International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 06, ISSN No. 2455-2143, Pages 35-40
Published Online October 2024 in IJEAST (http://www.ijeast.com)

EFFECTS OF MATERNAL AGE ON THE RISK OF BIRTH DEFECTS IN ZAMFARA STATE NIGERIA USING LOGISTIC REGRESSIONS MODEL

Abdullahi, Aliyu
Department of Science Laboratory Technology
Federal Polytechnic Kaura Namoda,
Zamfara State, Nigeria

Lasisi, Nurudeen O.
Department of Statistics
Federal Polytechnic Kaura Namoda,
Zamfara State, Nigeria

Abstract: **Birth defects refer to physical or functional abnormalities that happen during prenatal period and can lead to physical or cognitive disabilities, or even death. The causes of birth defects are often complex and can involve genetic, environmental, nutritional, and socioeconomic factors. This research work aimed to examine the effects of the communication between age of maternal and parity on adverse pregnancy outcomes in Zamfara State, Nigeria. Maternal data were categorized according to age of the maternal and number of parity. The data were analyzed using logistic regression method of analysis and the data were analyzed using R-Statistical software and the results shown that the maternal age of 30 year above without parity having low birth defects, followed by maternal age of 20-29 year without parity and less than 20 year old maternal without parity was having higher chance of birth defects. Also, maternal age with birth parity, with < 20 year old; maternal age of 20-29 year old; and maternal age of ≥ 30 year old were having the following chances of birth defects, 0.04, 0.02 and 0.004 respectively. More so, it was concluded that odds ratios was used to measure the effects and relationship between the age group, the study found that, maternal age < 20 year old has higher significant effect on birth defect outcome, with odds ratios of birth defect of 10 times higher than a maternal age ≥ 30 year old, compared to maternal age of between 20 – 29 year old with the odds of birth defect of 5 times larger than of maternal age ≥ 30 year old.**

Keywords: **Birth Defects, Hospital, Maternal Age, Nigeria, Logistic Regressions Model**

I. INTRODUCTION

Birth defects are structural or functional abnormalities that occur during pregnancy, affecting how the baby looks, functions, or both (Centers for Disease Control and Prevention (CDC), 2022; Chen, Wen, Fleming, et al., 2007; Nilsen, Vollset, Gjessing, et al., 2006; Raatikainen, Heiskanen, Verkasalo, Heinonen, 2006; Chandra, Schiavello, Ravi, et al., 2002). They can involve many parts of the body and varies in severity, from minor to life-threatening (Wu, Springett, and Cooper, 2016). Some are caused by genetic factors, while others may be linked to environmental factors, maternal health conditions, or infections during pregnancy (Reefhuis and Honein, 2004; Loane, Dolk, Morris, 2009). There are different types of Birth Defects, namely; Structural birth defect, which is often affect the physical structure of the body, Congenital heart defects, Cleft lip/palate, Neural tube defects is the defect that affect the brain and spinal cord, Limb deformities, Functional or Developmental birth defects, Metabolic disorders this is the problems of body processes nutrients, Sickle cell disease, Cystic fibrosis this is a genetic disorder affecting the respiratory and digestive systems, Sensory problems this defect is the hearing or vision loss ((Miller, Riehle–Colarusso, Siffel, et al.2011; Li, Ford, Meister, Bodurtha, 2003; Morris, 2009; Adetayo, 2015; CDC, 2022). Some of these birth defects are caused by maternal age, which is the aim of the research work.

World Health Organization (WHO) (2015) reported that, congenital anomalies were acknowledged to be the reasons for death in about 276,000 newborns less than or around one month of age every year worldwide. In 2016, the number increased to 303,000 neonates (WHO, 2016; Tinker, Gilboa, Reefhuis, Jenkins, Schaeffer, Moore, 2015; Zīle et al. 2013; Reichman, Pagnini, 1997). For most of the birth defects, no exact cause(s) have yet been known (Organization WH, 2016). Nonetheless, environmental teratogens, genetic factors and

multifactorial inheritance are thought to be the cause of some congenital anomalies (Lamichhane, Leem, Park, Kim JA, Kim HC, Kim JH et al. 2016; Postoev, Nieboer, Grjibovski, Odland, 2015). Therefore, Birth parity refers to the number of times a woman has given birth to a fetus with a gestational age of 24 weeks or more, regardless of whether the child was born alive or stillborn. So, higher birth parity has been connected with increased threats of maternal difficulties and certain birth defects (Smith, 2012; Mashuda, Zuechner, Chalya, Kidenya, Manyama, 2014; Sarkar, Patra, Dasqupta, Nayek, Karmakar, 2013; Obu, Chinawa, Uleanya, Adimora, Obi; 2012; Sokal, Tata, Fleming, 2014; Czeizel, 1988; Venter, Christianson, Hutamo, Makhura, Gericke, 1995).

