

 Open Access Full Text Article

ORIGINAL RESEARCH

# Prevalence and pattern of birth defects in a tertiary health facility in the Niger Delta area of Nigeria

Mkpe Abbey<sup>1</sup>  
 Olufemi A Oloyede<sup>2</sup>  
 Goddy Bassey<sup>1</sup>  
 Benjamin M Kejeh<sup>3</sup>  
 Barbara E Otaigbe<sup>4</sup>  
 Peace I Opara<sup>4</sup>  
 Austa U Eneh<sup>4</sup>  
 Chris I Akani<sup>1</sup>

<sup>1</sup>Department of Obstetrics and Gynaecology, University of Port Harcourt Teaching Hospital, Port Harcourt, <sup>2</sup>Department of Obstetrics and Gynaecology, Olabisi Onabanjo University Teaching Hospital, Sagamu, <sup>3</sup>Department of Surgery, <sup>4</sup>Department of Paediatrics, University of Port Harcourt Teaching Hospital, Port Harcourt, Nigeria

**Objective:** To ascertain the prevalence and pattern of congenital abnormalities that are peculiar to the Niger Delta area of Nigeria.

**Methods:** This is a descriptive retrospective cross-sectional study. It involved data from the labor ward and neonatal birth registers of the University of Port Harcourt Teaching Hospital on the total number of births and the babies that were delivered with major birth defects between August 2011 and December 2014. We also conducted a statistical comparison of the prevalence of congenital abnormalities in the Niger Delta with that in other regions of Nigeria and the developed world of Europe.

**Results:** Out of the 7,670 deliveries that occurred, 159 maternities had babies with major birth defects giving a prevalence of 20.73 cases per 1,000 live births. This figure is far more than that which was obtained in other regions of Nigeria – 4.15:cases per 1,000 live births in the South East ( $P<0.001$ ), 15.84:1,000 in the South West ( $P<0.01$ ), and 5.51:1,000 in the North East ( $P<0.001$ ). Eighty-five (53.46%) of the defects occurred in 1,681 unbooked patients, while 74 (46.54%) happened in 5,989 booked maternities ( $P<0.001$ ). The predominant abnormalities were those of the central nervous system at 27.0%, gastrointestinal system 11.95%, cardiovascular system 10.69%, anterior abdominal wall 8.18%, skeleton 6.29%, and chromosomal abnormalities at 5.66%.

**Conclusion:** The prevalence of major birth defects at the University of Port Harcourt Teaching Hospital was 20.73 cases per 1,000 live births and it was more in the unbooked than the booked maternities. All body systems were affected with those of the central nervous system predominating at 27.0% of the total diagnosed defects.

**Keywords:** maternity, congenital abnormalities, birth defects, unbooked, booked, Niger Delta, Port Harcourt

## Introduction

Congenital abnormalities are defects of structure or function, including metabolism, which can be diagnosed during intrauterine fetal life, at birth, or later in life.<sup>1</sup> Major abnormalities may be life threatening or have the potential to result in disability and therefore constitute a tremendous physical, financial, and emotional burden on the affected families.

Worldwide, an estimated 9 million infants, representing ~7% of all births are born annually with a serious birth defect. Ninety-four percent of the defects (ie, 8.46 million infants) and 95% of deaths from them occur in developing countries.<sup>2–4</sup> So it is obvious that the burden of congenital abnormalities in Nigeria and other developing countries is enormous and therefore demands adequate attention from the Government of these countries.

