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**A SYSTEMATIC REVIEW AND META-ANALYSIS OF POTENTIAL FACTORS AFFECTING INFANTS BIRTH WEIGHT.**

**“Maternal Smoking and Infant’s Birth Weight”**

**BY**

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# Dedication

This project work is dedicated to almighty God, the one whom all good and perfect gifts come from, in him there is no variableness neither shadow of turning. Also, to my late father MR O.E. ADENIGBA whom this year marks his 15th year death anniversary, may his gentle soul continually rest in perfect peace.

# Abstract

**Objectives**: The purpose of this project is to investigate the prevalence of infants' low birth weight and its association with maternal smoking and other factors affecting birth weight.

**Study Design**: US Birth 2016-2018, this research identified infants whose mother smokes, stopped smoking, and didn’t smoke during pregnancy (and their birth categories), 278711 (7.9%) infants with low birth, 3233101 (92.1%) infants with normal birthweight.

**Methods**: Correlation analysis was used to estimate the degree of association among factors affecting infant birth weight and general linear regression was used to investigate the significant level of effect of each factors affecting infant birth, Factors with high information about infant’s birthweight were selected using the Variable/Model selection criteria (AIC).

**Findings**: The sample of 3,511,812 women contained 282,349 pregnant women who smokes daily during pregnancy, 3,217,052 pregnant women who didn’t smoke during pregnancy, and 12,411 pregnant women who stopped smoking during pregnancy**.** The degree of association between maternal smoking and infant’s birthweight remains minimal. However, there were statistically significant differences in infant’s birthweight with the shifts in rate of maternal smoking during pregnancy (P-value < 2.2e-16). Shifts in gestation periods shows a significant difference in the infant’s birthweight with P-value < 2.2e-16. High level of cigarettes smoking during pregnancy resulted to 7.9% prevalence of low birth weight as observed in this study.

**Research implications:** The percentage of infants with low birth weight from mothers who smoke daily during pregnancy is less than those who didn't smoke during pregnancy. It turns out that the amount of changes that occur in birth weight is not majorly determined by how often a pregnant woman smoke, and this suggests there are combinations of other factors that affect infants' birth weight.

**Conclusion:** The research results are concerning infants birth weight and potential factors affecting it, furthermore, the research confirms the significant level of all the factors in data set as a whole, and a well as individually**.**

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Table of Contents

[i. Dedication 2](#_Toc92463927)

[**ii.** Abstract 3](#_Toc92463928)

[**iii.** **Acknowledgments** 4](#_Toc92463929)

[**LIST OF TABLES** 5](#_Toc92463930)

[**LIST OF FIGURES** 5](#_Toc92463931)

[**REPOSITORY LINK** 6](#_Toc92463932)

[**Chapter One** 6](#_Toc92463933)

[1. INTRODUCTION AND PROBLEM DEFINITION 6](#_Toc92463934)

[1.1 Background of Study. 6](#_Toc92463935)

[1.2 AIM AND OBJECTIVES 10](#_Toc92463936)

[**1.2.1** **Aim** 10](#_Toc92463937)

[**1.2.2** **Objectives** 11](#_Toc92463938)

[1.3 Proposed Research Questions: 11](#_Toc92463939)

[1.4 Significance of The Study 11](#_Toc92463940)

[**Chapter Two** 11](#_Toc92463941)

[**2. LITERATURE REVIEW** 11](#_Toc92463942)

[2.1 Low Birthweight 12](#_Toc92463943)

[2.2 Maternal Smoking and Weight loss 12](#_Toc92463944)

[2.3 Maternal Weight Loss and Child’s Birthweight 13](#_Toc92463945)

[2.4 Maternal Smoking and Child’s Birthweight 14](#_Toc92463946)

[2.5 Maternal Smoking and Its General Effects 16](#_Toc92463947)

[2.6 The Impacts of Maternal Infections on Child’s Birth Weight 19](#_Toc92463948)

[2.7 Pregnancy Length and Birthweight 21](#_Toc92463949)

[2.8 Socio Economic Factors 22](#_Toc92463950)

[2.9 Literature Summary. 23](#_Toc92463951)

[**Chapter Three** 24](#_Toc92463952)

[**3** **Research Methodology** 24](#_Toc92463953)

[3.0 Research method 24](#_Toc92463954)

[3.1 Sources and Method of Data Collection 25](#_Toc92463955)

[3.2 Limitation and Potential Data Problem 25](#_Toc92463956)

[3.3 Statistical Tools 25](#_Toc92463957)

[3.4 Data Preparation 26](#_Toc92463958)

[3.5. Statistical Methods 27](#_Toc92463959)

[**3.5.1. Exploratory Data Analysis** 27](#_Toc92463960)

[**3.5.2 Pearson Product-Moment Correlation. 28**](#_Toc92463961)

[**3.5.3 Assumptions of Pearson correlation 29**](#_Toc92463962)

[**3.5.4 Pearson correlation in R 30**](#_Toc92463963)

[**3.5.5 Simple Linear Regression Analysis (Bivariate/Multivariate relationships) 30**](#_Toc92463964)

[**3.5.6 linear regression in R. 30**](#_Toc92463965)

[**3.5.7 Reasons for Regression Model 31**](#_Toc92463966)

[**3.5.8 Variable Selection and Model Building Criterion. 31**](#_Toc92463967)

[**3.5.9 Implementation of Variable Selection criteria (AIC) in R. 31**](#_Toc92463968)

[**3.5.10 Hypothesis Testing 32**](#_Toc92463969)

[**Chapter four** 32](#_Toc92463970)

[**4.** **Results and discussion** 32](#_Toc92463971)

[4.1 Descriptive Statistics. 33](#_Toc92463972)

[4.2. Descriptive Statistics for Selected Key Variables 34](#_Toc92463973)

[**4.2.1** **Birth Weight.** 34](#_Toc92463974)

[**4.2.2** **Gestation Period.** 36](#_Toc92463975)

[4.3 Correlation Analysis. 37](#_Toc92463976)

[**4.3.1** **Correlation Coefficients.** 38](#_Toc92463977)

[4.4 Regression Analysis 39](#_Toc92463978)

[4.5 Variable/Model Selection 43](#_Toc92463979)

[4.6 Impact of Maternal Smoking Rate on Infants’ Birth Weight 44](#_Toc92463980)

[4.7 Impact of Gestation Period on Infants’ Birth Weight 46](#_Toc92463981)

[4.8 Discussion. 46](#_Toc92463982)

[**Chapter five** 48](#_Toc92463983)

[**5.** **Conclusion.** 48](#_Toc92463984)

# **LIST OF TABLES**

**Table 1. Strength of Associations (Pearson’s Correlation Coefficient) …….… 23**

**Table 2. contingency table (Smoking Rate / Birth Weight) …………..……….. 29**

**Table 3. contingency table (Gestation Period / Birth Weight) …………………30**

# **LIST OF FIGURES**

**Figure 1. Data analysis …………………………………………………...……… 20**

**Figure 2. Types of Association …………………………...……………………… 22**

**Figure 3. General Data structure ………………….……………………………. 28**

**Figure 4. Distribution of maternal smoking rate & Birth weight …………..… 29**

**Figure 5. Distribution of infants Birth weight………………………………..…. 30**

**Figure 6. Distribution of gestation period ………………………….…………… 31**

**Figure 7. Correlation Plot ……………………………………………………….. 32**

**Figure 8. correlation plot (Coefficients) ………………………….……………... 33**

**Figure 9. Model 1. Multiple linear regression …………………..……………… 35**

**Figure.10. Model 2 Multiple linear Regression …………………...……………. 36**

**Figure. 11 Model 2.1 linear Regression (Bivariate) ………………….………… 37**

**Figure 12. Mosaic Plot (maternal smoking rate and infants birth weight) …... 38**

**Figure 13. model 2.2 linear Regression (Bivariate) …………………………….. 39**

**Figure 14. Mosaic Plot for Gestation Period………………..…………………... 39**

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**https://gitlab.uwe.ac.uk/sa2-adenigba/dissertation-codes\_rmarkdown\_and\_python**

# **Chapter One**

# 1**. INTRODUCTION AND PROBLEM DEFINITION**

## 1.1 Background of Study.

It is now well accepted that a child's birth weight is a vital predictor of the child's survival and a valuable indicator of both the baby's growth and development. Premature infants with low birth weights represent a population frequently exposed to transfusions and extremely susceptible to complications and mortality. It is also a critical component that can affect the mother's health, nutrition, and quality of life. More than 9 million babies die each year, 98% of the death which occur in developing countries are mostly caused by low birthweight. Low birthweight (< 2,500 grams), of infants or preterm increases the risks of neonatal mortality and infant mortality, poor cognitive development, stunting, and lifelong susceptibility to non-communicable diseases. Low birthweight remains a major public health problem. Low birthweight can be caused by a variety of factors depending on the scenario, such as preterm babies, baby born more than three weeks before their anticipated due date. A preterm birth, in other terms, is one that happens before the 37th week of pregnancy. Drugs taking before and during pregnancy such as antipsychotic drugs, infection of the mother uterus such as rubella, serially transmitted infection, exposure to passive smoking, maternal illiteracy, previous LBW baby, shorter inter-pregnancy interval, maternal weight, late childbearing, weight gain during pregnancy, eating disorder of the mother. However, information obtained from Kaggle, one the of world's largest data science community with powerful tools and resources categories the causes of Low birthweight into the following: Cigarettes smoking Before Pregnancy, Cigarettes smoking during Pregnancy, Mother’s Hispanic Origin, child’s birth month, Father’s Hispanic Origin, Number of Maternal Morbidity. Most Low birthweight have been caused by a whole lot of factors. Healthy Birth weight is of primary importance in the early stage of growth of a child, because of the first question always being asked by parents after the sex of their newly delivered baby is announced is “how much did my baby weigh?”. A big baby according to the common saying is a healthy baby. Therefore, prominent among the factors responsible for low birthweight are highlighted and discussed below:

1. **Maternal Illiteracy:** several previous research shows the association between maternal education and low childbirth weight. Most pregnant women seek healthcare from the roadside or private healthcare providers in developing countries. Most of them are not certified and buy medicines from private pharmacies without a proper prescription from the formal medical trained healthcare provider. research shows how a new baby from a remote village in northern India presented with exogenous Cushing syndrome. This baby was a full-term low birth weight delivered by a private/roadside healthcare provider. As the baby was not growing well, treatment was started by a private doctor with no formal medical training. The mother, on her own volition, continued giving the betamethasone drops by buying the medicine over the counter from a private pharmacy. this case shows the importance of improving the health services in developing countries and prioritizing secondary education for women as one of the approach essential for increasing maternal literacy.
2. **Exposure to Passive Smoking:** smoking before and during pregnancy is susceptible to delivering a full-term low birth weight child. Few studies in UK have shown and rated Passive Smoking before and during pregnancy as the major factor causing low birth weight. The side effect of exposure to passive smoking cannot be over emphasized. This causes obstetric complications, such as spontaneous abortions, ectopic pregnancies, preterm birth, placenta previa, abruptio placentae, and premature rupture of membranes. Exposure to passive smoking also induces early morphological changes of the placenta, which results to reduce in maternal space between chorionic villi and reduces the amount of blood flow through the umbilical artery from the foetus to the placenta. This result in a smaller head circumference at birth.
3. **Late Childbearing:** After adjustment for maternal complications and other risks due to preexisting medical disorders which tend to exacerbate with age, such as hypertension, cardiovascular problems, diabetes, kidney disease and uterine fibroids. There has been compelling evidence that delayed childbearing or late childbearing is significantly associated with an increased risk of poor pregnancy outcomes or late childbearing. Technologies, economy, and other social changes have increase women reproductive freedom, and these changes are more likely to have actively influenced the decision of women to postpone childbearing beyond normal.
4. **Shorter Inter-Pregnancy Interval**: The time between the delivery of a new live born child and the beginning of the next pregnancy is a potential factor of adverse delivery and birth outcomes. Women who go through Short interpregnancy interval experience loss of stores of important nutrients, such as folate, which are supposed to be adequately replenished before new pregnancies, hence this leads to poor health of the mother and fetus. Studies shows significant difference in the birthweight of the first and second born infant in pregnancies affected by shortened Inter-Pregnancy Interval, the second pregnancy outcome was affected.
5. **Maternal Weight Gain:**Several investigators have studied the relationship between maternal weight gain and birth weight either directly or indirectly. The finding shows that Pregnant women with inadequate maternal weight gain often resulted in low baby birth weight and increased the number of deaths of the fetus. On the other hand, an excessive increase in maternal weight gains also resulted in poor fetal outcomes and affected the delivery methods later.
6. **Maternal Eating Disorders**: This is defined as a persistent disruption of eating or eating-related behaviors during pregnancy that results in changed of food consumption or absorption, compromising physical or psychological health. Previous studies of the relationship between maternal eating disorders and adverse perinatal outcomes have showed that there is significant relationship between eating disorder and birth weight of a child, the study also showed that eating disorder could either lead to underweight or overweight.
7. **Quality of maternal Care**: The quality of follow-up maternal care received during pregnancy is a vital predictor of a child birthweight. According to research, more than a third of pregnant women who do not receive sufficient care give birth to babies who are underweight. A focus on maternal nutrition and care, would go a long way in reducing the problem of low birthweight in the community, thereby assuring a safe and healthy future for the next generation.
8. **Maternal infection:** **some studies have provided a consistent result for the association between maternal infection and low birth weight. On the other hand, other research showed no association was found between any maternal infection and diagnosis with the offspring. In studies, significant associations were found; maternal infection is generally regarded as one of the more plausible risk factors for schizophrenia, given that microbial pathogens have been documented to cause congenital brain anomalies and a variety of learning and behavioral disorders in childhood. For many years, it has been known that people who have been exposed to rubella, toxoplasma, and other infections during pregnancy are at substantially increased risk of neurodevelopmental disorders, including mental retardation, learning disabilities, sensorineural dysfunction, and structural brain anomalies.**

**1.1.1 Socio-Economic Effect of low birth weight**

Several aspects of low birthweight have significant effect, which they have adverse impact on the economic and social welfare of a nation. The effect on the economy usually takes the form of costs which under certain circumstance can be measured. Some of these costs; private costs are born by parents and family of the children affected, while others are social in nature in that society, or the government bears them. In this section, the study examines specific Socio-Economic effects of low birth weight.

1. **Medical Bills for Treating the Affected Baby**: Medical bills of affected babies are some of the adverse effects of children with low birth weight. Treatment in the children ward with complications are time consuming and expensive. High medical bills could convincingly lead to withdrawal of untreated babies from the hospital increasing the number of mortalities in the community.
2. **Unavailability of space for new patients in the hospital:** Children delivered with low birth weight are often delayed in discharge from the hospital due to complications with both the mother and the child. The clinical impression is that low birth weight children are often delayed growth and short stature and are expected to be treated and corrected before being discharged.
3. **General growth:** Due to correct and normal birthweight, urban children grow taller and faster than their rural peers, according to research. A wide range of social-economic determinants have been linked to children's physical development in proportion to their birthweight, according to studies. Parental occupation, income, education, birth order, family size, and urbanisation are among the variables.
4. **Hospitalization:** Due to high risk of complications and mortality of children with low birth weight, the number of children being hospitalized increases as the number of cases increases daily. It is an important part of achieving better health outcomes and controlling long-term health care by hospitalizing and ensuring that patient could see a qualified health provider within a reasonable period. However, it has now apparent that the major limit to treatment capacity is not only the number of hospitals, nor even the number of intensive care beds, it is also the number of appropriately skilled nurses available to provide care. All these therefore point to the risks of not having enough equipment’s and registered nurses on duty which poses high annual hospital management cost on the government.

## 1.2 AIM AND OBJECTIVES

### **1.2.1 Aim**

The aim of this project is investigating various factors affecting child’s birthweight, considering cigarette smoking as case study and recommend ways of reducing the loss of child’s birthweight to the institutions concerned for child’s birth management and the child-bearer.

### **1.2.2 Objectives**

The objectives of this project are to.

1. Identify the factors that causes loss of child’s birthweight.
2. Determine the degree of association between factors that causes changes in infants’ birthweight.
3. Identify the risks involved in the growth of a child with low birth weight
4. Investigate whether the effect of maternal smoking during pregnancy on infant’s birthweight is significant.
5. Investigate the mean difference in the effect of smoking and other factors responsible for low birth weight.

## 1.3 Proposed Research Questions:

1. What are the factors that causes loss of child’s birthweight?
2. Is smoking a significant factor in birthweight of a child?
3. How does smoking affect the birthweight/growth of a child?

## 1.4 Significance of The Study

This study aims to identify the effect of smoking before and during pregnancy on the weight of the newborn and other pregnancy.

# **Chapter Two**

# **2. LITERATURE REVIEW**

**Introduction to literature**

This chapter highlights and discusses the contributions of other researchers on the matter of smoking and other factors that affects child birthweight, this chapter will also highlight and investigate methods applied in determining the factors that determines child’s birthweight. This will furnish us with a better understanding of the problem associated with low birth weight and factors which can well predict the birthweight of a baby such as prenatal and postnatal exposure to tobacco smoke and help define and support the direction of the research. Additionally, this chapter highlights various statistical test and methods applied in finding the relationships between potential factors that can well predict birthweight.

## 2.1 Low Birthweight

In a recent study (WHO, 2014), Low birth weight is a significant public health problem globally and is associated with a range of short- and long-term consequences. Overall, it is estimated that 15% to 20% of all births worldwide are low birth weight, representing more than 20 million births a year. The issue of low childbirth weight is not only common to one specific area in the United Kingdom, but it is a universal hazard in almost all part of the world. It is obviously of great social and economic concern, and it has increasingly become a topic for scientific investigation.

The discussion of and about Low birthweight and factors responsible for it has received huge scholastic attention and research in the past.

## 2.2 Maternal Smoking and Weight loss

Prenatal exposure to tobacco smoking is a major risk factor for the newborn. It has been proven that smoking is a major factor that affect the body weight, people who often smokes’ claim that they use smoking to control their weight because they believe smoking cigarettes suppresses their frequency of food and liquid intake, they also claim that smoking changes their general eating behavior. Williamson et al 1991 observed that smoking cessation in women can result in weight increase of about 4 kg or more in the women. This they said, varied on certain factors especially the body make up of such women as this increase can be considerably higher in some women. Ohlin et al, who conducted research entitled Stockholm Pregnancy and Weight Development Study found out that women who stopped smoking when they learnt of their pregnancy gained about 17% more weight at delivery more than those who quit smoking. Also, that 35% of those who had quit smoking retained more than 5kg a year after delivery as against 11 to 12% for non-smokers and smokers. Using the framework proposed by Baron and Kenny (1986), which deals with a series of multiple logistic regression models with SAS-callable program, Li et al (1997) considered children of ages 2 to 15 of Hispanic, Black, and White origins and checking out for their BMI.

From the foregoing, one can easily notice that the challenges that come with smoking during pregnancy are multifaceted and that they have been met with a wide range of reaction from scholars, researchers, and critics. Jauniaux and Burton also hold that cigarette and tobacco smoke have huge effect on placental make up, which is caused by the restriction of placenta growth brought about through smoking. According to them, the chemicals contained in tobacco smoke have huge negative impacts such as altering trophoblast proliferation and differentiation. They opine those substances such as nicotine, cadmium, metallothionein (MT) Fowles and Bates (2000). These substances are harmful to the human body. Nicotine for instance, is said to utterly depress amino acid uptake by human placenta villi. Yang et al (2006) discovered that tobacco smoke is a new class of endocrine disruptors which have drastic effect on mammalian reproduction. Metallothionein, which is found in high level in the body of smokers as against non-smokers.

## 2.3 Maternal Weight Loss and Child’s Birthweight

It has been established by some scholars that timing and cessation in the manner of smoking has a way of influencing the weight and eventual health condition and weight of a newborn. Smoking does not just have immediate effects on the child but also bear huge consequences on the mother. These effects range from the eating habits and rate, nausea and even the bodyweight of the mothers themselves. (Williamson et al 1991; Clark 1999 and Ohlin 1990).

This however is highly contentious as some other scholars and researchers have divergent opinions and discoveries. While some hold that women who quit smoking before pregnancy or within the period of their first trimester bears no additional risks than non-smokers while some researches have established that others women who have, at any point engaged in thorough smoking are at risk of birthing a low weight baby (LWB), even when they have quitted before pregnancy as against those who did not smoke at all, who stand much less chances. Prenatal smoking might affect the cognitive abilities of the child because of the huge impacts it bears on the weight of the child. It is important to note that metabolites of cigarette serve as blockages for blood flow (Suzuki, Minei & Johnson). This, as such limits and affects the amount of oxygen and other key nutrients that reach the fetus, and ultimately resulting into intrauterine growth retardation. In a similar study conducted by Jauniaux and Burton (2007), it was concluded that cigarette smoking has disastrous effect on the general wellbeing and that it has substances and contents that are liable to destroy key body parts and impede growth. While considering the effect of maternal smoking on placenta anatomy, Jauniaux and Burton hold that the damage caused by maternal smoking can be realized and detected as early as the first trimester and that chronic exposure of the placenta tissue to tobacco smoke is closely related and can be likened to changes found in the organs of heavy smokers who are adults. Demir et al (1994) hold that the placenta villi from smokers display abnormalities of the microvilli, focal syncytial necrosis, decreased syncytial pinocytotic activity as well as degenerate cytoplasmic organelles. These morphological changes caused by maternal smoking have however spurred contentious reactions from scholars and researchers and they have been met with varying discoveries and opinions. For instance, Burton (1992) and Larsen et al (2002) concluded that no deformation whatsoever was found in the pattern of lobation not any incidence of infarcts whereas, some have suggested that such infarcts is very low among smokers.