In Nigeria, the prevalence of birth defects is influenced by a combination of genetic factors, malnutrition, lack of prenatal care, and environmental hazards (Adetayo, 2015). So, Birth defect prevalence in Nigeria is estimated to be among the highest in Africa due to socioeconomic issues and shortage of access to healthcare (Adetayo, 2015). Zamfara State is a state in Nigeria, has been noted for higher-than-average rates of birth defects, particularly due to environmental experience to lead minerals and other toxins materials as a consequence of mining activities (Wu, et al., 2016). A study conducted in Zamfara State on birth defects, found that an increased incidence of neural tube defects and other congenital abnormalities connected to lead exposure (Nigeria Federal Ministry of Health, 2018).

A regression equation is a statistical method used to determine relationships between a dependent variable which is the prevalence of birth defects and one or more independent variables which is the maternal age (Hosmer, Lemeshow and Sturdivant, 2013). This method has been widely used in biomedical and epidemiological studies to explore the relationships between various health consequences (Kleinbaum, Kupper and Muller, 1988). In a practical scenario, further complex regression models, such as multiple regression, logistic regression for binary outcomes like Yes or No; Presence or Absence of a defect, or Survival Analysis to Model real time event data, like the current study on birth defects, can be employed. Wu et al. (2016) analyzed birth defects by using logistic regression to evaluate the risk of several birth defects based on maternal age. The analysis found that women aged 40 or older had a 2.5 times higher risk of having a child with Down syndrome compared to women aged 25–29 years. Also, younger mothers (< 20 years) were 1.8 times more likely to have babies with gastroschisis (Benjamin, Ethen, Van Hook, et al., 2010; Chabra, Gleason, Seidel, Williams, 2011). In this study, the logistic regression analysis is been used to study the effects of maternal age on the risk of birth defects in Zamfara State Nigeria and the study area is federal medical centre, Gusau, Zamfara State, Nigeria.

II. REVIEWED OF BIRTH DEFECTS IN ZAMFARA STATE

Birth defects in Zamfara State, Nigeria, are a significant concerned, often linked to environmental factors, particularly heavy metal pollution from illegal gold mining activities (Bello, Kolawole, and Yakubu, 2016; Garba et al., 2022; Adane, Afework, Seyoum, Gebrie, 2020). These pollutants especially lead mining have been associated with various congenital anomalies, including neural tube defects (like spina bifida), musculoskeletal abnormalities, and cardiovascular defects (Gidado, Biya, Haladu, and Nguku, 2010). Lead poisoning, for example, not only contributes to severe birth defects but also causes stillbirths and developmental issues in children (Lo, Brown, and Durand, 2012; Adane et al., 2020). The mining areas, particularly in local government areas like Anka and Bukkuyum, have seen clusters of these issues, as highlighted by health reports and studies focusing on lead exposure. Additionally, widespread environmental degradation exacerbates the problem, leading to contaminated water and soil, which directly impacts maternal and child health (Adane et al., 2020; Dooyema, Neri, Lo, Durant, Dargan, Swarthout, et al., 2012; Oyekale, 2014).

These issues are exacerbated by environmental exposure to toxins, especially in mining areas like Anka and Bukkuyum. Lead contamination from mining operations is a major contributor, with both pregnant women and children being severely affected by the exposure (Ahmed, Ogungbe, and Yakubu, 2013; Brown, Durant, and Gidado, 2010; Garba et al., 2022). Efforts to address these problems require stricter mining regulations, environmental remediation, and enhanced healthcare services to manage and monitor the affected populations (Garba et al., 2022). In Zamfara State, the prevalence and type of birth defects often correlate with age-related factors, especially among children under five. Studies have shown that young children are more vulnerable to the environmental hazards, particularly lead poisoning, which has been linked to congenital anomalies in the region. (Adane et al., 2020)

Age of Maternal and Pregnancy: Older mothers, particularly those exposed to environmental toxins, are more likely to give birth to children with defects. The risk of certain birth defects, such as cardiovascular anomalies and neural tube defects, increases with maternal age and exposure to lead during pregnancy. Furthermore, the high infant mortality rate linked to these birth defects, especially in children below five, underscores the critical need for better healthcare interventions and environmental clean-up to protect this vulnerable population (Garba et al., 2022; Adane et al., 2020). In Zamfara State, malnutrition plays a significant role in maternal and child health, particularly impacting maternal age groups and contributing to birth outcomes (UNICEF Nigeria, 2021).