The prevalence of major congenital abnormalities in different parts of Nigeria cannot be ascertained on the basis of the available literature. The data are mainly hospital-based without taking into consideration the general population. For instance, the prevalence of congenital malformations noted in Akwa Ibom and Cross River states

Correspondence: Mkpe Abbey  
 Institute of Maternal and Child  
 Health, Department of Obstetrics  
 and Gynaecology, University of Port  
 Harcourt Teaching Hospital, East/  
 West Road, P.M.B 6173, Port Harcourt,  
 Rivers State, Nigeria  
 Tel +234 84 818 494 6014  
 Email mkpeabbey@aol.com

in the South-South region and Kano state in the North-East region of Nigeria were 0.4% and 5.8%, respectively.<sup>5,6</sup> The figures for the South East and the South West were 0.42% and 1.58%, respectively.<sup>7,8</sup>

The figure for Rivers state in South Southern region, where the present study took place was 0.4% and 0.2% for University of Port Harcourt Teaching Hospital (UPTH) and Braithwaite Memorial Hospital, respectively for the period 1993–2003.<sup>9</sup> It has been >12 years since that study was carried out but for the past 5 years, there seems to be dramatic increase in the prevalence of congenital abnormalities in the region.

Factors that cause or are associated with congenital abnormalities are far more in the developing countries than in the developed ones.<sup>10</sup> Some of these factors are poor nutrition, uncontrolled exposure to agents or factors such as teratogenic drugs, infection and alcohol,<sup>1</sup> advanced maternal age, African ethnicity (certain birth defects), consanguinity, iodine and folate deficiencies, obesity, and diabetes mellitus. All these factors are in abundance in the Niger Delta area of Nigeria.

Of particular interest in the oil-rich Niger Delta is the issue of accidental or iatrogenic catastrophic environmental degradation by the process of crude oil exploration, extraction, refining, transport, and usage. Inhabitants of the Delta have been exposed to this danger from 1958 when oil was first found in the area till today. Mothers are exposed during the period of ontogenesis (4–10 weeks) and throughout pregnancy.

Therefore, we hypothesize that the inhabitants of the core Niger Delta States (Bayelsa and Rivers states) should have more cases of congenital abnormalities than those in any other region of Nigeria and in the developed countries. The present work was therefore executed at the UPTH in the Rivers State with a view of testing our hypothesis.

## Methods

The study was approved by the University of Port Harcourt Teaching Hospital Board or Ethics Committee before it was started and permission for using patient's data was not necessary because patients gave their consent on booking with the hospital that their data can be used if necessary for research. Data on all the deliveries, including major congenital abnormalities that occurred at the UPTH between August 2011 and December 2014 were extracted from the labor ward and special care baby unit birth and admission/discharge registers and case notes. None of the abnormalities were diagnosed before birth.

Although the study was scheduled for August 2011 to December 2014, it did not cover its entire life span because of series of strikes in Nigerian Teaching Hospitals and hospital

closure due to Ebola disease. Consequently, we did not have the data for some of the months. There was no adequate information on the following: maternal demographic features and history (medical, obstetric, drug, and social), condition of the babies at delivery, further management of the neonates, and the final outcome for the babies. Therefore, we did not consider in this study the risk factors for the identified abnormalities. We concentrated on the prevalence and the pattern of the abnormalities.

Birth defects were classified according to the systems that they affected, using the recommendation of the World Health Organization.<sup>11</sup> Data were analyzed using Epi info™7 (Centre for Disease Control and Prevention CDC, Atlanta, GA, USA). Simple proportions were used in the descriptive analysis. Bivariate analysis was also carried out. Comparison of related variables was performed, using the  $\chi^2$  and the *P*-values. When the *P*-value was  $<0.05$ , the difference between two variables was said to be statistically significant. When an expected count was lower than 5 in a cell, Fisher's exact test was used.

## Results

Out of the 4 years of the study period, the UPTH was closed for 340 days. The total number of women who delivered during the period and included in the study was therefore 7,670; 5,989 of them were booked with the Teaching Hospital, while 1,681 women were unbooked (Table 1). The unbooked maternities were either not booked with any health facility at all or had their antenatal care with traditional birth attendants, faith healers, chemists, primary health centers, or general hospitals.<sup>12</sup>

One hundred and fifty-nine of the 7,670 women who were considered during the study period had babies with major congenital abnormalities, thereby giving the combined prevalence (for the booked and the unbooked maternities) of 20.73 cases per 1,000 live births (Table 2). Although the

