PERFORMANCES OF BAYESIAN STRUCTURED ADDITIVE REGRESSION AND LOGISTIC MODELS IN ASSESSING FACTORS ASSOCIATED WITH MODERN CONTRACEPTIVE USE AMONG EVER-IN-UNION WOMEN IN NIGERIA

BY

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DECLARATION

I hereby declare that this research is original. This work is neither been presented to any other faculty for the purpose of the award of degree nor has it been submitted elsewhere for publication purposes.

Signature …… Date …….

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CERTIFICATION

I certify that this research work was carried out by ALADEKOMO, Oluwafunto Adepeju in the Department of Epidemiology and Medical Statistics, Faculty of Public Health, University of Ibadan, Ibadan, Oyo State, Nigeria under my supervision.

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Supervisor Date

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DEDICATION

I dedicate this research work to God who has been the director and controller of this research from the beginning to the end. I also dedicate this to my family who have been of great support to me.

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LIST OF ABBREVIATIONS

HIV/AIDS - Human Immunodeficiency Virus/ Acquired Immunodeficiency syndrome

EAs - Enumeration Areas

TFR - Total Fertility Rate

WHO- World Health Organization

IUD - Intrauterine Contraceptive Devices

NDHS - Nigeria Demographic Health Survey

NPHC - Nigeria Population and Housing Census

LGAs - Local Government Areas

NHREC - National Health Research Ethics Committee of Nigeria

CAPI - Computer-assisted personal interviewing

NHREC - Nigeria's National Health Research Ethics Committee

STAR - Structured Additive Regression models

ANOVA- Analysis of Variance

GAM - Generalized Additive Models

GAMM - Generalized additive mixed models

VCM - Varying coefficient models

MCMC- Markov chain Monte Carlo

Ref- Reference Category

Cr - Credible Interval

CI- Confidence Interval

MCs- Modern contraceptives

ABSTRACT

Background: Recognizing the factors that contribute to the use of modern methods of contraception serves a significant role in designing successful strategies that can lead to increased use and subsequently to a reduction in the rate of population growth. However, most studies on contraception methods did not consider the spatial effect with regard to the use of modern contraceptive methods. This study therefore compared the performance of Bayesian structured additive regression with the frequentist logistic regression in the identification of factors associated with modern contraceptive use among ever-in-union women across the six geo-political zones of Nigeria.

Method: This study adopted a cross-sectional data extracted from the 2018 Nigerian Demographic and Health Survey (NDHS) of ever-in-union women (15-49 years) selected in both urban and rural areas in the six geo-political zones in Nigeria. The analysis was done with SPSS software (version 25) and R-programming language with BayesX installed. The Bayesian structured additive regression and frequentist logistic regression models were used for analysis. Inference was based on Markov Chain Monte Carlo (MCMC) technique and model diagnostics was applied to examine the model that best explains the interest of this study with the use of Deviance Information Criteria (DIC).

Results: A total of 31,152 ever-in-union women were included in the analysis. The prevalence of modern contraceptive use was found to be 11.5% among these women. It was revealed that repondent's age at their first marriage is a great determinant of their usage of these methods and found that those who got married between the ages 15-19 and 20-24 have higher odds of 10.8% and 12.4% to use modern methods of contraception more than those who got married at an earlier

age. It was also interesting to observe that access to media and knowledge of these methods indeed had a part to play in their use of these methods as their exposure to media and knowledge gave an opportunity for these women to use it more with odds of 11.3% and 28% respectively.

The findings further showed there was a strong north-south difference, with the usage of modern contraceptive methods in the northern states being distinctly lower than in the southern states. The non-linear effect of respondent's age at first marriage was seen to have a great contribution, as a high percentage (20.9%) of these women got married at a very young age of less than 15 years which was seen to be majorly in the northern part of Nigeria in the year 2018. It was also revealed that the Bayesian approach was a better fit for the model in this study due to the DIC (110.152) which was lesser than that of the frequentist approach (17007.148).

Conclusion: These findings revealed that the Bayesian approach yielded better results as compared to that of the frequentist and so other researchers are encouraged to delve into that aspect for more accurate inferences in research work. In addition, all these being taken into proper consideration, will help the government, non-governmental agencies and policy makers to channel the interventions properly to the zones and states that are in dire need of them and also manage the limited resources available

Keywords: modern contraceptives, logistic regression, MCMC, bayesian, ever-in-union women, Nigeria.