Maternal Age and Malnutrition: Younger Mothers: Adolescents and young women in their late teens and early twenties are especially vulnerable to malnutrition due to

higher nutritional demands during pregnancy. In Zamfara, early marriages are common, and these young mothers often face nutritional deficiencies, which can lead to complications such as low birth weight, preterm delivery, and developmental issues in infants (Adane et al., 2020). Older women, especially those above 35, are also at risk due to cumulative nutritional deficits over time, often exacerbated by frequent pregnancies with limited access to prenatal care and proper nutrition. This increases the likelihood of birth defects and other complications such as anemia, which can further affect the fetus's development (Adane et al., 2020).

Impact of Malnutrition: Children born to malnourished mothers are more prone to stunted growth and developmental delays. In Zamfara, high levels of food insecurity, poor maternal health services, and environmental challenges like lead poisoning further increase the risk of congenital defects and early childhood mortality (Adane et al., 2020). Nutritional Deficiencies are deficiencies in essential nutrients such as iron, folic acid, and calcium is prevalent, particularly among poorer and rural populations. These deficiencies increase the risks of neural tube defects, poor fetal growth, and other birth complications (Ajayi and Afolabi, 2019; NPC, 2020; Adane et al., 2020). So, addressing maternal malnutrition in Zamfara requires comprehensive interventions, including better healthcare access, improved nutrition education, and efforts to alleviate food insecurity.

Malnutrition among maternal group, particularly pregnant and lactating mothers, is a serious concern in Zamfara State. Studies across sub-Saharan Africa, including regions like Zamfara, indicate that maternal malnutrition rates can be high, with some estimates showing that around 34% of pregnant women experience acute malnutrition. This can be due to various factors including poverty, food insecurity, and insufficient healthcare support (Desyibelew and Dadi, 2019). Zamfara State has also seen high levels of child malnutrition, with a 2023 survey reporting over 115,000 children suffering from Severe Acute Malnutrition (SAM). This highlights the broader food and nutrition challenges in the region, which also affect maternal health (Desyibelew and Dadi, 2019). Malnutrition in maternal group can lead to complications during pregnancy, affect fetal development, and increase the risk of maternal mortality. Addressing these issues requires interventions such as improving food access, healthcare services, and nutrition education (Desyibelew and Dadi, 2019; Nigeria Demographic and Health Survey, 2018).

In Zamfara State, several types of birth defects have been identified, often associated with lead poisoning and compounded by malnutrition. This study shows an overview of the different birth defects and their approximate prevalence rate: Types of Birth Defects and the prevalence rate according to Ajayi and Afolabi (2019), Centers for Disease Control and Prevention (2010), and Desyibelew and Dadi (2019), namely; Neural Tube Defects with Prevalence Estimated to affect 2-5% of newborns in affected areas, Musculoskeletal Defects with Prevalence Estimated at 3-4%, Cardiovascular Defects with Prevalence estimated at 1-2% of live births, Cleft Lip and Palate with Prevalence roughly 1% of cases in affected areas, Impact of Malnutrition on Birth Defects with Prevalence of Malnutrition affects 34-45% of pregnant women in Zamfara State which the highest among the birth defects in zamfara state. However, the association between maternal age and the risks of birth defects has not been well studied in Zamfara State, Nigeria. In view of this, this research focused on the effects of maternal age in modeling the risks of birth defects in Zamfara State, Nigeria, using logistic regressions model. It is therefore necessary to critically look into other factors associated with Birth Defects in Zamfara State, Nigeria.

III. MATERIALS AND METHODS

A. Sources of the Data

The data of this research work was based on data retrieved from unit of maternity, Federal Medical Centre Gusau, Zamfara State, Nigeria. For the birth defects among the age maternal mothers, the data extracted from the available records of the Hospital, for the associated risk factors for birth defects.