## 2.4 Maternal Smoking and Child’s Birthweight

It was discovered, after putting variations like age, sex, ethnicity, breastfeeding, gestational ages, education and others into consideration, maternal smoking during pregnancy was said to be hugely associated with childhood overweight as of birthweight accounted for 14% of the total effects of maternal smoking on childhood overweight cases.

Most countries with a high percentage of cigarette smoking during pregnancy have witnessed uncontrolled Low birthweight of infants small-for-gestational-age increasing the risks of neonatal mortality and infant mortality. Smoking is a threat to the health of the expecting mother and even her child. Products associated with smoking are no doubt responsible for the many complications that arise during childbirth process. Some of these complications are harmful or painful pregnancy outcomes, increase in infertility rate, placenta anomalies, undue delay in conception, premature rupture of membranes, delivery before due time, decreased duration of breastfeeding, stillbirth, and many others. Pre-natal smoking is responsible for 30% of small gestational age infants and 10% of preterm infants (Tong et al 2009). Also, according to the US Department of Health and Human Services, children who weighed less than 2500 grams at birth have been linked to pre-natal smoking. Many research carried out have established that reduction or stopping smoking during pregnancy results into a better and improved birth outcome as opposed to those who did. Smoking is inextricably linked to having babies with low weight who on most cases, die or suffer some chronic deformities before their first birthdays. A good number of research have been carried out in relation to how smoking during and after pregnancy affects the health of babies. Examples are of such studies are Kramer 1987; Mortensen et al 2003; Kim and Saada 2013; Mazurek and England 2016; Difraza and Lew 1995; Salihu and Wilson 2007; Kyrklund et al 2005; Tikkanen et al 2006; and numerous others. Most of these studies considered different aspects and factors that relate with smoking. For example, some of them considered the age range or educational levels of their while some others delved more on the race or nationality of the women. Pregnancy is an optimal time to promote smoking cessation because many women are concerned about the potential effects from smoking on their fetus. A wide variety of interventions have been used to promote smoking cessation during pregnancy. A recent meta-analysis, however, revealed that these interventions result in only about a six percent reduction in smoking (Lumley et al., 2009). Best practice interventions have had limited impact on pregnant women who are heavier smokers, poor, undereducated and have social networks with many smokers (L. Bullock et al., 2009). Spontaneous quit rates vary from 11% to 28% among publicly insured smokers and 40% to 65% among privately insured pregnant smokers (Melvin & Gaffney, 2004). In research conducted by Robl (2012) on women in their childbearing ages in Kentucky, she stated that compared to women who did not smoke in the three months prior to pregnancy,

women who continued to smoke had increased odds for low birth weight, preterm birth, NICU admission and no breastfeeding initiation. Women who reduced their tobacco exposure by at least 50% or quit smoking by the third trimester had increased odds for low birth weight and no breastfeeding initiation only. The odds were highest for adverse birth outcomes among women who continued smoking and lowest for women who quit smoking. These findings suggest that while cessation of tobacco use is the goal of interventions that reduction in tobacco use is also associated with better birth outcomes.

Action and Smoking and Health & the Smoking in Pregnancy Challenge Group. (Getting back on track: delivering a smoke-free start for every child, February 2021) When a woman smokes during pregnancy or is exposed to secondhand smoke, oxygen to the baby is restricted, making the baby's heart work faster and exposing the baby to harmful toxins. As a result, exposure to smoke in pregnancy is responsible for an increased rate of stillbirths, miscarriages, and congenital disabilities; it is estimated that babies whose parents smoke during or before pregnancy are on average of 30-40g lighter. However, due to the addictive nature of this significant factor (Smoking in Pregnancy), (Sven Cnattingius, M.D., PhD 2004). Many women who smoke during pregnancy are using e-cigarettes as an aid to quit or cut down as e-cigarettes are significantly less harmful than cigarettes and are an effective aid for quitting. The frequent occurrence of the incident (low childbirth weight) has impelled the government to necessitate a way of how to reduce cigarette smoking, if not stop it through her agencies concerned—organizing seminars for the awareness of these significant factors such as NHS stop smoking services, ASH (smoking in-pregnancy challenge group), and MHRA (Medicines and Healthcare products Regulatory Agency)

Maternal smoking harms human placental development by changing the balance between cytotrophoblast (CTB) proliferation and differentiation. Feltes et al (2013) when considering the effect of nicotine on retinoic acid signaling cell proliferation and differentiation in the embryonic

development of maternal smokers discovered that a connection between nicotine and JNK1, which are both inducers for cell proliferation. Using a chemo-biological approach, they observed that many proteins involved in cellular responses to stress, DNA damage and inflammation are closely connected to nicotine in the created CPI network. They also considered the placenta and blood cord of passive smoking women which showed an upregulation of interleukin receptors.

## 2.5 Maternal Smoking and Its General Effects

Some researchers, however, have also considered the impact of maternal smoking and the effects it bears on ultrasound and endocrinological markers during the first trimester, claiming that there is no substantial difference between the placenta of the smokers and the non-smokers. Jauniaux and Muttukrishna (2013) for instance gathered 32 smokers and 96 non-smokers with a normal pregnancy outcome. It was gathered and discovered that there was no significant difference for the MSAFP, MSuE3 placenta thickness, basal plate surface and volume between the two groups of smokers and non-smokers. This negates the seminal discovery carried out by Bruchuva et al () who maintain that maternal smoking affects the placenta and, in most situations, lead to hypoxia. They also found that it can cause placenta previa, which is a low-placed placenta that covers part or all the cervical os or even placenta abruption in which the placental partially or completely peels away, resulting in bleeding during delivery or premature rupture of the placental membranes.

The bulk of the discoveries from the research and findings delve more on how the maternal smoking affect the weight of the child, in that the child weighs much less than other children whose mothers did not engage in smoking before and during the pregnancy period. The prevalence of obesity has continued to increase over recent decades among both children and adults, a trend that may presage reduced life expectancy in the United States. A new paradigm for understanding health risks such as obesity and cardiovascular disease has emerged in recent years, evolved from the notion that environmental factors in early life and even in utero can profoundly influence lifelong health. Maternal smoking during pregnancy is one such early life exposure that may have a persistent influence on offspring body size and cardiovascular health. Several investigators have reported an increased risk of obesity in childhood or adulthood after intrauterine exposure to maternal cigarette smoking. This association seems paradoxical, given that maternal smoking during mid- to late pregnancy reduces fetal growth and babies born smaller tend to have lower BMI and lower risk of overweight in childhood and adulthood A smaller number of studies have also reported that maternal smoking during pregnancy is associated with child blood pressure, particularly in later childhood the influence of prenatal cigarette exposure on offspring health merits additional study. Recent nationally representative data suggest that approximately one-third of U.S. women smoked within a year before becoming pregnant, and 11% smoke during pregnancy. Many women may quit smoking when planning a pregnancy yet the influence of periconceptional smoking on offspring outcomes is not known. Although this appears to be implausible, there are studies that have been carried out in the past to back up this claim. The bulk of these studies seem to agree that because most women smoke during the first trimester, especially during the first week of pregnancy, this causes them to be and bear higher odds ratios related to smoking throughout pregnancy in bivariate analyses could be explained by confounding. This is because there are greater chances of bearing overweight children when the mother smoke during the first trimester. According to Toschke et al (2003), cigarette smoking has a huge role to play in the dirt of a child. In other words, smoking plays a huge role in the diet of a child. In industrialized countries, overweight and obesity are the most common nutritional disorders with an increasing prevalence. Overweight children have a high risk for being overweight in adulthood and to experience typical obesity-related morbidity. Because therapeutic interventions for overweight in children are costly and have far from satisfactory results, the development of strategies for prevention of overweight and obesity is a major challenge for health care professionals. The relation between maternal smoking during pregnancy and overweight/obesity in children was investigated in a cross-sectional study performed as part of the 1999–2000 Bavarian school entry health examination with an extensive questionnaire on a wide range of sociodemographic and lifestyle factors possibly related to overweight and obesity in children. This study was carried out by Kries et al (2000) where they employed and self- administered questionnaires, with focus on how women who had engaged in active or passive smoking during their childbirth period affected their children, as well as other contributory activities. The prevalence of overweight and obesity for maternal smoking during pregnancy, expressed as percentages, increased with the amount of cigarettes: never smoked (overweight: 8.1, 95 percent CI: 7.2, 9.0; obesity: 2.2, 95 percent CI: 1.7, 2.7); less than 10 cigarettes daily (overweight: 14.1, 95 percent CI: 11.1, 17.7; obesity: 5.7, 95 percent CI: 3.7, 8.2); and 10 or more cigarettes daily (overweight: 17.0, 95 percent CI: 10.1, 26.2; obesity: 8.5, 95 percent CI: 3.7, 16.1). There was a dose response with respect to the numbers of

cigarettes smoked (p < 0.001). among other factors and reasons that are said to be responsible for obesity in children, according to a study carried out by where the prevalence estimates for overweight and obesity with exact confidence limits were calculated. Additionally, they assessed a possible dose-response effect for a categorical smoking variable defined by zero: no smoking parent; one: sum of smoking mothers either before or in pregnancy smoking mother at interview smoking father at interview¼1; two sum¼2; three sum¼3) with the Cochrane–Armitage trend test. The connection between maternal smoking during pregnancy and childhood obesity may strike one as being incredulous in that there has been an agelong in respect to the long-known association of maternal smoking during pregnancy and low birth weight. A tempting explanation for most of the observed findings could be the recently described impact of catch-up growth in the first years of life on childhood obesity. This has been considered by many scholars and researchers. These data have shown that children with catch-up growth had a considerably higher body mass index, skinfold thickness, and waist circumference at the age of 5 years. During the first year of life, there is rapid catch-up growth regarding weight in children of mothers who smoked during pregnancy. A high weight gain was associated with an increased risk for overweight and obesity. If weight gain instead of birth weight was included in the model, the odds ratio for maternal smoking throughout pregnancy changed only marginally, however, suggesting that catch-up growth does not explain the effect of maternal smoking during pregnancy. What this suggests is that weight gain for children is not necessarily caused by maternal smoking but other factors too as children after their birth engage in other activities such as junk consumption, sedentary lifestyles, high sugar intake and so on. Suzuki et al (2009) conducted a study that focused on children aged 9-10 where they concluded the children whose mothers had smoked during early pregnancy exhibited an independent elevated risk for obesity when compared with children whose mothers were former and never smokers. They also found out that the association of maternal smoking during pregnancy with childhood obesity at five years of age persisted to the age of 9-10 years of age. In their analysis, maternal smoking status was associated with overweight in the children aged 9-10 years (adjusted R, 1.91; CI,1.47-3.16).