CHAPTER ONE

INTRODUCTION

1.1: Background of the Study

Family planning is the conscious effort made by a couple to limit or space the number of children desired through the use of contraceptive methods (National Population Commission NPC Nigeria & ICF Macro, 2009). This saves a woman from unintended pregnancies, pregnancy-related health risks, reduces infant mortality, helps to prevent HIV/AIDS, empowers people and enhances education, reduces adolescent pregnancies and in total, slows population growth (Nations, 2017). Contraceptive methods are approaches utilized by a person to help prevent unintended conception which includes many forms such as modern contraceptives, traditional contraceptives and folkloric contraceptives. However, for this research use of Modern Contraceptives will be concentrated on and then other methods of contraception will be classified as a Non-Modern form of contraception (Lori *et al*., 2018).

Modern contraceptives can be described as products or medical procedures designed to minimize possibilities of conception that enables couples to have sexual intercourse as desired when the need arises without any form of retreat. Every other approach which does not require the freedom of sexual intercourse between couples to act on their natural urges and desires is classified under what is called the Non-Modern Contraceptive Approach (Espoir & Amantha, 2020; Hubacher & Trussell, 2015). There are several types of modern contraceptives which include male condoms, female condoms, oral pills, intrauterine contraceptive devices (IUCDs), injectables, diaphragm, female sterilization, and male sterilization, implants, foam/jelly, and emergency contraception pills (Adebayo *et al*., 2013; National Population Commission(NPC)[Nigeria] & ICF International,

2019). Modern contraceptive use helps to slow population growth, improves birth spacing and maternal health which in turn becomes beneficial to the said population as regards her health and resources (Feldman *et al*., 2009; Kandala & Stranges, 2014; Nations, 2017). Worldwide, modern contraceptive prevalence increased among ever-in-union women in the reproductive ages (15-49 years) from 54% in 1990 to 57.4% in 2015 (Organization, 2018). According to the results of the 2015 Revision of World Population prospects, total fertility was at 2.5 children per woman globally (United Nations, Department of Economic and Social Affairs, 2015). In 2017, about 63% of sexually active women in their reproductive ages used some form of contraception (Nations, 2017).

Africa recorded a minimal rise in modern contraceptive usage from 23.6% in 2008 to 28.5% in 2015 (Organization, 2018). The proportion of demand for family planning methods satisfied by modern contraceptives was 78% with the lowest proportion in Africa regions with 56% compared to other regions which were above 75% such as Europe (Nations, 2017). However, there are wide disparities in the use of contraception across countries affecting developing countries more significantly (Wang & Cao, 2019). Sub-Saharan Africa has the highest rate of non-use of modern contraceptives accounting for 21% of the global burden of low use of modern contraceptives (Wang & Cao, 2019).

The prevalence of contraceptive use among ever-in-union women in Nigeria only increased by 9% out of which the use of modern methods increased by 6% over an 18-year period from 1990-2008 (National Population Commission NPC Nigeria & ICF Macro, 2009). In 2013, the prevalence of modern contraceptive use among Nigerian women was 11.1% which is a slight increase from 10.5% in 2008 by the Demographic Health Survey (Babazadeh *et al*., 2018). Despite all the resources agencies and the government have put into this, all this still leading to a constant increase

in the population of Nigeria by 3.2% yearly (Fagbamigbe *et al*., 2015). According to the 2018 Nigeria Demographic Health Survey (NDHS), the current prevalence of modern contraceptive use in Nigeria is 17%, which shows a gradual increase but can be said to be rather slow.

Although the prevalence of contraceptives in Nigeria has been highlighted, the existence of geographical inequalities in the use of modern contraceptives seems to have received inadequate publicity. The Nigerian government collaborated with donor agencies to boost media campaigns to push contraceptive demand and increase the availability of family planning services in primary health care facilities at no cost to women (Darroch, 2013). The literature shows that the use of modern contraceptives is lowest among women in the least developed regions in Nigeria, where early marriages and low levels of female education are also prevalent and only small proportion of women use maternal health services (Campbell & Bunche, 2011; Darroch, 2013). Therefore, these regions require urgent and practical solution as it has become a major public health challenge.

Geographical disparities in contraceptive use has a tendency to create a high social imbalance among women in the core of the disadvantaged regions who are unfortunately already struggling with a variety of health and socio-economic problems. Hence, substantial progress is impossible if geographical equity disparities are not addressed effectively. The use and choices of contraceptives differ widely in Nigeria, depending on the type of health facility, geographical area, supply and demand-related variables. These all account for disparities and lead to Nigeria's low levels of contraception use and options; problems such as insufficient access, efficiency and cost of family planning facilities are on the supply side. Several Nigerians, especially in rural areas, lack access to modern contraception and family planning facilities because of limited availability. The efficiency is often low in places where facilities operate with scarce contraception resources,

limited numbers of qualified service providers, weak interpersonal skills on the part of suppliers, and minimal essential equipment (Essien *et al*., 2010).