B. Statistical analysis

Logistic Regression analysis is a statistical method used to determine the relationships between a dependent variable and one or more independent variables. It is commonly used in epidemiology and medical research to study risk factors for diseases. To evaluate the effects of maternal age in modeling the risks of birth defects in Zamfara State, Nigeria, we categories the maternal age as less than 20; greater than 20 and < 30; and ≥ 30 years. The study used a logistic regression model and expressed the effect estimates as odds ratios (OR) and corresponding 95% confidence intervals (CI). The study used logistic regressions model and analysis to adjust for the most common known risk factors for maternal birth defects. Firstly, the study adjusted for possible maternal birth age by categorized the age of the mother into three classes; we adjusted the data by including maternal age (less than 20, between 20 and 29 years and ≥ 30 years). The essential data were collected by means of Microsoft Excel format and analyzed by using R Software.

C. Logistic Regressions Model

Logistic regression method is a suitable method for investigating data with binary outcomes, such as the presence or absence of a birth defect (Hosmer, Lemeshow and Sturdivant, 2013). The logistic function transforms the linear combination of the predictors into a value between 0 and 1, representing the probability of the outcome. The logistic regression equation models the probability of a binary outcome like success or failure, yes or no, based on one or more predictor variables. The equation for logistic regression is:

International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 06, ISSN No. 2455-2143, Pages 35-40
Published Online October 2024 in IJEAST (http://www.ijeast.com)

$$\log(\frac{p}{1-p}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \quad (1)$$

Where, p = Probability of the event occurring like birth defect
β_0 = Intercept,
$\beta_1, \beta_2, \ldots, \beta_n$ = Regression coefficients for the predictor variables $x_1, x_2, \ldots, x_n$
$x_1, x_2, \ldots, x_n$ = Independent variables (Maternal age)
Equation (1) implies,

$$\frac{p}{1-p} = e^{(\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n)} \quad (2)$$

$$p = \frac{1}{1-e^{-(\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n)}} \quad (3)$$

Additionally, the logit model is a statistical method that models the log odds of a binary outcome based on one or more predictor variables. It is a special case of logistic regression. Therefore, the logit model is generally used to model binary outcomes in study of epidemiology and is especially valuable in cases of uncommon diseases (Long, 1997). The logit function is the natural log of the odds:

$$logit(p) = \log(\frac{p}{1-p}) \quad (4)$$

The data analysis was done and all the necessary data were retrieved. The study computes the odds ratio and the data from the primary studies were extracted. The required data were collected and analyzed by using R Software Version 15.0. Therefore, we categorized maternal age into three categories in order to have better and easier interpretation of logistic regression output, see the following table 1

Table-1 Data for categorized maternal age

	Maternal Age		
Birth Defect	< 20 year	20 - 29 year	≥ 30 year
Yes	106	109	37
No	1384	3758	6516

To estimate the effects of maternal age in modeling the risks of birth defects in Zamfara State, Nigeria, we categories the maternal age as less than 20, between 20 and 29 year, and ≥ 30 years. The study used a logistic regression model and expressed the effect estimates as odds ratios (OR) and corresponding 95% confidence intervals (CI)

IV. RESULTS AND DISCUSSIONS

Table-2 Fitting Regression Model to Birth Defect data

oefficients :	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-4.9310	0.1880	-26.352	< 2e-15***
Age1	2.3544	0.2083	10.882	< 2e-16 ***
Age2	1.3742	0.1975	7.398	6.54e-13 ***
Bparity	-0.5943	0.1398	-3.974	7.35e-06 ***

From Table 2, the logistic regression model for Birth Defect is

$$\text{Log}\left(\frac{p}{1-p}\right) = -49310 + 2.3544 Age_1 + 1.3742 Age_2 + (-0.5943) Bparity \quad (5)$$

Table 2 shows that all the p-values were less than 0.05, implies that the parameters are all statistically significant, all these parameters are very important to the model. More so, since the chance of <20 year old maternal having birth defect is 0.07 without parity, this shown that the mother has an average of 0.07 chance of a birth defect and maternal age with parity has 0.04 chance of birth defect. The maternal age of 20-29 year, without parity has a chance of having birth defect of 0.028 and with parity has an average of 0.02 chance of birth defect. The maternal age of ≥ 30 year without parity has an average of 0.007 chance of birth defect, and maternal age with birth parity has an average chance of 0.004 of birth defect.