## 2.6 The Impacts of Maternal Infections on Child’s Birth Weight

Another important factor deserving of consideration is infection. Infections play no small role in affecting the wight of children at birth. Pregnancy-associated Plasmodium falciparum malaria remains a major public health problem in endemic regions. In Africa for instance, 24 million pregnancies are threatened every year by malaria. Pregnant women are at significantly greater risk of being infected with P. falciparum than non-pregnant women, and among pregnant women, P. falciparum infection is more often seen in pauciparous and in the youngest. Pregnancy-associated P. falciparum infection is one of the major causes of morbidity, and mainly low birth weight in areas of intense malaria transmission. Low birth weight (less than 2,500 g) constitutes the most important risk factor for infant mortality. In case of malaria infection of the placenta an immune tolerance phenomenon has been described as responsible for the higher susceptibility of newborns to malaria infection during the first months of life. Mutabingwa et al (2005), Le Port et al (2011) According to research that was carried out by Adenigba et al. (2006), malaria infection, with particular focus on P. falciparum, they established that the birth weight of newborns from mothers with CRP levels \_ 6 mg/L was significantly lower (2,913 ± 230 g) compared with those from mothers with CRP levels less than 6 mg/L (3,174 ± 394 g, P \_ 0.0001). Similarly, the proportion of children with a low birth weight born to women with CRP levels that marked systemic inflammation (greater than 6 mg/L) was significantly higher (17%) than in women who had no evidence of inflammation (6%, P \_0.031. Previous studies Steketee et al (1996), Menendez (1995) Singh et al (2001) Luxemburger et al (2001) have also established that even asymptomatic P. falciparum infections during pregnancy play an important role in the pathogenesis of low birth weight. In a similar study, the impact of HIV virus and other related infections and its eventual effect on the body weight of children was the focus of Newell et al (2006). In the paper, they considered the impact of HIV on the growth pattern of 1587 children, where it was discovered that Differences in growth velocities between the infected and uninfected children increased after 2 years of age for height and after 4 years of age for weight and were more marked in the latter. Between 6 and 12

months, uninfected children grew an estimated 1.6% faster in height and 6.2% in weight than infected children; between ages 8 and 10 years, these figures were 16% and 44%, respectively. By 10 years, uninfected children were on average an estimated 7 kg heavier and 7.5 cm taller than infected children.

Also, a study done by Berhane et al. (1997) they also discover that HIV has a way of affecting the weight of a child as children who were HIV + weighed much less than those that were not. Using Of the 459 patients with known HIV status, 51.9% were male and 48.1% were female. A total of 3820 weight measurements and 3811 length measurements were available for ages 0 to 25 months (mean of 8.3; range 1–11 measurements/child). Apgar scores, Dubowitz scores, gender, socioeconomic status, duration of breastfeeding, and ethnic background were not different between HIV1 infants, seroeverters and HIV2 controls. The three weight-for-age curves are significantly different (P, .0001). The weight-for-age curve for HIV1 children differs significantly from that of HIV2 controls and of seroeverters (P 5 .0012 and P, .0001, respectively). At six months of age, HIV1 children had a significantly lower mean weight than both HIV2 and seroeverters (P 5 .004 and P 5 .027). Similarly, (see Fig 2), differences are noted in the length-for-age curves between HIV1, HIV2 and seroeverters (P,.0001). As it must have been noticed already, infections and diseases greatly affect the weight of newborns. This, and some other factors remain the reason why sexually transmitted infections remain one of the health problems all over the world. As much as early treatment of this infections is advised, there is usually little interventions that can be made. In research carried out by Chawlar et al (1998) in Harare, Zimbabwe, they observed that because of the slow detection of syphilis at the initial stage, it makes it difficult to be quickly. Among other congenital issues that arise because of syphilis

Other infections such as sepsis, meningitis and intrauterine infections can cause low birth weight for children. Some researchers have even stated that in some cases, infections treated can cause extreme low birth weight (ELBW) for children. Infections cause huge challenge among VLBW preterm infants. Previous studies from the NICHD Neonatal Research Network have demonstrated that as many as 25% of these infants have one or more positive blood cultures

and about 5% have a positive cerebrospinal fluid culture over the course of their neonatal hospitalization. Rates of infection increase with decreasing birth weight and gestational

age. Moreover, postnatal infection is associated with an increased risk of neonatal complications, prolonged hospitalization, and death. In an analysis conducted by Stoll et al (2006), infants in the sepsis alone group were classified by the following pathogen types: coagulase negative staphylococci; other gram positive; gram-negative; fungal; and combinations (episode of infection, each with a different pathogen, or polymicrobial bacteremia); and compared with uninfected infants. This goes to show that infections are great determinants and contributory factors to low birth weight in children. Most of the surveyed studies align in their discoveries in that infections contribute largely to the weight of the child. Gonorrhea for instance, among other complications such as higher risk of prematurity, fever in the puerperium and delayed intra-uterine growth which led to eventual weight loss upon and after the child’s delivery. Prematurity rate of women with Gonorrhea during and after pregnancy is usually between 12% and 40%. Edwards et al (1978) reported that there is an increase in prematurity rate, especially in women with positive intrapartum cultures. Although Stoll et al (1982) found no notable difference in birth weight and gestational age and weight at delivery for women with and without gonorrhea during pregnancy, some other studies such as Amstey and Steadman (1976) Donders et al (1993) have linked the infection to a sharp reduction in the weight of the babies. Dewey and Meyers (2011), states that the negative impacts of infections on growth can be reduced by strengthening the immune system; compensating for malabsorption, reallocation, or losses of key nutrients; allowing for catch-up growth following infection; enhancing appetite; and favoring the growth of beneficial gut microorganisms.” (p.136). Molbak et al (1997) provide a thorough research on the effect of Cryptosporidium infection on selected children in a community in Guinea-Bissau in Africa. In the study, they established that cryptosporidium parvum causes dire diarrhea among children in many developing countries. When the findings were conducted on children slightly younger than the age of 3, there were no significant effect on weight and height: P= 0.16 and P= 0.38 respectively. However, cryptosporidiosis in infancy was accompanied by 392g of weight loss in boys and 294g in girls. The conclusion of the study was that there is always the case of an unredeemable effect of growth if the infection takes place during the infant stage.

## 2.7 Pregnancy Length and Birthweight

The possibility that the low birth weight of infants of women who smoke during pregnancy could be attributed to the length of gestation. This element may be affected by a variety of factors associated with the variability and developmental potential of premature infants, those born at term and those born later than the standard gestation period. According to Tina Gutbrod et al. (2019), In their retrospective study of the effect of gestation and birth weight. Confirmation of the findings that smoking has little or no effect upon the duration of gestation. However, the relationship between the gestation period is significant. As nephron development is typically complete around 36-39 weeks of pregnancy, infants with shorter gestations are particularly susceptible to lower birth weights. More studies show that preterm infants performed more poorly in weight than full-term infants.

## 2.8 Socio Economic Factors

Another factor that may be responsible for child weight loss is severe malnutrition and some other socioeconomic factors such as illiteracy, lack of breastfeeding, low feeding, and some other factors. Low birth weight remains a huge maternal challenge in many instances. Nutrition even before and after childbirth is said to be the main cause and should be taken care of.

Birth weight, to a reasonable extent, shows mothers’ health status and nutritional status, which consequently predicts the future growth and development of the child. The role of education and knowledge in this regard cannot be overemphasized, in that it is the knowledge that the mother has that helps in building and bringing forth a healthy child. Being born with LBW is generally recognized as a disadvantage for the infant. Among all neonatal death 60 to 80% occur due to LBW. It is an important cause of perinatal mortality and both short- and long-term infant and

childhood morbidity. Mortality rate of LBW infant were up to 40 times higher than infants with birthweights of at least 2500 g, and they are many times more likely to end up with long-term handicapping conditions Antenatal care, for instance are crucial to determine and quickly detect risks and danger and treat them accordingly. A mother's level of education correlates closely with a child's risk of death before age two (Kickbusch, 2001). Children born to uneducated mothers are nearly twice as likely to die before age 5 as those born to mothers who completed primary school (Bicego and Ahmad, 1996). The lack of female education also has a direct bearing on several factors: reproductive behavior, fertility, morbidity, and child mortality (National Institute of Population Research and Training [NIPORT], 2003). Education for women helps the health of their children, and themselves too. Bhutta (2012) opined that lack of education, among other factors are responsible for low birth weight in children. In his study apropos lack of knowledge about LBW on South Asian children, Bhutta avers that More than two thirds (68%) of all LBW infants are born with evidence of intrauterine growth retardation (IUGR), the majority in South-Central Asia, where more than a quarter (27%) of all infants weigh less than 2500 g at birth [2]. Such IUGR infants mostly include those born at term (about 9.6% of all newborns weigh between 2000 and 2499 g at birth).

Some mothers, rather than consume good and well-cooked meals result to consuming junks and foods that are detrimental to the proper growth of the fetus. In a study conducted by Girma et al (2019) where a total of 279 (93 cases and 186 controls) were participants in the study. Mean birthweight of cases and controls were 2138.28 g ± 206.87 and 3145.16 g ± 414.99. Majority of the newborns were males 49 (52.7%) for cases and 117(62.9%) for controls. Fifty-two (55.9%) of cases and 111(59.7) of controls came from an urban setting. Mothers of 61cases (65.6%) and 154 controls (82.5%) did not attend formal education. Mean maternal height for cases and controls was 155 cm ± 0.07 and 159 cm ± 0.07. Under-nutrition in mothers as defined by MUAC < 23 cm was 52.7% for cases and 13.4% for controls. Findings of multivariable logistic regression indicated that lack of maternal iron and folic acid supplementation during pregnancy. It is however safe to state that macronutrients and micronutrients are both important for the short-term and long-term health of mothers and children, especially in resource-poor settings in which women can have many deficiencies.

To see long term improvements in child mortality due to the weight of a child at birth, maternal education must be included as part of any child survival program. The need for connecting the issues of maternal illiteracy and child health is vital to see lasting changes in the future lives of populations served. Child health projects need to advocate, train, and support the ability of women to be able to read and write. General literacy has a significant impact on child survival. Health literacy, as an outcome of general literacy, will improve outcomes in clinic settings, but general literacy still will have the greatest impact for the lives of the next generations.