The composition and location of ever-in-union women is better associated with clusters where findings in the same cluster are likely to draw on clustered data information and interpretation. This is due to the similar exposure to a wide range of common community factors such as traditional norms, exposure to family planning programs, to mention a few, which can affect similar fertility behavior and in turn behavior towards modern contraceptive use in the same village but differ by community (Kazembe, 2009).

To this end, the conventional generalized linear model (GLM) is inappropriate to analyze data collected in clustered two-stage survey design (Kazembe, 2009), due to its inability to take into consideration the spatial correlation and nonlinearity of the data as severe challenges might arise in the estimation of small area spatial effects (Osei *et al*., 2012).

Considering the prevailing pattern and low usage of modern contraception among ever-in-union women in Nigeria, it has become necessary to assess the level and pattern of geographical variations in modern contraceptive use in order to have a focus on the particular areas that need an intervention as regards its knowledge, affordability, supply and ease of access (Adebayo *et al*., 2013). This paper aims to assess and describe factors affecting the relationship between geographical settings and the use of modern contraceptives among ever-in-union women in Nigeria.

1.2: Problem Statement

One of the major challenges faced in Nigeria is the annual population growth rate of 3.2% as at 2016, therefore making Nigeria the most populous nation in Africa (Fagbamigbe *et al*., 2015; Population Reference Bureau, 2014) with a total fertility rate (TFR) of 5.5 births per woman in 2015 that rose to 5.8 births per woman in 2016 (National Bureau of Statistics, 2017). Nigeria's population pyramid shows that the majority of the population lies between ages 0-14 years with 15% aged 0-4 years which shows a young population and high fertility rate (National Bureau of Statistics, 2017). A study by Osam, 2019 found that early marriages, sexual reproduction rates, voracious appetite for coitus, general ignorance and unwillingness to embrace family planning interventions, intense cultural pressure for male children, and polygamy among Muslims and traditionalists caused overpopulation.

The uncontrolled population growth has had a major impact on the nation's health in terms of nutrition, morbidity and mortality among the young population. Research shows that Nigeria is one of West Africa's most vulnerable countries with high levels of malnutrition as seen in wasting and underweight cases due to rapid population growth, higher cost of living and desertification costs affecting accessibility, availability, and development of food (Akombi *et al*., 2017). Family planning, according to WHO, is crucial to reducing unsustainable population growth and the resulting negative economic, financial, national and regional development efforts. It was also reported that 214 million women of reproductive age who wish to avoid pregnancy are not using a modern contraceptive method in developing countries (Nations, 2017). Unfortunately, one of the initiatives for an increased level of modern contraceptive usage in Africa; FP2020, concentrated her intervention on the South West; Lagos which already had a reasonable exposure to modern contraceptives before the intervention.

1.3: Justification of the study

This study will investigate the spatial effect on modern contraceptive utilization in Nigeria's six geopolitical zones as the location and beliefs surrounding individuals in such may have an impact on the use of modern contraceptives. This is important to concentrate on the specific areas that require intervention in terms of knowledge, affordability, supply, and easy access (Adebayo *et al*., 2013).

Many studies about modern contraceptive usage have concentrated on the sexual health of individuals, and only a few have investigated the impact of the non-use of these methods on overpopulation resulting to some public health matters such as; malnutrition, unfavourable living environment, lack of access to safe drinking water that can contribute to cholera and child-related survival problems. Identification of particular regions and use of location-specific interventions would go a long way in increasing the usage as regards to its knowledge, affordability, supply, and ease of access (Adebayo *et al*., 2013).

The nature of the data gives possibilities of observations in the same cluster to be dependent due to similar exposures which gives an allowance to use the Frequentist binary logistic regression and the Bayesian structured additive regression model since the latter provides flexible modelling for non-linear and spatial effects not just fixed and random effects alone.

As new interventions have been implemented, such as the objectives of the FP2020 initiative by the London Summit on Family Planning, initiatives like the availability of modern contraceptives, educating people about how to use it, its advantages and disadvantages, and alleviating the uncertainty that emerges from myths about side effects will encourage proper understanding of the intent of modern contraceptives use by women. It is then of great importance to update the body of knowledge and this approach helps with that.