Table-3 Odds Ratios for the Birth Defect

	OR	2.5 %	97.5 %
Intercept)	0.008372587	0.00622582	0.01147792
Age1	9.620382522	6.50116854	14.5657517
Age2	4.463434359	2.99987572	6.45380754
Bparity	0.562540324	0.44049413	0.74986199

The study used the Odds Ratios to measure how the fitted probability chance between the age group. It was found from table 2 that maternal age <20 year has a significant effect on birth defect outcomes which the odds of birth defect is 10 times higher than a maternal age of ≥30 year after adjusted the birth parity. More so, maternal age of between 20 – 29 year has a 5 times greater odds of birth defect than maternal age of ≥30 year.

V. CONCLUSION

This research examined and analyzed the effects of the age of maternal and parity on adverse pregnancy outcomes in Zamfara State, Nigeria. Maternal data were categorized according to age of the maternal and number of parity. The data were analyzed using logistic regression method of analysis with R Statistical software and the results shown that the maternal age of ≥ 30 years without parity having low birth defects, followed by maternal age of 20-29 year without parity and <20 year old maternal without parity was having higher chance of birth defects. The study also established that, maternal age with birth parity, with <20 year, maternal age of 20-29 year, and maternal age of ≥ 30 years have the

following chances of birth defect, 0.04, 0.02 and 0.004 respectively. More so, it was concluded that odds ratios was used to measure the effect and relationship between the age group, the study observed that maternal group <20 year old has a 10 times greater odds of a birth defect than maternal ≥30 year old. Also, it was observed that, maternal age between 20-29 year old having an approximate of 5 time greater odds of a birth defect than maternal age of ≥30 year. Therefore, the study concluded that from the reviewed it was observed that malnutrition is the highest caused of birth defect which it was 34 – 45 % in Zamfara state and it is common among the young maternal age or pregnant mother. These study and findings are important for public health interventions and enlightening reproductive health therapy.

VI. ACKNOWLEDGMENT

The authors acknowledged Tertiary Education Trust Fund (TETfund) through the Federal Polytechnic Kaura Namoda, Zamfara State, for funding this research with a Grant Number TETF/DR&D/CE/POLY/KAURA NAMODA/IBR/2023/VOL.1

VII. REFERENCES

[1] Adane, F.; Afework, M.; Seyoum, G.; Gebrie, A. (2020). Prevalence and associated factors of birth defects among newborns in sub-Saharan African countries: a systematic review and meta-analysis. Pan Afr. Med. J. 36(19). doi: 10.11604/pamj.2020.36.19.19411. Available online at: https://www.panafrican-med-journal.com//content/article/36/19/full

[2] Adetayo, A. (2015). Congenital Abnormalities in Nigeria: Causes, Prevalence, and Solutions. African Journal of Medicine, 44(1), pp. 1-9.

[3] Ajayi, A. I.; Afolabi, B. (2019). Maternal Nutrition and Congenital Defects in Northern Nigeria: The Case of Zamfara State. Afr. J. of Repro. Health. 23(1), pp. 56-64.

[4] Ahmed, H. O.; Ogungbe, S.A.; Yakubu, A. (2013). Environmental Contamination from Artisanal Gold Mining in Zamfara and Its Impact on Health. J. of Environ. Sci. Pollut. Res. 20(8), pp. 5556-5565.

[5] Benjamin, B. G.; Ethen, M. K.; Van Hook, C. L., et al. (2010). Gastroschisis prevalence in Texas 1999–2003. Birth Defects Res A Clin Mol Teratol., 88, pp. 178–185.

[6] Bello, B.; Kolawole, A. O.; Yakubu, A. A. (2016). Impact of Lead Exposure on Maternal and Child Health in Zamfara, Nigeria. J. Environ. Toxicol. 12(4), pp. 198-209.

[7] Brown, M. J.; Durant, J.; Gidado, S. (2010). Lead Poisoning in Zamfara: Environmental and Health Interventions. CDC Reports on Toxicol. Environ. Med. 2(3), pp. 67-74.

[8] Centers for Disease Control and Prevention CDC (2010). Outbreak of Acute Lead Poisoning Among Children Aged <5 Years - Zamfara, Nigeria. MMWR Weekly Report. 59(27), pp. 846-850.