Child survival programs need to be built with local coalitions of community members, ensuring that grassroots planning completes an effective assessment, facilitates clear goals and objectives, designs an effective program, and oversees implementation, quality program monitoring and evaluation. It is worthy to mention that smoking is highly detrimental and largely compounds childbirth issues as it contains elements that are not favorable to both the health of the mother and the child. The bulk of the research works, and scholarly inputs considered above hold that smoking, good feeding habits and adequate information are important factors and considerations to have healthy children.

## 2.9 Literature Summary.

Reviewing several studies which investigates the socioeconomic, biological, and behavioural factors influencing birth weight, using some machine learning techniques such as correlation, bivariate and multivariate regressions analysis to investigate methods applied in determining the factors that affect child’s birthweight. The research which also investigates the significant level of effect of smoking in relation to birthweight. several studies found that the major possible risk factors follow birth weight were, exposure to passive smoking, gestation period, low or no Education, infection of the mother uterus such as rubella, serially transmitted infection, maternal weight, late childbearing, weight gain during pregnancy. However, further investigation was carried using the information(data) obtained from Kaggle to further justify previous research carried out on this topic.

# **Chapter Three**

# **Research Methodology**

## 3.0 Research method

The aim and objective this research is to investigate and contribute to the ongoing debate on the significance level of the factors that affect child’s birthweight, considering smoking as one of the major potential factor to be checked. However. This research work was completed incrementally from the beginning by continuous findings, reviews, and learning, wherein questions are asked from the supervisor on an ongoing basis. There was Iterative meeting between I and the supervisor for the research planning and evaluation. I performed tasks incrementally and iteratively with deliverables which enhance more communication and collaboration between me and my supervisor. When new demands and situations develop, the work was constantly examined and updated.

## 3.1 Sources and Method of Data Collection

In this project work, data were collected from Kaggle, one the of world's largest data science community with powerful tools and resources.

The data used for this project work was collected internally in secondary form as earlier mentioned in the introduction. Secondary data imply statistical materials or information not originated or obtained by the investigator himself, but obtain from someone’s record or published source such as the central bank, government agencies and non-governmental duties such as universities, research institutes etc. The data were however, provided by Kaggle, one the of world's largest data science community with powerful tools and resources. This data contains Information about all the childbirth in the United States in the year of 2018).

## 3.2 Limitation and Potential Data Problem

The problems encountered during collection and preparation of data cannot all be stated here. This research work posed a lot of problems. Since I did not originally collect the data, there was mistrust between the primary users and the secondary user of the data, so many variables within the dataset were not properly coded, while some were also coded with lot of null values. The variable was not clearly named as some they were also named with abbreviations. Because one of the reasons why the data was initially put on Kaggle was for a competition, there were many unfiltered rows and columns in the dataset for users to detect and add essential filters before using it.

## 3.3 Statistical Tools

Because the data was uploaded to Kaggle for a competition, it, therefore, required several data preparations; as a result, different statistical packages were used to complete this process: python was used for data preparations, R was used for general statistical data analysis, and tableau was used for some basic data visualization in this research project.

## 3.4 Data Preparation

Data preparation is a fundamental process for any data analysis. Due to the structure of the original data posted, several stages of data preparation were carried out on (3,511,812 observations of 72 variables) to develop a dataset to significantly improve the efficiency of the statistical data analysis. This process was carried out on the dataset by sifting through the data in search of some interesting information such as missing values, duplicates, the data type of each variable, selected variables needed for the analysis and summary statistics (frequency distribution, measures of central tendencies, and measures of spread) of the dataset.

Diagram

Description automatically generated

Figure 1. Data analysis

For this project, the following preparation was carried on the dataset:

* Load in the data into the statistical analysis tool to be used
* Remove all special characters with special interpretation in R from the column names
* Check and remove Missing values In the Rows/Columns
* Create new column useful for the analysis in python
* Convert all columns to the proper datatype required for the analysis
* Select The Samples to Be Used for The Analysis.
* Group-By some of the factor variables for efficient exploratory data analysis

The process of data exploration was carried out using three different tools: statistical analysis tool R, which gives the general structure of the initial(original) datasets, machine learning tool Python, which was used for variable selection (filtering and wrapper methods), removing anomalies, or eliminating duplicate records. This tool was also used for Reducing data: sampling or instance selection. A visualization tool called tableau was also used for the data preparation, this tool was used to create aliases for some variables which were originally coded with different values to enable easy visualizations. However, as the data preparation progress, the data has been shuffled between these analytical tools for better and swift implementation of codes used for the analysis.

## 3.5. **Statistical Methods**

Considering the nature of the project work and its aims borne in my mind, the analytical tools to be used includes:

1. Pearson product-moment correlation.
2. Simple linear regression analysis (considering only one predictor: smoking).
3. Multivariate regression analysis, having more than one predictor variable, this test will estimate the number of variations in birthweight of a child these factors could explain.
4. Akaike's information criterion (AIC variable/model selection).
5. Exploratory Data Analysis was also carried out after the data preparations using the general descriptive statistics such as. Measures of Frequency: Count, Percent, Frequency. Measures of Central Tendency: Mean, Median, and Mode. Measures of Variation: Range, Variance, Standard Deviation.

### **3.5.1. Exploratory Data Analysis**

This process was carried out on the data to analyze, investigate, and summarize their main characteristics and structure, it was also used to provides a better understanding of data set variables and the general relationships between them. There are various data explorations that could be carried out on a dataset. However, for this project three main data explorations were carried out on the data set:

* Measures of Frequency: Count, Percent, Frequency.
* Measures of Central Tendency
* Measures of Variation

These data explorations are also shown using graphical illustrations such as Histograms, a bar plot in which each bar represents the frequency (count) or proportion (count/total count) of cases for a range of values.

Scatter plot, which is used to plot data points on a horizontal and a vertical axis to show how much one variable is affected by another.

Box plots, which graphically depict the five-number summary of minimum, first quartile, median, third quartile, and maximum.

Point & line graph, used to track changes over short and long periods of time

### **3.5.2 Pearson Product-Moment Correlation.**

The Pearson product-moment correlation coefficient is a measure of strength of linear association between two variables and this linear association is denoted with, r, it indicates how well these variables are related.

The Pearson correlation coefficient, r, can take a range of values from +1 to -1. When a value of r is equal to 0, this indicates that there is no association between the two variables involved. However, when the value of r is either greater or less than 0, these indicates a positive or negative association between the variables. As the value of one variable increase or decreases so does the value of the other increases or decreases. Different relationships and their correlation are shown in the figure below:

Chart, scatter chart

Description automatically generated

figure 2. Types of Association

**Basic Guidelines to Interpreting Pearson’s Correlation Coefficient**

|  |  |  |
| --- | --- | --- |
| Strength of Association | **Positive (r)** | **Negative (r)** |
| Very strong relationship | **0.8 to 1** | **-0.8 to -1** |
| Strong relationship | **0.5 to 0.8** | **-05 to -0.8** |
| Moderate relationship | **0.3 to 0.5** | **-0.3 to -0.5** |
| Weak relationship | **0.1 to 0.3** | **-0.1 to -0.3** |
| No relationship | **0** | **0** |

Table 1 Strength of Associations (Pearson’s Correlation Coefficient)

### **3.5.3 Assumptions of Pearson correlation**

In this research work, the assumptionsPearson product moment correlation was not fully considered, however, the assumptions are highlighted as follows.

level of measurement, related pairs, absence of outliers, normality of variables, linearity, and homogeneity of variance.

* Level of measurement refers to each variable. For a Pearson correlation, each variable should be continuous. (i.e., the two variables should be measured at the interval or ratio level)
* Linearity assumption. For a Pearson correlation, there needs to be a linear relationship between the two variables. For this research, the assumption was checked by plotting a scatter plot and visually inspected the graph.
* There should be no significant outliers. Outliers are data points within your sample that do not follow a similar pattern to the other data points. Having an outlier can skew the results of the correlation by pulling the line of best fit formed by the correlation too far in one direction or another, the assumption was checked by plotting a boxplot and visually inspected the graph to confirm the presence of significant outliers.
* Data is normally distributed. in this research, after linear correlations present within this data was confirmed, further investigation was carried to determine Which of the potential factors present in the dataset has the strongest linear relationship with the child’s birthweight. Hence a check on the normality distribution of the data was demonstrated to satisfy the assumption of bivariate normality.
* Homogeneity of variance refers to the distance between the points to that straight line. The shape of the density plot generated for should be tube-like in shape.

### **3.5.4 Pearson correlation in R**

A measure of relationships between two variables is carried out using an inbuilt function in R language. The correlation between cigarette smoking and child’s birthweight is computed by default with the cor () function in R. i.e.

*Correlation <- cor (Df$Cigarettes\_smoking, Df$ Birth\_Weight)*.

Where cor is the inbuilt function in R, Cigarettes-smoking & Birth-Weight are the variables and Df is the data frame.

### **3.5.5 Simple Linear Regression Analysis (Bivariate/Multivariate relationships)**

In this research, bivariate relationship between birthweight and smoking were the major factors that were considered. However, estimate of relationships between other factors as seen in the linear correlation performed was also carried out. Simple Linear Regression Analysis is a statistical method for obtaining a formula to predict the values of the birth weight from the amount so cigarette smoking before and during pregnancy where the relationship between these two variables have been confirmed using the Pearson Product-Moment Correlation. The general statistical equation for this relationship is: y = βo + β1x.

The variable y and x are those whose relationship we are studying, i.e., birthweight and cigarette smoking respectively, these variables are referred to as:

y: dependent (or response) variable

x: independent (predictor or explanatory) variable.

βo: intercept

βi: gradient

**Birthweight = βo + β1(smoking).**

### **3.5.6** **linear regression in R.**

The statistical approach that allows us to quantify more precisely the relationship between two or more variables, this approach which also allows us to significantly evaluate and model the relationship between a dependent variable and independent variable(s) is performed in R using the lm () function (which stands for linear model). The function requires to set the dependent variable first then the independent variable, separated by a tilde (~). This function is applied to our analysis on smoking and child’s birthweight. We have

model *<- lm (Birth\_Weight ~ Cigarette’s\_smoking, data = Df).*

*summary(model)*

Where the first argument inside the function lm () is the dependent variable Y and the second argument is the independent variable X.

### **3.5.7** **Reasons for Regression Model**

Descriptive: To form the strength of the association between the two factors under consideration.

Predictors: To determine the important risk factor affecting the outcome (birthweight).

Predictions: To quantify the number of new cases.

### **3.5.8** **Variable Selection and Model Building Criterion.**

In this research, after running the general multiple linear regression using one response variable with all other variables as the predictor. we find unimportant variables inside the input variables that can decrease precision and complicate interpretations of the study, so we want to  
select a best or a better subset of input variables that are important and sufficient for  
linear regression modeling. There are variable selection methods such as AIC.