1.4: Objectives of the Study

The objectives of this study are divided into two main parts; the general objective which is the main aim of this study and the specific objectives which gives a break down as to how the general objective is achieved.

1.4.1: General Objective

The general objective of this study is to compare the performances of the Bayesian structured additive and Frequentist binary logistic regression models in the assessment of factors associated with modern contraceptive utilization among ever-in-union women in Nigeria.

1.4.2: Specific objectives

The specific objectives are to

1. Assess the performance of the Frequentist logistic regression model in assessing the factors associated with modern contraceptive utilization among ever-in-union women in Nigeria.
2. Assess the performance of the Bayesian structured additive regression models in assessing the factors associated with modern contraceptive utilization among ever-in-union women in Nigeria.
3. Identify factors associated with modern contraceptive use among ever-in-union women in Nigeria.
4. Model the spatial pattern and effects of modern contraceptive use among ever-in-union women in Nigeria.

1.5: Research Questions

1. Which statistical modeling approach between the Bayesian structured additive and the frequentist logistic regression best fit the model.
2. What are the factors influencing the use of modern contraceptive methods among ever-in-union women in the six geo-political zones of Nigeria?
3. What are the spatial variations in the use of modern contraceptives among ever-in-union women in Nigeria?

1.6: Definition of Terms

Enumeration areas: These are the operational geographical units for the collection, dissemination, and analysis of census data and are often used as a national sampling frame for various types of survey

Reference Category: This is such a category that is identified as a comparison for other categories.

Credible Interval: This is the interval in which an (unobserved) parameter has a given probability.

pD: This is the effective number of parameters (which is similar, but not equal, to degrees of freedom

CHAPTER TWO

LITERATURE REVIEW

2.1: Contraceptive Prevalence and Family Planning

Contraceptive prevalence is characterized as a measure of the percentage of women who confirm the use by themselves and/or their spouses of at least one method of contraception (National Population Commission(NPC)[Nigeria] & ICF International, 2019). According to the World Health Organization in 2018, the prevalence of contraception use has risen globally due to the creation and implementation of new contraceptives and the establishment of coordinated family planning initiatives. The prevalence of contraceptive use among ever-in-union women within their reproductive ages increased from 55% in 1990 to 64% in 2015 globally (Ajayi *et al*., 2018a). About 63% of women in their reproductive ages who are sexually active were said to be using some form of contraception in 2017 (Nations, 2017).

More significantly, in the least developed countries of the world, the proportion of women utilizing modern contraceptives rose from 39.4% in 2000 to 58.5% in 2018, compared with the global average of 74.9% in 2000 to 77.4% in 2018. Consequently, the proportion of demand for family planning approaches addressed by modern contraceptives was 78%, with the proportion in Africa being the lowest in regions with 56% compared to the rest of 75% (Nations, 2017). There are however wide disparities in the use of contraceptives around countries that have a greater impact on developing countries. Sub-Saharan Africa is said to have the largest non-use prevalence of modern contraceptives, accounting for 21% of the world's low-use strain of modern contraceptives (Wang & Cao, 2019).

The prevalence of contraceptive use among ever-in-union women in Nigeria only increased by 9%, of which the use of modern methods increased by 6% over 18 years from 1990-2008 (National Population Commission NPC Nigeria & ICF Macro, 2009). In 2013, the prevalence of modern contraceptive use among Nigerian women was 11.1% which is a slight increase from 10.5% in 2008 by the Demographic Health Survey (Findings, 2016). Given all the resources institutions and governments have expended on this, all of this always translates to a steady increase in Nigeria's population by 3.2% annually (Population Reference Bureau, 2014). Contraceptive usage increased from 15% in 2013 to 17% in 2018 for currently married women. The use of any modern method of contraception has also risen from 10% to 12% (National Population Commission(NPC)[Nigeria] & ICF International, 2019).

While Nigeria has emphasized the prevalence of contraception, the presence of regional differences in the use of modern contraceptives continues to have gained insufficient publicity. According to (Adebayo *et al*., 2013), the northern states have a low level of acceptance and use of modern contraceptives among married women in their reproductive age with prevalence ranging from 2%-7% (National Population Commission(NPC)[Nigeria] & ICF International, 2019) and Ajayi *et al*, 2018 reported that there was a reasonable level acceptance of contraception methods and significant use of contraceptives in the south-western states with prevalence ranging from 25%-29% (National Population Commission(NPC)[Nigeria] & ICF International, 2019).

