrocephalus. This study finding shows clearly higher levels of occurrence of adverse pregnancy outcomes between an oil polluted community and non-oil polluted community in the Niger Delta region of Nigeria. Therefore, remediation of oil polluted area in addition to prevention of further contamination of the environment will significantly improve outcomes of pregnancy in this area.

CONSENT AND ETHICAL APPROVAL

Ethical approval was obtained from the University of Port Harcourt ethics committee and University of Port Harcourt Teaching Hospital Ethics Committee before the commencement of the project. Community entry was performed in each of the communities to secure their approval and support for the survey. Every participant in the study was informed adequately about the nature, extent and purpose of the research. They signed a consent form after being adequately informed. They were only enlisted in the study after giving their consent. Refusal to give consent did not in any way negatively affect the members of the community.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

Pictorial Evidence of Adverse Pregnancy Outcomes

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