I used variable selection criteria to assess the amount of variations each predictor variables could explain in the response variable. The purpose of variable selection in regression is to identify the best subset of explanatory variable among many variables to include in a model. Akaike information criterion (AIC) finds the important variables among the complete set of variables by deleting both irrelevant variables (variables not affecting the dependent variable), and redundant variables (variables not adding anything to the dependent variable). This process of variable selection is implemented in R statistical tool using stepAIC () command on our model which is a part of the R package MASS.

### **3.5.9** **Implementation of Variable Selection criteria (AIC) in R.**

***# Create a linear model to model this relationship***

Model <- lm (Birth\_Weight ~., data= SmkBirthWeight)

*summary (Model)*

*#****Variable Selection***

*stepAIC (Model, direction = "both")*

where “Model” is the first argument in the function stepAIC () is the linear regression model created using all the potential predictor variables.

### **3.5.10 Hypothesis Testing**

By referring to the central objectives in this research, there are two main hypotheses posted.

1. Investigate whether the factors considered has a significant relationship/effect on infant birthweight. I.e.

**Null Hypothesis H0** = Factors considered has NO effect on infant’s birthweight

**Alternative Hypothesis H1** = Factors considered has effect on infant’s birthweight

1. Investigate whether maternal smoking has a significant effect on infant birthweight. I.e.

**Null Hypothesis H0** = Maternal smoking has NO effect on infant’s birthweight

**Alternative Hypothesis H1** = Maternal smoking has effect on infant’s birthweight

The two hypotheses to be tested will be checked on 99, 95 and 90 percent confidence interval.

# **Chapter four**

# **Results and discussion**

This chapter present, analyses and discusses the data collected to achieve the aims and objectives of this study. The description of the data collected are presented in a tabular form, relevant and necessary information collected would help to achieve the aim and objective of this research work. Analysis is a systematic and scientific approach to reaching a conclusion by examining data. Hence, this section therefore outlines and explains the analysis of data collected to make the research work more meaningful and understandable, the data is therefore used to facilitate ideal and proper analysis of the potential factors that a predict infant birth weight.

## 4.1 Descriptive Statistics.

The data frame which contained 3,511,812 observations and 72 columns which includes new columns that were added during data preparation. The dataset consists of several potential factors that could predict or affect infant birth weight.

Fig.1 Compactly display the internal structure of the data frame, only one line for each ‘basic’ structure is displayed. i.e., it compactly displays the abbreviated contents of possibly nested lists. The idea is to give reasonable output for the data frame.

Fig.2 and others provides descriptive statistics of some selected variables in the data frame with higher coefficient of variation when checked with the dependent variable (Birth Weight).

**Table

Description automatically generated**

Fig. 3. Data Structure

## 4.2. Descriptive Statistics for Selected Key Variables

### **4.2.1** **Birth Weight.**

The basic data investigation on infant birthweight are presented in table1 and Fig. 2.

The table below is comprised of information on Birth Weight categorized by mothers who smokes daily, mothers who didn’t smoke and mothers who quitted smoking during pregnancy. These variables are described in terms of total and proportion.

|  |  |  |  |
| --- | --- | --- | --- |
| **Smoke/Birthweight** | **Low** | **normal** | **sum** |
| **Daily** | 34,532 (0.0098) | 247,817 (0.0706) | **282349** |
| **None** | 242,836 (0.0691) | 2,974,216 (0.8469) | **3217052** |
| **Stopped smoking** | 1,343 (0.0004) | 11,068 (0.0032) | **12411** |
| **sum** | **278711** | **3233101** | **3511812** |

Table 2 contingency table (Smoking rate / Birth Weight) **x-squared = 7928.9 p-value < 2.2e-16**

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Figure 4. Maternal Smoking Rate.

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Figure 5. Birth Weight

Total of 3,511,812 infant’s birthweight were collected, among which, normal birthweights where 2,974,216 of infants whose mother didn’t smoke during pregnancy, 247,817 of infants whose mother smoked daily during pregnancy and 11,068 of infants whose mother stopped smoking during pregnancy were recorded. For low birthweights, 1,343 infants whose mother stopped smoking during pregnancy, 34,532 of infants whose mother smoked daily, and 242,836 of infants whose mother didn’t smoke during pregnancy were recorded.

### **4.2.2** **Gestation Period.**

The possibility of variations in birth weight of infants is attributed to the duration of gestation. Table 2 and Fig. 3. focuses on the distribution of birth weight of infants in relation to their duration of gestation.

|  |  |  |  |
| --- | --- | --- | --- |
| **Gestation period/ birthweight** | **Low** | **Normal** | **Total** |
| **Late** | **42,791 (0.012)** | **41,660 (0.012)** | **504225** |
| **10months** | **7,859 (0.002)** | **496,366 (0.101)** | **474993** |
| **9months (Normal)** | **86,469 (0.025)** | **2,335,392 (0.665)** | **2421861** |
| **8months** | **120,141 (0.034)** | **354,852 (0.034)** | **26282** |
| **Early** | **21,451 (0.006)** | **4,831 (0.001)** | **84451** |
| **total** | **278711** | **3233101** | **3511812** |

Table 3 **x-squared = 639459 p-value < 2.2e-16**

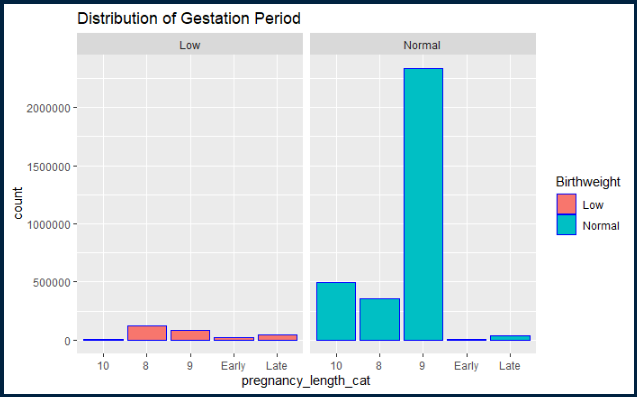
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Figure 6. Pregnancy length

Exploring the distribution of the gestational period in relation to infant birthweight, the sum of 3,511,812 pregnancy were observed. for low birthweight, 42,791 of infants whose gestation period was later than regular gestation period was observed to come out with low birthweight, 7,859 of infants with gestation period of 10 months came out with low birthweight, 86,469 of infants whose gestation period was normal (9 months) came out with low birthweight, the sum of 141,592 infants whose birthweight was lesser that the normal gestation period came out with low birthweight. Distribution of infants with normal birthweight in relation to their gestation period were also observed. 41,660 of infants whose gestation period was later than regular gestation period was observed to come out with normal birthweight, 496,366 of infants with gestation period of 10 months came out with normal birthweight, 2,335,392 of infants whose gestation period was normal (9 months) came out with normal birthweight, the sum of 359,683 infants whose gestation period was lesser that the normal came out with normal birthweight.

## 4.3 Correlation Analysis.

Fig 7. shows the degree of association between the changes in infants’ birthweight and the selected potential independent variables(factors). The correlation plot helps to visualize the association between each of these variables under consideration. Positive correlations are displayed in blue and negative correlations in red color.

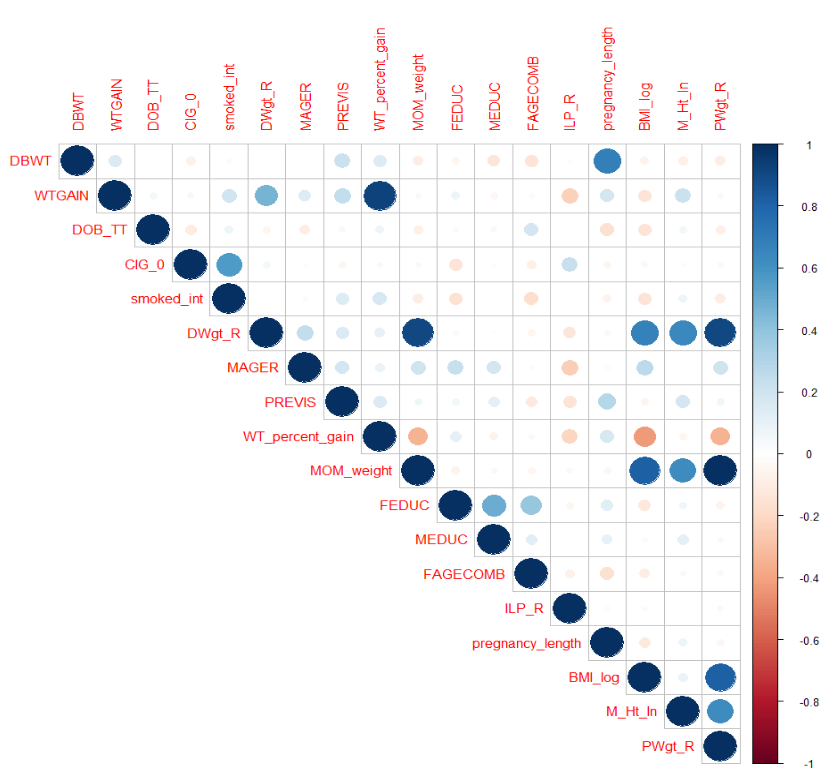


Figure 7. Correlation Plot

Color intensity and the size of the circle are proportional to the level of association between the variables which is also proportional to the correlation coefficients.

In the right side of the correlogram, the legend color shows the correlation coefficients and the corresponding colors.

### **4.3.1** **Correlation Coefficients.**

***Fig.*** *5* Depicts the result obtained from the correlation analysis which shows the strength of association between each of the selected variables. The factors observed appeared to be associated with the birthweight in their respective strength level. (0.08)8% of changes in infants’ birthweight are associated to the number of cigarettes smoked per day during pregnancy. (0.03)3% of changes in infants’ birthweight were also associated with different categories of smoking (daily, non, stopped smoking) during pregnancy. However, the result indicated that gestation period has the highest level of association 0.68 (68%) with the variations in infant birthweight.

**Chart

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Figure 8. Cor.Plot (Coefficients’)

## 4.4 Regression Analysis

Fig. 8 Shows the quantification of the relationships between infant birth weight and all potential factors that could affect or predict it. With every change in the potential factors, there is changes that occurs in birth weight is evaluated.

**Table

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Figure 9. Model 1. Multiple linear regression

This model assesses the significant level of the relationship between infant birth weight and 58 potential factors that affect it, 7 factors were statistically significant at 0.1(90%) significant level, out of which are, (smoking p= 0.0686, Birth Month p=0.774, Interval Since Last Live Birth p=0. Last Normal Menses Year p= 0.0756).