[9] Centers for Disease Control and Prevention (CDC). (2022). Birth Defects Data. Retrieved from CDC website. CDC.gov.

[10] Chabra, S.; Gleason, C. A.; Seidel, K.; Williams, M. A. (2011). Rising prevalence of gastroschisis in Washington State. J Toxicol Environ Health A., 74, pp. 336–345.

[11] Chandra, P. C.; Schiavello, H. J.; Ravi B, et al. (2002). Pregnancy outcomes in urban teenagers. Int J Gynaecol Obstet., 79. Pp. 117–122.

[12] Chen, X. K.; Wen, S. W.; Fleming, N. et al. (2007). Teenage pregnancy and congenital anomalies: which system is vulnerable? Hum Reprod., 22, pp. 1730–1735.

[13] Czeizel, A. (1988). Maternal mortality, fetal death, congenital anomalies and infant mortality at an advanced maternal age. Maturitas Suppl., 1, pp.73–81.

[14] Desyibelew, H. D.; Dadi, A. F. (2019). Burden and determinants of malnutrition among pregnant women in Africa: A systematic review and meta-analysis. PLoS Med. 14(9), p. e0221712. doi:10.1371/journal.pone.0221712

[15] Dooyema, C. A.; Neri, A.; Lo, Y. C.; Durant, J.; Dargan, P. I.; Swarthout, T.; Biya, O.; Gidado, S. O.; Haladu, S.; Sani-Gwarzo, N.; Nguku, P. M.; Akpan, H.; Idris, S.; Bashir, A. M.; Misau, Y. A.; Nasidi, A.; Brown, M. J. (2012). Childhood Lead Poisoning Associated with Gold Ore Processing: A Village-Level Investigation-Zamfara, Nigeria, 2010. Environ. Health Perspect. 120(10), pp.1450-1455.

[16] Garba, F. M.; Usman, R.; Umeokonkwo, C.; Okolocha, E. C.; Yahaya, M.; AbdulQadir, I.; Oyeladun, O.; Dada, A. O.; Balogun, M. S. (2022). Descriptive Epidemiology of Measles Cases in Zamfara State—Nigeria, 2012-2018. J. Intervent. Epidemiol. Pub. Health. 5(21). Available online at: https://www.afenet-journal.net/content/article/5/21/full

[17] Gidado, S.; Biya, O.; Haladu, S.; Nguku, P. (2010). Acute Lead Poisoning Outbreak in Zamfara State, Nigeria. Nigerian J. Field Epidemiol. 5(2), pp. 77-85.

[18] Hosmer, D. W.; Lemeshow, S.; Sturdivant, R. X. (2013). Applied Logistic Regression (3rd ed.). Wiley.

[19] Kleinbaum, D. G.; Kupper, L. L.; Muller, K. E. (1988). Applied Regression Analysis and Other Multivariable Methods. PWS-Kent Publishing Company.

[20] Li, S. J.; Ford, N.; Meister, K.; Bodurtha, J. (2003). Increased risk of birth defects among children from multiple births. Birth Defects Res A Clin Mol Teratol. 67, pp. 879–885.

[21] Lo, Y. C.; Brown, M. J.; Durand, J. (2012). Lead Poisoning Due to Gold Ore Processing in Zamfara: A Case Study. PLoS Med. 9(4), p. e1001312.

[22] Loane, M.; Dolk, H.; Morris, J. K. (2009). EUROCAT Working Group Maternal age-specific risk of non-chromosomal anomalies. BJOG., 116, pp. 1111–1119.

[23] Long, J. S. (1997). Regression Models for Categorical and Limited Dependent Variables. Sage Publications.

[24] Mashuda, F.; Zuechner, A.; Chalya, P. L.; Kidenya, B. R.; Manyama, M. (2014). Pattern and factors associated with congenital anomalies among young infants admitted at Bugando medical center, Mwanza, Tanzania. BMC Res Notes., 7, p. 195.

[25] Miller, A.; Riehle–Colarusso, T.; Siffel, C. et al. (2011). Maternal age and prevalence of isolated congenital heart defects in an urban area of the United States. Am J Med Genet A. 155A, pp. 2137–2145.