**Table I** Number of deliveries during the study period

Categories of patients	2011	2012	2013	2014	Total
<b>Booked patients</b>					
Singleton	269	2,738	1,959	852	
Twins	6	72	63	16	
Triplet		9	3	1	
Quadruplet		1			
Total	275	2,820	2,025	869	5,989
<b>Unbooked patients</b>					
Singleton	396	588	473	180	
Twins	12	3	17	10	
Triplet		2			
Quadruplet	408	0		0	
Total		593	490	190	1,681
<b>Grand total for the year</b>	<b>683</b>	<b>3,413</b>	<b>2,515</b>	<b>1,059</b>	<b>7,670</b>

**Table 2** Systemic distribution, percentage, and prevalence of CA

Birth defects and the systems and organs affected	Number of babies who had birth defects			% of recorded anomalies (N=159)	Prevalence per 1,000 births (N=7,670)
	From booked patients	From unbooked patients	Total		
Central nervous system	24	19	43	27.0	5.61
Hydrocephalus	7	4	11	6.92	1.43
Microcephaly	1	2	3	1.9	
Neural tube defect	15	13	28	17.61	3.65
1. Anencephaly	1	0	1		
2. Encephalocele	0	3	3		
3. Spinal bifida (MMC, etc)	14	10	24	15.09	
Craniosynostosis	1	0	1		
Face	0	7	7	4.40	0.91
Cleft lip/palate	0	6	6	3.9	1.0
Exophthalmos	0	1	1	0.6	0.16
Neck and skin	1	1	2	1.26	0.26
Cardiovascular system	8	9	17	10.69	2.22
Ventricular septal defect	3	2	5		
Other congenital heart defect	2	4	6		
Patent ductus arteriosus	0	2	1		
Tetralogy of Fallot	3	1	4		
Urinary tracts	5	4	9	5.66	1.17
Hydronephrosis	0	1	1		
Polycystic kidney disease	3	1	4		
Bladder outlet obstruction	1	0	1		
Ectopia vesicae	0	1	1		
Obstructive uropathy	0	1	1		
Potter's disease	1	0	1		
Anterior abdominal wall	6	7	13	8.18	1.69
Omphalocele	6	7	13		
Gastrointestinal tracts	7	12	19	11.95	2.48
Tracheoesophageal fistula	2	3	5		
Duodenal stenosis	0	1	1		
Duodenal atresia	0	2	2		
Jejunal atresia	0	1	1		
Intestinal obstruction	3	2	5		
Imperforate anus	1	2	3		
Biliary atresia	0	1	1		
Hirschsprung's disease	1	0	1		
Genital tracts	2	2	4	2.52	0.52
Rudimentary phallus	0	1	1		
Hydrocele	1	0	1		
Hypospadias	1	0	1		
Atypical genitalia	0	1	1		
Skeleton	3	7	10	6.29	1.30
Talipes equinovarus	1	2	3		
Congenital dislocation of the hip joint	2	2	4		
Osteogenesis imperfecta	0	1	1		
Absent radius and thumb	0	1	1		
Scoliosis	0	1	1		
Multiple anomaly	14	8	22	13.84	2.87
Chromosomal anomaly	3	6	9	5.66	1.17
Down syndrome T21	1	3	4		
Edwards syndrome T18	2	3	5		
Fetal tumor	1	1	2	1.23	0.26
Sacrococcygeal teratoma	1	0	1		
Nephroblastoma	0	1	1		
Unclassified	1	2	3	1.89	0.39
Beckwith-Wiedemann syndrome	0	1	1		
Hypothyroidism	0	1	1		
Prune belly	1	0	1		
Total	74	85	159	2.07%	20.73
% of the total abnormalities	46.54	53.46			