The result above indicated the significance level of the relationships between birth weight and all factors, considering them generally. Although all factors considered in this research work affect birth weight in their little ways. In general, 75% of variations in birth weight could be explained by all factors considered. this model could be simplified by removing some factors whose significant levels are minimal and, if removed, may not affect the general changes in infant birth weight.

## 4.5 Variable/Model Selection

The model is simplified by removing the factors with very low effect on infants’ birth weight, hence setting a linear model for the dependent variable against the independent variable with very high information/correlation about it.

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Figure.10. Model 2 Multiple linear Regression

16 variables were automatically selected after applying the variable/model selection techniques. This represents the improved significant relationship between infant’s birth weight and 16 potential variables. 4 out of 16 variables was observed to be statistically significant at 99% (0.01) confidence interval. (Prior Other Terminations p= 0.000363, first natal p= 0.006908, Interval Since Last Pregnancy p= 0.003328). The relationship of 8 variable with infant’s birth weight were observed to be statistically significant at 95% (0.05) confidence interval. (Smoking p= 0.022, first live birth p = 0.015968, first birth p= 0.020505, Mother’s Race p= 0.031821, Last Normal Menses(year) p= 0.028257, Last Normal Menses Month p= 0.040510, Mother’s pregnancy body mass index (BMI) p= 0.033465). The new model has shown some improvement in level of significance for the relationship between smoking and infants birth weight.

## 4.6 Impact of Maternal Smoking Rate on Infants’ Birth Weight

Accurate information on smoking rate during pregnancy and its effect on infant’s birth weight for the basic data frame is presented in Fig.2.

**A screenshot of a computer

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Figure. 11 Model 2.1 linear Regression (Bivariate)

Based on the regression analysis, there is a significant relationship between the difference in smoking rate and the infant birth weight. The birth weight if infants whose mother smokes daily appeared to be statistically significant with p-value 2e-16 < 0.05(95%) level of significance, The birth weight if infants whose mother didn’t smoke during pregnancy appeared to be statistically significant with p-value 2e-16 < 0.05 level of significance, while the birth weight of infants whose parents stopped smoking during pregnancy is statistically significant with p-value 2e-08 < 0.05(95%) level of significance.

Graphical user interface, application

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Figure 12. Mosaic Plot Multiple R-Squared 0.002258 p-value = <2.22e-16

In general, 0.2% of variation found in infant birth weight could be explained by the maternal smoking rate. However, this variation remains statistically significant at 95% confidence interval.

## 4.7 Impact of Gestation Period on Infants’ Birth Weight

The possibilities of variations in infants birth weight are attributed to changes in pregnancy length. These possibilities were examined after the correlation analysis was carried out on all potential variable considered in this analysis. Information on gestation period is presented in Fig. 8.

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Figure 13. model 2.2 linear Regression (Bivariate)

To obtain accurate information on pregnancy length and its relation to infants’ birthweight, bivariate regression analysis was carried out to investigate the coefficient of variations in birth weight. Multiple R-Squared 0.1975: 19.75% of variations in infant birth weight was linked to changes pregnancy lengths, where all the levels are statistically significant at 95% confidence interval with p-value: < 2.2e-16.

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Figure 14. Mosaic Plot for Gestation Period

## 4.8 Discussion.

7.9% prevalence of low birth weight is observed in this study. The investigation has shown the association of smoking rate, gestation period, maternal infection, body mass index, Last Normal Menses, and time of birth with infant’s birth weight. There is 8.03% of Infants whose mother smokes during pregnancy. 0.3% of infants whose mother stopped smoking during pregnancy, 91.6% of infants whose mother didn’t smoke during pregnancy. It appeared that the frequency distribution of infants whose mothers didn’t smoke & stopped smoking during pregnancy was much more than the number of those who smoked during pregnancy. However, the effect of smoking on infants’ birth weight remains significant with p-value < 2.2e-16.

A more credible explanation is that the amount of variation in birth weight explained by smoking during pregnancy is minimal (Multiple R-squared: 0.002258). However, the variation is significant; hence smoking remains an important factor that affects birth weight. This research also confirms that each duration of gestation provided in table 3 has a significant relationship with infants’ birth weight. p-value < 2.2e-16. However only 19.75% of the variations in birth weight could be explained by pregnancy length, as shown in fig. 4.

**Chapter five**

# **5. Conclusion.**

In contribution to the investigation of several factors affecting infant birth weight, among which are maternal factors such as gestation period, maternal smoking rate, Prior Other Terminations, first natal, Interval Since Last Pregnancy, first birth, Mother’s Race Last Normal Menses(year), Last Normal Menses Month Mother’s pregnancy body mass index.

Based on reviews from previous research and study, several studies have merely concentrated on the theoretical descriptive aspect and not considered the inferential aspect of the findings. This research investigates the statistical significance of all potential factors affecting the birth weight of infants whose mother smokes during pregnancy.

The originality of this research is that it uses secondary data from Kaggle, which was initially posted for competition.

To investigate these factors, some basic descriptive statistics were deployed to get the frequency distribution of the data and gain insight into each factor. Correlation analysis was carried out on the factors to check if there exists any association among them, regression analysis was also carried out to estimate the degree of relationship. Fifty-eight factors were considered in this analysis, and these factors explained about 75% of variations in infant's birth weight. The number of variables considered was reduced to the barest minimum by removing variables with less or no information about infants' birth weight. The Akaike information criteria (AIC) was used for variable selection and model improvement. Sixteen variables remained significant. They were later selected for the multiple linear regression, and the amount of variation explained by these variables remains the same.

Though the findings show that the amount of variation smoking could explain infants' birth weight is minimal. However, smoking remains a significant factor that affects infant birth weight.

**5.2 Research implication**

* The research has successfully Identified significant factors that affect infant’s birthweight among which are maternal smoking rate, gestation period, maternal infection, body mass index, Last Normal Menses. etc.
* The study has successfully investigated the degree of association between factors that affect infants birth weight.
* The study result verified that the effect of smoking on infant is minimal. However, the results show smoking remains a significant factor affecting infants birth weight.
* The study, through highlights and discussion of the contributions of several researchers on the matter of smoking and other factors that affects child birthweight, have identified several risks involved in the growth of infants with low birth weight.

**5.3 Research Recommendations**

To a reasonable extent, maternal cigarette smoking has been proven to be a significant factor affecting infants birth weight. This effect therefore poses adverse impact on the economic and social welfare of a nation. Based on the findings and suggestion; I, therefore, make the following recommendations to individuals (pregnant women and child-bearer), government of all levels, and all agencies or forces concerned.

* Child-bearer should not only strive to reduce the number of cigarettes smoked per day during and before pregnancy, but also try to put a stop to the action. Smoking during pregnancy restrict oxygen to be baby making the babies heart work faster and exposing the baby to harmful toxins.
* Government and agencies or forces concerned set out for smokefree society should bring their ambitions on smoking in pregnancy and a smokefree society into a reality.
* Government should not only strive to set aside committee that would see to the maternal smoke free society but ensure the implementation of the committee plans.
* More awareness of the effect of maternal smoking should be carried out by agencies concerned.

## References:

Smoke-free Action coalition o/c action on smoking and health (ASH 2021). Getting back on track: Delivering a smoke-free start for every child (2021) London: ASH. Available from: https://smokefreeaction.org.uk/smokefree-nhs/smoking-in-pregnancy-challenge-group [Accessed 08 June 2021].

John Waldron, Senior Policy and Public Affairs Officer, ASH, (2021). Action and Smoking and Health & the Smoking in Pregnancy Challenge Group. Getting back on track: delivering a smoke free start for every child. [Accessed 8 June 2021].

Saville, N.M., Shrestha, B.P., Style, S., Harris-Fry, H., Beard, B.J., Sen, A., Jha, S., Rai, A., Paudel, V., Sah, R. and Paudel, P., (2018). Impact on birth weight and child growth of Participatory Learning and Action women’s groups with and without transfers of food or cash during pregnancy: Findings of the low-birth-weight South Asia cluster-randomized controlled trial (LBWSAT) in Nepal. PloS one, 13(5), p.e 0194064. [Accessed 05 June 2021].

Debusscher, P. and De Almagro, M.M. (2016) Post-conflict women's movements in turmoil: The challenges of success in Liberia in the 2005-aftermath. Journal of Modern African Studies [online]. 54 (2), pp.293-316. [Accessed 20 June 2020].

Karanda, Sunil. (2015) Consequences of low birth weight, maternal illiteracy, and poor access to medical care in rural India: Infantile iatrogenic Cushing syndrome [online10.1136/bcr-2015-211387. [Accessed 14 August 202].

Cnattingius, S., Forman, M.R., Berendes, H.W. and Isotalo, L., 1992. Delayed childbearing and risk of adverse perinatal outcome: a population-based study. Jama, 268(7), pp.886-890.

Barkan, S.E. and Bracken, M.B., 1987. Delayed childbearing: no evidence for increased risk of low birth weight and preterm delivery. American journal of epidemiology, 125(1), pp.101-109.

Appareddy, S., Pryor, J. and Bailey, B., 2017. Inter-pregnancy interval and adverse outcomes: evidence for an additional risk in health disparate populations. The Journal of Maternal-Fetal & Neonatal Medicine, 30(21), pp.2640-2644.

Julia Schechter, PhD, Elizabeth K Do, PhD, MPH, Junfeng (Jim) Zhang, PhD, Cathrine Hoyo, PhD, Susan K Murphy, PhD, Scott H Kollins, PhD, Bernard Fuemmeler, PhD, MPH(2002), Effect of Prenatal Smoke Exposure on Birth Weight: The Moderating Role of Maternal Depressive Symptoms, Nicotine & Tobacco Research, Volume 22, Issue 1, January 2020, Pages 40–47, <https://doi.org/10.1093/ntr/nty26>

Lumbanraja, S., Lutan, D. and Usman, I., 2013. Maternal weight gain and correlation with birth weight infants. Procedia-Social and Behavioral Sciences, 103, pp.647-656.

Law, C. M. (2002). Significance of birth weight for the future.

Sven Cnattingius, M.D., Ph.D.(2004), The epidemiology of smoking during pregnancy: Smoking prevalence, maternal characteristics, and pregnancy outcomes, Nicotine & Tobacco Research, Volume 6, Issue Suppl\_2, April 2004, Pages S125–S140, <https://doi.org/10.1080/14622200410001669187>

Bullock, L., Everett, K. D., Mullen, P. D., Geden, E., Longo, D. R., & Madsen, R.(2009). Baby BEEP: A randomized controlled trial of nurses' individualized social support for poor rural pregnant smokers. [Randomized Controlled Trial Research Support, N.I.H., Extramural]. Maternal & Child Health Journal, 13(3), 395-406.