It has been recognized that the enhancement of state-specific family planning systems is a very important aspect of the success of modern contraceptive use among ever-in-union women in their reproductive age, as there are considerable differences between states (Lamidi, 2015).

2.2: Contraceptive Knowledge, Attitude, and Practice

Multiple surveys across Nigeria's six geopolitical zones signify that contraceptive knowledge and awareness appear to be very strong, particularly among female students aged 15 to 24 (Essien *et al*., 2010). Among students in a tertiary institution, it was indicated that more than 98% of males and 85% of females indicated that the primary sources of their knowledge of contraceptive methods were peers such as friends and sexual partners (Iyoke *et al*., 2014).

In a survey conducted in a north-central state by (Abiodun & Balogun, 2009), it was discovered that most respondents were able to identify at least one contraceptive method but the commonly reported methods were condom (69.0%), Oral contraceptive pill (OCP, 38.8%), Intrauterine Contraceptive Devices (IUCD, 29%) and intermittent abstinence (32.9%).

For sexually active unmarried women, the perception of modern methods of contraception is higher (98%) than currently married women (94%), where the sexually active unmarried women have an idea of approximately nine methods and the currently married women know seven methods. The most widely employed modern methods for presently married women are Injectables (88%) and tablets (87%), accompanied by Implants (78%), Male contraceptives (77%), and Lactational amenorrhoea (58%). 72% of actually married women are conscious of a traditional method of contraception (National Population Commission(NPC)[Nigeria] & ICF International, 2019).

Rural areas have always been complaining about the lack of exposure to contraceptive methods, but in the course of the study, qualitative evidence throws additional insight on the main reasons for the non-use of contraceptive methods in the settings of the sample. It was observed that this

was attributed to their apprehension of the side effects of conventional contraception, postponement of contraceptive use and lack of access, these were among the explanations for the non-use of contraceptives. This is consistent with previous research (Ajayi *et al*., 2018b; Olamijulo & Olorunfemi, 2012) not simply inadequate exposure to them, as they have previously claimed. The methods of contraception (known to be more effective) are small because of fear of the side effects of modern contraception, many women rely on less efficacious traditional contraceptive methods (Ajayi *et al*., 2018b).

It was noticed by (Adebayo *et al*., 2013) that the use of family planning by unmarried respondents who claimed that contraceptives were inexpensive was about four times higher than that of currently or formerly married respondents. Married respondents were less inclined to use modern family planning relative to their non-married counterparts who consider emergency contraceptive pills are readily accessible and affordable (Adebayo *et al*., 2013; Mosha, 2017).

Women currently married or those who used to be, who assumed that Injectables and Intrauterine Contraceptive Devices (IUCDs) were inexpensive and that pills were easily obtainable, were more likely to use modern family planning approaches than those who had never married. Such findings are consistent with studies showing a higher use of Injectables and Intrauterine Contraceptive Devices (IUCDs) among married and older women, whereas in Nigeria, awareness, and attitude to emergency contraceptives, especially among married couples, is low (Adebayo *et al*., 2013; Okonofua *et al*., 2009).

Ajayi *et al*, 2018 admitted that women practice at least one form of the family planning method, particularly in the south-western states of Nigeria, which was performed among women attending antenatal clinics and those in small communities.

In Nigeria, there is a very low probability of using injectables out of marriage. Non-married respondents are likely to perceive injectables as being meant for married individuals. The use of emergency contraceptive pills by unmarried women is considered to be the preferred method (Adebayo *et al*., 2013; Umoh & Abah, 2011).

Currently/formerly married women were twice less likely to use modern family planning approaches than female respondents who at the time of the study were never married. Of those who believed that condoms and pills are easy to obtain, the chances are almost two times higher, but this was not significant for those who felt other perceived approaches were easy to obtain. Respondents who felt contraceptives were accessible had a two-fold greater use of modern family planning relative to those who assumed other approaches would be effective (Adebayo *et al*., 2013).

Unfortunately, all the studies showing sufficient knowledge and awareness did not show a heavy prevalence of contraceptive use. Rather, these studies showed a high level of sexual behaviour that corresponded to a weak prevalence of contraception. The effect of high sexual behaviour and poor contraception use is an increased frequency of unplanned pregnancies and resulting caused abortions or unplanned births (Essien *et al*., 2010).

The justifications in these studies for not using contraceptives were fear of side effects, opposition from their spouse, clashes with their religious beliefs, opposition from members of the family, no consideration of using contraceptives, no sexual debut (Essien *et al*., 2010; National Population Commission NPC Nigeria & ICF Macro, 2009).