**Abbreviations:** CA, congenital abnormalities; MMC, myelomeningocele.

**Table 3** Comparison of the prevalence of birth defects in babies from the unbooked and the booked patients

Birth defects and the systems and organs affected	Recorded birth defects				P-value	$\chi^2$	OR	CI
	Unbooked patients	Prevalence per 1,000 birth (N=1,681)	Booked patients	Prevalence per 1,000 live births (N=5,989)				
Central nervous system	19	11.30	24	4.01	0.001	11.08	2.82	1.54, 5.16
Neural tube defects	13	7.73	15	2.5	0.004	9.87	3.09	1.47, 6.50
Face	7	4.16	0	0	0.001			
Cardiovascular system	9	5.35	8	1.34	0.01	7.80	4.01	1.54, 10.40
Urinary tracts	4	2.38	5	0.83	0.113			0.56, 13.26
Anterior abdominal wall	7	4.16	6	1.00	0.015	5.97	4.16	1.40, 12.38
Gastrointestinal tracts	12	7.14	7	1.17	0.001	16.45	6.11	2.40, 15.54
Genital tracts	2	1.19	2	0.40	0.211			0.26, 49.17
Skeleton	7	4.16	3	0.33	0.002			1.89, 49.86
Multiple anomaly	8	4.75	14	2.33	0.169	1.90	2.04	0.85, 4.86
Chromosomal anomaly	6	3.57	3	0.50	0.01			1.52, 44.06
Fetal tumor	1	0.59	1	0.17	0.390			0.05, 279.71
Unclassified	2	1.19	1	0.17	0.123			0.37, 420.45
Total	85	50.57	74	12.36	0.001	86.92	4.09	2.98, 5.62

**Abbreviations:** CI, confidence interval; OR, odds ratio.

unbooked patients were fewer than the booked ones, they contributed 53.46% of the abnormalities with prevalence of 50.57:1,000 live births, while the booked maternities – 46.54% with prevalence of 12.36:1,000 live births ( $P<0.001$ ) (Tables 2 and 3). However, there was no significant difference between the two groups when considering the abnormalities of the genitourinary tracts, fetal tumors, multiple and the unclassified abnormalities (Table 3).

In decreasing order of frequency, the prevalence of birth defects for different body systems as shown in Table 2 was as follows: central nervous system (5.61:1,000), gastrointestinal tracts (2.48:1,000), cardiovascular system (2.22:1,000), anterior abdominal wall (1.69:1,000), skeletal system (1.30:1,000), chromosomal abnormalities and urinary tract (1.17:1,000), face (0.91:1,000), genital tract (0.52:1,000), and neck and skin (0.26:1,000). Multiple birth defects occurred 87:1,000 live births, while fetal tumors and unclassified birth defects were diagnosed in 0.28 and 0.38 per 1,000 live births, respectively. The unclassified birth defects were

Beckwith–Wiedemann syndrome, prune belly syndrome, and hypothyroidism. The term “unclassified” was used because the abnormalities cannot be included in the other major groups in this study.

Furthermore, as shown in Table 4, the prevalence of congenital abnormalities at the UPTH in the South Southern Nigeria is significantly higher than the figures in other regions of Nigeria where the same study methodology was adopted.<sup>6–8</sup> The only differences in the studies were the years when they were performed and the inclusion of birth abnormalities in the data diagnosed at postmortem in the South Western region of Nigeria.<sup>7</sup> There is no significant difference in the prevalence of birth defects in the Niger Delta and Europe.

## Discussion

The study demonstrated that the prevalence of major congenital abnormalities at the UPTH in the Niger Delta during the period 2011–2014 was 20.7 per 1,000 live births, with those of the central nervous system predominating at 27% of the

**Table 4** Comparison of the prevalence of congenital abnormalities in the Niger Delta, South Southern Nigeria (present study) with that in different regions of Nigeria and the developed world

Regions	Study period, duration	Number of live births	Number of births with birth defects	Prevalence per 1,000 live births	P-value	$\chi^2$	OR	CI
SSN <sup>a</sup>	2011–2014, 4 years	7,670	159	20.73				
SEN <sup>b</sup>	2002–2012, 10 years	14,446	60	4.15	0.001	135.32	4.99	3.70, 6.73
SWN <sup>c</sup>	1981–1990, 10 years	22,288	353	15.84	0.01	7.55	1.31	1.08, 1.58
NEN <sup>d</sup>	1998–2004, 10 years	13,619	75	5.51	0.001	100.53	3.76	2.86, 4.96
Europe –	2012	783,556	15,867	20.25	0.803	0.06	1.02	0.87, 1.20
EUROCAT 2014								