Centers for Disease Control and Prevention. (2004). Smoking during pregnancy--United

States, 1990-2002. MMWR Morb Mortal Wkly Rep, 53(39), 911-915. doi: mm5339a1 [pii].

Lumley, J., Chamberlain, C., Dowswell, T., Oliver, S., Oakley, L., & Watson, L. (2009).

Interventions for promoting smoking cessation during pregnancy. Cochrane Database Syst Rev(3), CD001055. doi: 10.1002/14651858.CD001055.pub3.

Melvin, C. I., & Gaffney, C. A. (2004). Treating nicotine use and dependence of pregnant

and parenting smokers: An update. [Article]. Nicotine & Tobacco Research, 6,S107-S124.

Kahn RS, Certain L, Whitaker RC. A reexamination of smoking before, during, and after pregnancy. Am J Public Health. 2002;92:1801– 8. Toschke AM, Montgomery SM, Pfeiffer U, von Kries R. Early intrauterine exposure to tobacco-inhaled products and obesity. Am J Epidemiol 2003;158:1068–74.

Bullock, L., Everett, K. D., Mullen, P. D., Geden, E., Longo, D. R., & Madsen, R.(2009).

Baby BEEP: A randomized controlled trial of nurses' individualized social support for poor rural pregnant smokers. [Randomized Controlled Trial Research Support, N.I.H., Extramural]. Maternal & Child Health Journal, 13(3), 395-406.

Centers for Disease Control and Prevention. (2004). Smoking during pregnancy--United

States, 1990-2002. MMWR Morb Mortal Wkly Rep, 53(39), 911-915. doi:

mm5339a1 [pii].

Lumley, J., Chamberlain, C., Dowswell, T., Oliver, S., Oakley, L., & Watson, L. (2009).

Interventions for promoting smoking cessation during pregnancy. Cochrane Database Syst Rev(3), CD001055. doi: 10.1002/14651858.CD001055.pub3.

Melvin, C. I., & Gaffney, C. A. (2004). Treating nicotine use and dependence of pregnant and parenting smokers: An update. [Article]. Nicotine & Tobacco Research, 6,S107-S124.

Kahn RS, Certain L, Whitaker RC. (2002). A reexamination of smoking before, during, and after pregnancy. Am J Public Health.;92:1801– 8.

Toschke AM, Montgomery SM, Pfeiffer U, von Kries R. (2003).Early intrauterine exposure to tobacco-inhaled products and obesity. Am J Epidemiol; 158:1068–74.

Toschke AM, Ehlin AG, von-Kries R, Ekbom A,Montgomery SM. (2003). Maternal smoking during pregnancy and appetite control in offspring. J Perinat Med N; 31:251–56.

Von Kries R, Toschke AM, Koletzko B, Slikker W Jr. 2002 Maternal smoking during pregnancy and childhood obesity. Am J Epidemiol.;156:954–61.

Steketee RW, Wirima JJ, Slutsker L, Heymann DL, Breman JG, 1996. The problem of malaria and malaria control in pregnancy in sub-Saharan Africa. Am J Trop Med Hyg 55: 2–7.\

Menendez C, 1995. Malaria during pregnancy: a priority area of malaria research and control. Parasitol Today 11: 178–183.

Singh N, Mehra RK, Srivastava N, 2001. Malaria during pregnancy and infancy, in an area of intense malaria transmission in central India. Ann Trop Med Parasitol 95: 19–29.

Luxemburger C, McGready R, Kham A, Morison L, Cho T, Chongsuphajaisiddhi T, White NJ, Nosten F, 2001. Effects of malaria during pregnancy on infant mortality in an area of low malaria transmission. Am J Epidemiol 154: 459–465.

Marie-Louise Newell, Mario Cortina-Borja, Claire Thorne, Catherine Peckham, (2002)

Institute of Child Health, University College, London, United Kingdom.Centre for Paediatric Epidemiology and Biostatistics, Institute of Child Health, 30

Barbara J. Stoll, Nellie I. Hansen, Ira Adams-Chapman, Avroy A. Fanaroff, Susan R. Hintz, Betty Vohr, Rosemary D. Higgins, Impairment Among ExtremelyLow-Birth-Weight Infants

With Neonatal Infection. National Institute of Child Health and Human Development

Neonatal Research Network Neurodevelopmental and Growth 25, (2) 268-291

Mutabingwa TK, Bolla MC, Li JL, Domingo GJ, Li X, Fried M, et al. Maternal malaria and gravidity interact to modify infant susceptibility to malaria. PLoS medicine. 2005; 2(12):e407. doi: 10.1371/journal.pmed.0020407 PMID: 16259531

Le Port A, Watier L, Cottrell G, Ouedraogo S, Dechavanne C, Pierrat C, et al. Infections in infants during the first 12 months of life: role of placental malaria and environmental factors. PloS one. 2011; 6(11):e27516. doi: 10.1371/journal.pone.0027516 PMID: 22096588

Kickbusch, I. (2001). Health literacy: addressing the health and education divide. Health

Promotion International, 16 (3) 289-297.

Bicego, D. & Ahrnand, 0. (1996). Infant and child mortality. Demographic and health

surveys comparative studies No. 20. Retrieved March 12, 2006 fromhttp://www.measuredhs.com /pubs/pdf/CS20/00FrontMatterOO.pdf

Bhutta ZA. (2012) The ignominy of low birth weight in South Asia. Indian Pediatrics;49:15–16.

Dewey, Kathryn C. and Mayers, Daniel R. 2011. “Early Child Growth: How do Nutrition and Infection Interact?” Maternal and Child Nutrition. Vol. 7 (Suppl. 3), pp. 129–142.

Molbak K, Anderson M., Aaby P., Jakobsen M., Sodemann M. (1997) Cryptosporidium Infection in Infancy as a Cause of Malnutrition: a community study in Guinea-Bissau, West Africa. The American Journal of Clinical Nutrition 65(1) 149-152

Kramer, M.S 1987 Determinants of low birth weight: Methological assessment and meta-. Bulletin of the world Health Organisation, 65 636-737.

Mertensen, E., Michaelson, K., Sanders, S., & Reinish, J. (2005) A Dose-response relationship between maternall smoking during late pregnancy and adult intelligence in male offspring. Pediatric and Perinatal Epidemiology 19, 4-11.

Clark M., Ogden J. The Impact of Pregnancy on eating behavior and aspects of weight concern. (1999) Int J Obes 23, 18-24.

Willaimson D.F., Madan J., Anda R.F.,Kleinman J.C., Giovino G.A., Byers T. (1991) Smoking Cessation and Severity of Weight gain in National Cohort. Engl Med 324, 739-745.

Ohlin A., Rossner S. Maternal body Weight Development After Pregnancy (1990) Int J Obes 14: 159-173.

Li C., Mayo M., Ahluwalia S., Maternal Smoking During Pregnancy, Birthweight and Childhood Overweight: a Suppression Effect Model.

Jauniaux E. & Burton J. (2007) Morphological and Biological Effects of Maternal Exposure to Tobacco Smoke in the Fetoplacental Unit. Early Human Development, 83: 699-706.

Yang K., Julian L., Rubio F., Sharma A., Guan H., (2006) Cadmium Reduces II Beta-hydroxysteriod Dehydrogenase Type 2 Activity and Expression in Human Placental Trophoblast Cells AmJ Physiol Endrocrinol Metab 2006: 290 (10)135-142.

Fowles J., & Bates M. (2000) The Chemical Constituents in Cigarette and Cigarette Smoke: Priorities for Harm Reduction. Available athttps:/www.moh.govt.nz/moh.nsf/pagescm/1003/File/Chemicalconstituentscigarettepriorities.pdf. Accessed on October 2, 2021.

Feltes B.C., Poloni J., Notari D., Bonatto D., Toxological Effects of the Different Substances in Tobacco Smoke on Human Embryonic Development by a System Chemo-Biology Approach.

Debusscher, P. and De Almagro, M.M. (2016) Post-conflict women's movements in turmoil: The challenges of success in Liberia in the 2005-aftermath. Journal of Modern African Studies [online]. 54 (2), pp.293-316. [Accessed 20 June 2021].

Karande, Sunil. (2015) Consequences of low birth weight, maternal illiteracy, and poor access to medical care in rural India: Infantile iatrogenic Cushing syndrome [online10.1136/bcr-2015-211387. [Accessed 14 August 202].

Appareddy, S., Pryor, J. and Bailey, B., 2017. Inter-pregnancy interval and adverse outcomes: evidence for an additional risk in health disparate populations. *The Journal of Maternal-Fetal & Neonatal Medicine*, *30*(21), pp.2640-2644.

julia Schechter, PhD, Elizabeth K Do, PhD, MPH, Junfeng (Jim) Zhang, PhD, Cathrine Hoyo, PhD, Susan K Murphy, PhD, Scott H Kollins, PhD, Bernard Fuemmeler, PhD, MPH, (2020). Effect of Prenatal Smoke Exposure on Birth Weight: The Moderating Role of Maternal Depressive Symptoms, Nicotine & Tobacco Research, Volume 22, Issue 1, Pages 40–47,

Xiao, P.L., Zhou, Y.B., Chen, Y., Yang, M.X., Song, X.X., Shi, Y. and Jiang, Q.W., (2015). Association between maternal HIV infection and low birth weight and prematurity: a meta-analysis of cohort studies. BMC pregnancy and childbirth, 15(1), pp.1-11.

Fergusson, D.A., Hébert, P., Hogan, D.L., LeBel, L., Rouvinez-Bouali, N., Smyth, J.A., Sankaran, K., Tinmouth, A., Blajchman, M.A., Kovacs, L. and Lachance, C., (2012). Effect of fresh red blood cell transfusions on clinical outcomes in premature, very low-birth-weight infants: the ARIPI randomized trial. *Jama*, *308*(14), pp.1443-1451.

Roy, S., Motghare, D.D., Ferreira, A.M., Vaz, F.S. and Kulkarni, M.S., (2009). Maternal determinants of low birthweight at a tertiary care hospital. J Fam Welfare, 55(1), pp.79-83.

Lumbanraja, S., Lutan, D. and Usman, I., (2013). Maternal weight gain and correlation

with birth weight infants. *Procedia-Social and Behavioral Sciences*, *103*, pp.647-656.

Yamashita, T., Yamashita, K. and Kamimura, R., 2007). A stepwise AIC method for variable selection in linear regression. *Communications in Statistics—Theory and Methods*, *36*(13), pp.2395- 2403.

Levin-Schwartz Y, Curtin P, Svensson K, Fernandez NF, Kim-Schulze S, Hair GM, et al. (2019) Length of gestation and birth weight are associated with indices of combined kidney biomarkers in early childhood.  PLoS ONE 14(12). [Accessed 23 November 2021].