2.3: Modern Contraceptive Methods

Oral Contraceptive pills are short-acting hormonal methods that and the combined oral contraceptive pill is said to reduce the risk of endometrial and ovarian cancer (Nations, 2017). Pills were mostly discontinued due to a desire to become pregnant (33%) with a 1.4% current prevalence rate among married women (Croft *et al*., 2018).

Intrauterine contraceptive devices (IUDs) are long-acting reversible contraceptions that is T-shaped and inserted into the uterus to prevent pregnancy which could be hormonal or copper. Some research also suggests that these IUDs maintain their effectiveness up to a year beyond their recommended use period (Williams, 2015). Only 13% of the world's married women use Intrauterine Contraceptive Device (IUD) as their method of contraception (Regassa *et al*., 2016). In sub-Saharan Africa, in spite of its attractive features, IUD remains underutilized; only two percent of users rely on the IUD as a method of contraception (Ali *et al*., 2011). According to the 2018 NDHS report, the prevalence level among married women is 0.8%.

Injectables are one of the most commonly used modern methods of contraception among currently married women with 3% prevalence level according to the 2018 NDHS release also Injectables were mostly discontinued due to side effects/health concerns (37%) (Croft *et al*., 2018).

Diaphram is a shallow, flexible latex or soft rubber cup that is inserted into the vagina before intercourse, preventing sperm from entering the uterus.

Male condoms, according to the 2018 NDHS release, this is the most common modern method used by sexually active unmarried women with (19%) prevalence level.

Female condoms are sheaths, or linings, that fit loosely inside a woman's vagina, made of thin, transparent, soft plastic film which forms a barrier to prevent sperm and egg from meeting with 90% success rate of consistent and rightful use and protects against sexually transmitted infections including HIV (Nations, 2017).

Male sterilization is a non-reversible form of birth control such that a man is prevented from releasing sperm and this is usually done by a health care provider, this is rare among Nigerian men.

Female sterilization is a non-reversible form of birth control such that a woman is prevented from getting pregnant and this is not a popular method among Nigerian women which shows a low prevalence of 0.2% (Croft *et al*., 2018).

Implants are one of the most commonly used modern methods of contraception among currently married women with a 3% prevalence level according to the NDHS 2018 release.

Foam/ Jelly is a spermicide that should be injected into the vagina close to the uterus no more than 30 minutes prior to intercourse and left in place 6 to 8 hours after intercourse. Spermicides do not prevent the transmission of STDs and can cause vaginitis or allergic reactions.

Emergency contraception pills are used after unprotected intercourse or if a condom breaks with a prevalence rate of 0.2% among married women (Croft *et al*., 2018).

2.4: Factors Affecting Contraceptive Use

Nigeria has one of the highest fertility rates and lowest contraception prevalence rates worldwide, more than three decades after the start of its fertility decline (Population Reference Bureau, 2014). Nonetheless, national-level data on female reproductive activities mask major geographic differences in the country (National Population Commission NPC Nigeria & ICF Macro, 2009).

In understanding the dynamics of contraceptive use in Nigeria and sub-Saharan Africa by extension, Ajayi *et al* found that the metropolitan region of residence was correlated with contraception use, which was not the case in rural areas, and their rights and access to the distribution of family planning services in urban areas were logical hypotheses. Respondents living in rural areas, or located in the northern part of the country, were less inclined to use methods of contraception (Ankomah *et al*., 2011), which showed that the greater prevalence of contraception in urban areas as contrasted with rural areas demonstrated the higher educational level of urban residents (Onwujekwe *et al*., 2012).

According to Lamidi, it was shown that the higher the odds of modern contraceptive use among married and cohabiting women, the greater the shares of educated and employed women, as well as women with health care decision-making power in a state. Women who were married or cohabiting with educated men had significantly higher chances of using modern contraception compared to women whose husbands had no knowledge of modern contraceptives (Lamidi, 2015). Ankomah *et al.* suggested that respondents of poor health, under-educated or low socioeconomic status are less inclined to use contraception than other categories. Furthermore, there was an indication that those respondents who did not give any specific number of ideal children were at the low end of contraception use (Ankomah *et al*., 2011).