**Notes:** <sup>a</sup>SSN – present study, <sup>b</sup>SEN – Federal Medical Centre Abakaliki, Ebonyi State, data from Onyeanya and Onyire,<sup>8</sup> <sup>c</sup>SWN – Lagos University Teaching Hospital, data from Iroha et al,<sup>7</sup> and <sup>d</sup>NEN – Aminu Kano Teaching Hospital, Kano, data from Mukhtar-Yola et al.<sup>6</sup>

**Abbreviations:** CI, confidence interval; NEN, North Eastern Nigeria; OR, odds ratio; SEN, South Eastern Nigeria; SSN, South Southern Nigeria; SWN, South Western Nigeria.

total. These figures are extremely high, when compared with the finding from previous work that was conducted in the same hospital. The study reviewed cases of obvious major birth defects from 1990 to 2003.<sup>9</sup> The prevalence of birth defects in that study was 4.0 per 1,000 live births. Prevalence studies in other tertiary institutions in Nigeria also showed significantly lower figures than the values obtained in our study (Table 4).

The first question that demands urgent answer is as following: Why were there more major congenital abnormalities at the UPTH from 2011 to 2014 than they were during the period 1990–2003? This finding may represent a natural trend of events, whereby the prevalence of major congenital abnormalities tends to increase with time as is presently happening in Europe irrespective of the measures that have been put in place to curb the trend.<sup>13,14</sup> Another explanation is that in the Niger Delta, the number of environmental teratogens may be increasing with time; it can as well be that we are getting better at diagnosing these abnormalities at birth.

The second important question to be answered is as following: Why is it that there are more major congenital abnormalities in the Niger Delta area of Nigeria (represented by the figures in our study) than in other parts of the country and in the developed continent of Europe? We assume that this is due to the poor socioeconomic and maternal nutritional status in the region; the catastrophic environmental degradation in the Delta is probably another contributing factor.

The inhabitants of the Delta are fishermen and farmers. Unfortunately, marine life in the area is almost in extinction and the yield from farming activities is not even enough for personal consumption. The main explanation for this woe in the Delta is that the region has been plagued with significant environmental pollution over the past 52 years by the products of crude oil production and many other sources.

The Niger Delta is the industrial powerhouse of Nigeria because of its abundant oil and gas resources, seaports, fertilizer plants, and many other firms. In the region, there have been issues of oil pipe vandalism and oil spillage, inappropriate discharge of waste waters, gas flaring, acid rain, toxic leakage from underground petroleum storage tanks, dumping of dangerous chemical wastes, use of cars that are not road worthy, burning of biofuel including kerosene, bush, biomass, coal, and inappropriate incineration of refuse.<sup>15,16</sup>

The sources of pollution have led to the contamination of soil, water, and air with heavy metals (arsenic, mercury, cobalt, manganese, etc), different gases (sulfur dioxide, nitrogen dioxide, ozone, and carbon monoxide), particulate matters, benzene, toluene, ethylbenzene, and xylene, and other volatile organic compounds.<sup>10,17,18</sup>

The abundant environmental teratogens that contaminate the Delta can cause congenital abnormalities through preconception mutagenic action (maternal or paternal) giving rise to chromosomal abnormalities and syndromes or through postconception teratogenic action in pregnancy, depending on the nature of the teratogen and the precise timing of exposure – embryonic or fetal period. Therefore, it is not surprising that women who have lived in that environment for years should experience high prevalence of congenital abnormalities, than women who live in other region of Nigeria.