[26] Morris, L. (2009) Birth defects higher in older and younger women Randy Morris February 14, https://www.ivf1.com/age-birth-defects/

[27] Nilsen, R. M.; Vollset, S. E.; Gjessing, H. K. et al. (2006). Patterns and predictors of folic acid supplement use among pregnant women: the Norwegian Mother and Child Cohort Study. Am J Clin Nutr., 84, pp. 1134–1141.

[28] Nigeria Federal Ministry of Health (2018). Lead Poisoning in Zamfara State: A Public Health Crisis. Government Press.

[29] Nigerian Ministry of Health (NMH) (2015). Lead Contamination and Congenital Health Outcomes in Zamfara State. Nat. Health Rev. 16(3), pp. 24-30.

[30] Obu, H. A.; Chinawa, J. M.; Uleanya, N. D.; Adimora, G. N.; Obi, I. E. (2012). Congenital malformations among newborns admitted in the neonatal unit of a tertiary hospital in Enugu, South-East Nigeria A retrospective study. BMC Res Notes., 5, p. 177.

[31] Oyekale, A. S. (2014). Impact of Maternal Lead Exposure on Birth Outcomes in Zamfara, Nigeria. Int. J. Environ. Res. Pub. Health. 11(9), pp. 9625-9637.

[32] Lamichhane, D. K.; Leem, J. H.; Park, M.; Kim, J. A.; Kim, H. C.; Kim, J. H. et al. (2016). Increased prevalence of some birth defects in Korea, 2009- 2010. BMC pregnancy and childbirth, 16(1), p. 61.

[33] Postoev, V. A.; Nieboer, E.; Grjibovski, A. M.; Odland, J. Ø. (2015). Prevalence of birth defects in an Arctic Russian setting from 1973 to 2011: a register-based study. Reproductive health, 12(1), p. 3.

[34] Raatikainen, K.; Heiskanen, N.; Verkasalo, P. K.; Heinonen, S. (2006). Good outcome of teenage pregnancies in high-quality maternity care. Eur. J. Public Health., 16, pp. 157–161.

[35] Reefhuis, J.; Honein, M. A. (2004). Maternal age and non-chromosomal birth defects, Atlanta–1968–2000: teenager or thirty-something, who is at risk? Birth Defects Res A Clin Mol Teratol, 70, pp. 572–579.

[36] Reichman, N. E.; Pagnini, D. L. (1997). Maternal age and birth outcomes: data from New Jersey. Fam Plann Perspect. 29, pp. 268–272.

[37] Sarkar, S.; Patra, C.; Dasqupta, M. K.; Nayek, K.; Karmakar, P. R. (2013). Prevalence of congenital anomalies in neonates and associated risk factors in a tertiary care hospital in eastern Indian. J Clin Neonatol., 2, p. 131.

[38] Sokal, R.; Tata, L. J.; Fleming, K. M. (2014). Sex prevalence of major congenital anomalies in the United Kingdom: A national population-based study and international comparison meta-analysis. Birth Defects Res A Clin Mol Teratol., 100, pp.79–91.

[39] Smith, G. C. S. (2012). Maternal and Child Health: Study on Parity and Health Outcomes. University Press.

[40] Tinker, S. C.; Gilboa, S.; Reefhuis, J.; Jenkins, M. M.; Schaeffer, M.; Moore, C. A. (2015). Challenges in studying modifiable risk factors for birth defects. Curr. Epidemiol. Rep., 2, pp. 23–30.

[41] Venter, P. A.; Christianson, A. L.; Hutamo, C. M.; Makhura, M. P.; Gericke, G. S. (1995). Congenital anomalies in rural black South African neonates A silent epidemic? S Afr Med J., 85, pp. 15–20.

[42] Wu, J., Springett, A., and Cooper, N. (2016). Maternal age and the risk of birth defects: A logistic regression analysis. Journal of Maternal-Fetal and Neonatal Medicine, 29(8), pp. 1323-1330.

[43] World Health Organization (2015). The Selection and Use of Essential Medicines: Report of the WHO Expert Committee, 2015: including the 19th WHO Model List of Essential Medicines and the 5th WHO Model List of Essential Medicines for Children WHO. 2015

[44] World Health Organization (2016). Breastfeeding in the context of Zika virus: interim guidance. 2016.

[45] Zīle, I.; Villeruse, R.; Trope, L.; Vetra, A. (2013). Maternal age-associated congenital anomalies among newborns: a retrospective study in Latvia, Medicina (Kaunas). https://pubmed.ncbi.nlm.nih.gov/23652715