Subsequently, the use of modern contraception by women was substantially linked to their intended as well as actual fertility. A desire for four or fewer babies, compared to having more than four children, was said to increase the chances of women utilizing modern contraceptives significantly. This study appeared to confirm much well-documented evidence in the literature showing that understanding one's preferences for fertility is an important first move towards accomplishing small family size and eventual decline in use (Ankomah *et al*., 2011). The more people who had living children the more likely they were to use modern contraception. Variations in women's involvement in health care decisions across states remained strongly related to modern contraceptive usage, regardless of socioeconomic status at the individual level and other covariates of modern contraceptive use (Lamidi, 2015).

Current contraception use peaks from 24 years of age for married women and drops from 42 years of age owing to no aspirations of children again and the start of menopause at that point (Adebayo *et al*., 2013; National Population Commission NPC Nigeria & ICF Macro, 2009). The results further indicate that respondents aged 45 years and older, and those aged 24 years and younger, were less inclined to use contraceptives. The observation that respondents who addressed family planning with their partners were more inclined to use contraception is of crucial importance and is a well-established result in the literature (Essien *et al*., 2010). Similarly, respondents who spoke with partners and health workers regarding family planning were more inclined to use contraceptive methods. It was found in a study that the three primary sources of information concerning contraception use our partners, peers and health workers (Ankomah *et al*., 2011). The respondent's age was also important in the contraceptive commodity source, in the same survey. Many teens using patent medication shops but there is a greater tendency to get contraception from

private or general clinics from the age of 25. This discovery is primarily due to the social stigma of premarital sex, the community to which most teens belong (Essien *et al*., 2010) whereby the chances of using modern contraception decrease with age (Lamidi, 2015).

Evidence revealed in a study by Oye-Adeniran *et al*. in 2005 that while Roman Catholics got their contraceptives mostly from commercial drug stores, most Christians got theirs from general healthcare facilities. Catholic and Protestant women, as opposed to their Muslim equivalents, had relatively higher levels of modern contraceptive use (Lamidi, 2015). It had often been consistently demonstrated that faith and religious belief can affect contraceptive use. Catholic sponsorship may be attributed to a religious objection to the use of modern methods of contraception in commercial drug stores and marketplaces. In the same research, Muslims were said to patronize the patent medicine shops more often because of their recorded strong criticism of contraceptive use (Essien *et al*., 2010).

It was discovered that while the conversation with religious leaders had a negative impact on contraceptive usage, respondents who believed that religion is not against family planning were more inclined to use contraceptive methods. These findings reflect inconsistencies in the population at large between the role of certain religious authorities and verifiable facts on family planning (Ankomah *et al*., 2011). Several researchers discovered that religion played an important part in embracing modern contraception in northern Nigeria (Onwujekwe *et al*., 2012)

Onwujekwe *et al*., 2012 stated that private sectors are the major source of contraceptives in both urban and rural areas, particularly patent drug dealers and pharmacy stores in contrast with the

public sector, which have become negligible in contraception supply. It was also acknowledged that vendors far from consumers can lead to reduced access and use (Onwujekwe *et al*., 2012).

In relation to causes that could be attributed to the use of modern contraception, early marriages and early sexual activity have largely contributed to high fertility and the resulting higher prevalence of maternal and fetal abnormalities, especially in northern Nigeria (Essien *et al*., 2010). Conclusively, geographical location, age, race, religion, level of education, preference for fertility and amount of surviving children are factors responsible for the use of modern contraception (Lamidi, 2015).

2.5: Conceptual Framework

Based on the Andersen healthcare utilization model which states that usage of health services is determined by three dynamics namely; predisposing factors, enabling factors, and need also accompanied with reviewed literature, there is therefore an hyphothesis that these factors determine the use of modern contraceptives (Mbalinda *et al*., 2020).