The prevalence of congenital abnormalities in Europe in 2012 was 25 per 1,000 births.<sup>5</sup> The figure included 15,867 women who had babies with congenital abnormalities at birth, 364 women who had intrauterine fetal death due to abnormalities, and 3,660 women who had termination of pregnancy for fetal abnormalities, giving a total of 19,891 in 30 countries. Therefore, the prevalence of abnormalities diagnosed at birth will be 15,867/19,891 multiply by 25, which is 19.94 cases per 1,000 live births. Again this figure is <20.73 cases per 1,000 live births that was recorded in our study, although not statistically significant ( $P<0.803$ ).

Another important finding of the present work is the significant difference between the prevalence of congenital abnormalities in the babies of the booked patients when compared with that in the babies of the unbooked maternities. This is probably due to the fact that poverty and illiteracy in the unbooked patients is far higher than in the booked patients. Since there is no universal free maternal care in Nigeria, the unbooked patients tend to undergo antenatal care with traditional birth attendants, faith healers, health centers, and some with general medical practitioners.<sup>12</sup> All these categories of obstetric practitioners have no formal training in obstetrics and therefore can neither conduct prepregnancy care nor offer effective maternal or neonatal care. All these factors coupled with the environmental pollution in the Niger Delta could be responsible for the higher prevalence of birth defects in the unbooked patients.

The pattern of congenital abnormalities varied from one region of Nigeria to the other. In our study, those of the central nervous system constituting 27.0% of the cases were followed by multiple abnormalities – 13.84%, abnormalities of the gastrointestinal system – 11.95%, cardiovascular system – 10.69%, and the anterior abdominal wall at 8.18%. If we add the abnormalities of the anterior abdominal wall to those of the gastrointestinal system as was done in other studies in Nigeria, then the abnormalities of that system will come second. This was in contrast to the pattern in other regions of Nigeria.

In the North Eastern Nigeria, the predominant abnormalities were those of the gastrointestinal system at 34.5%,

unclassified abnormalities at 33%, and those of the central nervous system at 13.6% of the total birth defects.<sup>6</sup> In the South Western Nigeria, abnormalities of the cardiovascular and gastrointestinal systems predominated, this was followed by the abnormalities of the musculoskeletal, cardiopulmonary, and genitourinary systems.<sup>7</sup> In the South East of Nigeria, abnormalities of the gastrointestinal system predominated at 36.7% of the total cases that were diagnosed; this was followed by those of the skeletal and then the cardiovascular systems.<sup>8</sup>

Therefore, it is clear that there were some similarities in the pattern of the abnormalities in the South West, South East, and North Eastern Nigeria in contrast to the Niger Delta, where the pattern was distinct. Again, this may be explained by the much talked-about environmental pollution in the Delta.

## Recommendations

In view of the limitations of the study (Teaching Hospital-based, lost patient's case notes, poor collation of patient's information in the available notes and haphazard documentation in the labor and pediatric registers of births, absence of maternal demographic features and work profile of parents, full obstetric, gynecological, and medical history), it is highly recommended that a prospected study on the same subject is carried out. Attention will be paid to the risk factors for birth defects, including environmental pollution. Both physical and laboratory-based human biomonitoring (levels of the biochemical teratogens and the end products of their metabolism) may be indicated.

Furthermore, given the staggering high prevalence of congenital abnormalities that were recorded in the study, it is highly recommended that a dedicated Foetal Medicine unit be created in the UPTH. The primary function of the unit will be to assist in evidence-based obstetric practice, prenatal diagnosis, management of multiple pregnancies, complex obstetric conditions, and of course, antenatal diagnosis of the abnormalities. This will enable the obstetrician to offer women suitable management options, for example, termination of pregnancy where indicated instead of carrying the pregnancy to term.

## Conclusion

The prevalence of major congenital abnormalities at birth at the UPTH was 20.73 cases per 1,000 live births with the frequency in the unbooked maternities significantly higher than that in the booked patients. The predominant abnormalities are those of the central nervous, gastrointestinal, and the cardiovascular systems. These figures are significantly higher

than those obtained from other regions of Nigeria namely South West, South East, and the North East.

## Disclosure

The authors report no conflicts of interest in this work.

## References

- WHO. *Congenital Anomalies*. Fact sheet No. 370; Updated April 2015.
- MOD (March of Dimes). *The March of Dimes Global Report on Birth Defects: The Hidden Toll of Dying and Disabled Children*. White Plains: NY: March of Dimes Birth Defects Foundation; 2006. Available from: <http://www.marchofdimes.com/MOD-Report-PF.pdf>
- Turnpenny P, Ellard S. *Emery's Elements of Medical Genetics*. 12th ed. Edinburgh, UK: Elsevier Churchill Livingstone; 2005.
- World Bank. *Country Classification*; 2005. Available from: [www.worldbank.org/data/countryclass/countryclass.html](http://www.worldbank.org/data/countryclass/countryclass.html). Accessed October 16, 2008.
- Ekanem TB, Okon DE, Akpantah AO, Mesembe OE, Eluwa MA, Ekong MB. Prevalence of congenital malformations in Cross River and Akwa Ibom states of Nigeria from 1980–2003. *Congenit Anom (Kyoto)*. 2008; 48(4):167–170.
- Mukhtar-Yola M, Ibrahim M, Belonwu R. Prevalence and perinatal outcome of obvious congenital malformations among inborn babies of Aminu Kano University Teaching Hospital, Kano. *Niger J Paediatr*. 2005; 32(2):47–51.
- Iroha EO, Egri-Okwaji MTC, Odum CU, Anorlu ROI, Oye-Adeniran B, Banjo AAF. Prenatal outcome of obvious congenital malformation as seen at the Lagos University Teaching Hospital, Nigeria. *Niger J Paediatr*. 2001;28(3):73–77.
- Onyearugha CN, Onyire BN. Congenital malformations as seen in a secondary healthcare institution in Southeast Nigeria. *J Med Investig Pract*. 2014;9:59–62.
- Ekanem B, Bassey IE, Mesembe OE, Eluwa MA, Ekong MB. Incidence of congenital malformation in 2 major hospitals in Rivers state of Nigeria from 1990 to 2003. *East Mediterr Health J*. 2011;17(9):701–705.
- WHO. Benzene. In: *Air Quality Guidelines*. 2nd ed. Environmental Health Criteria, No 150. Geneva: World Health Organization; 1993; 82:165–169.
- Kupka K. International classification of diseases: ninth revision. *WHO Chron*. 1978;32:219–225.
- Mkpé Abbey, Diuto Akani, Chris I. Akani. *A Case for Medical Education and Referral Cascade in the Maternal Healthcare Service in the Niger Delta, Nigeria*. UK: BJOG, RCOG World Congress in Birmingham; 2016;123(S2):145–169.
- Dolk H, Loane M, Garne E. The prevalence of congenital anomalies in Europe. *Adv Exp Med Biol*. 2010;686:349–364.
- EUROCAT Special Report: Geographic Inequalities in Public Health Indicators related to Congenital Anomalies. EUROCAT Annual Surveillance 2014 Report.
- Obire O, Amusan FO. The environmental impact of oilfield formation water on a freshwater stream in Nigeria. *J Appl Sci Environ Manag*. 2003; 7(1):61–66.
- UNEP. *UNEP Environmental Assessment of Ogoniland*. Nairobi: United Nations Environment Programme; 2011.
- Ghosh JK, Wilhelm M, Su J, et al. Assessing the influence of traffic-related air pollution on risk of term low birth. *Am J Epidemiol*. 2012; 175(12):1262–1274.
- Lupo PJ, Symanski E, Waller DK, et al. Maternal exposure to ambient levels of benzene and neural tube defects among offspring: Texas, 1999–2004. *Environ Health Perspect*. 2011;119(3):397–402.

**International Journal of Women's Health****Dovepress****Publish your work in this journal**

The International Journal of Women's Health is an international, peer-reviewed open-access journal publishing original research, reports, editorials, reviews and commentaries on all aspects of women's healthcare including gynecology, obstetrics, and breast cancer. The manuscript management system is completely online and includes

a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <http://www.dovepress.com/international-journal-of-womens-health-journal>