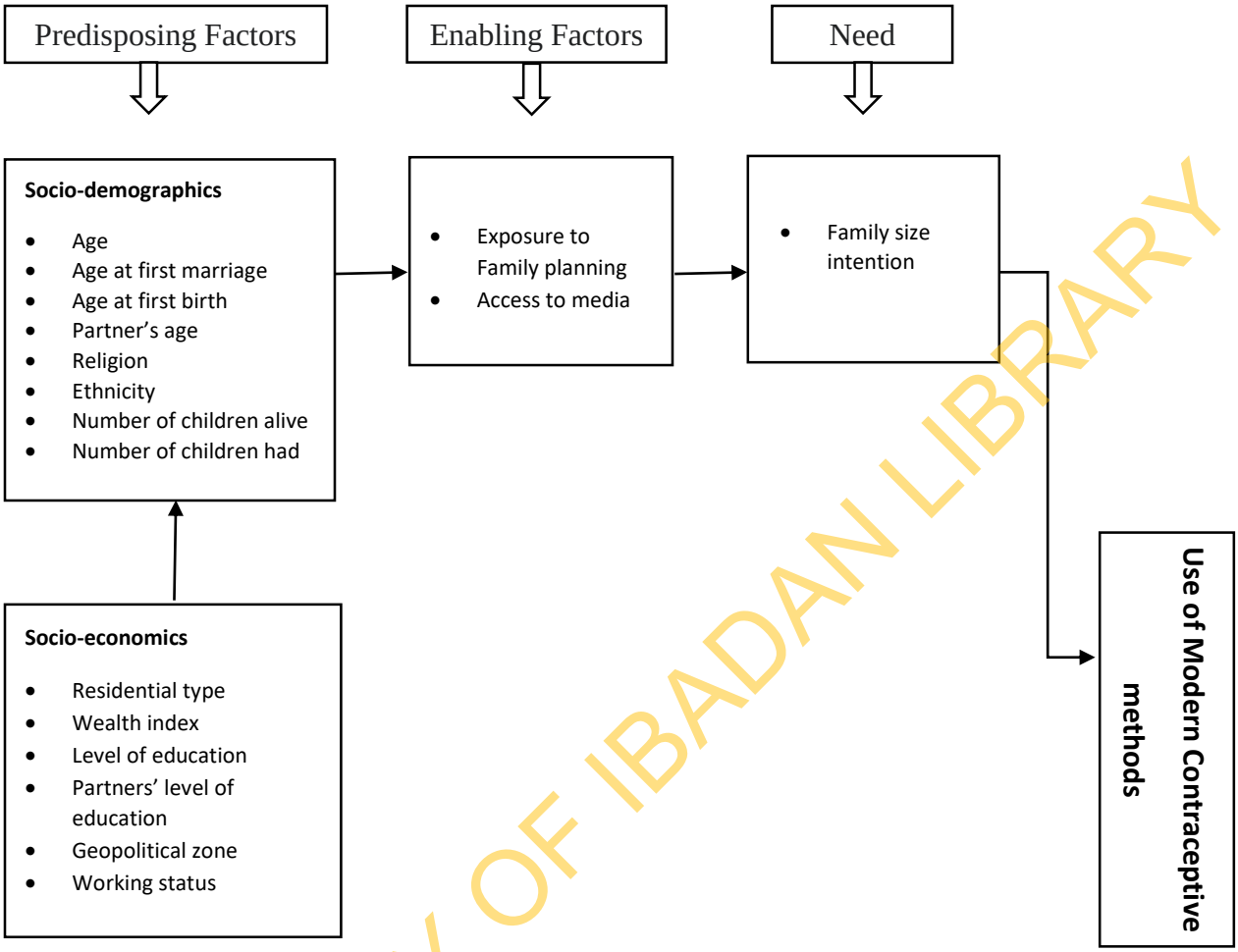

Figure 1: Conceptual Framework

Source: Modified from Andersen healthcare utilization model

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1: Study Area

The study setting is Nigeria, the largest country in Africa with an annual population growth rate of 3.2% (Population Reference Bureau, 2014) and a total fertility rate (TFR) of 5.8 births per woman (National Bureau of Statistics, 2017). Nigeria comprises of 36 states and a Federal Capital Territory (FCT). All the states and FCT are grouped into six geopolitical zones and each geopolitical zone has a minimum of five and a maximum of seven states. Within these states are public and private sectors, the public sectors are the largest providers of modern methods of contraception as compared to the private sectors. The public sectors include government health centres, hospitals and the private sectors include private chemists/ patent medicine stores.

3.2: Study population

This 2018 NDHS included sexually active women of the reproductive age 15-49 years in Nigeria and 41,821 women were sampled.

3.3: Target population

A total number of 31,152 sexually active women out of 41,821 sampled women were ever-in-union which comprises of currently married, living with partner, widowed, divorced and separated. This was used for this study as the interest is ever-in-union women.

3.4: Study Design

This is an analytical cross-sectional study. It uses nationally representative data (2018 NDHS) was a two-stage stratified study.

3.5: Sampling design

The sampling frame used for the 2018 NDHS is the Federal Republic of Nigeria Population and Housing Census of the (NPHC), which was administered by the National Population Commission in 2006. Every state is categorized into local government areas (LGAs), and each LGA is divided into wards. In relation to these institutional divisions, each region was subdivided into accessible areas called census enumeration areas (EAs) during the 2006 NPHC. The primary sampling unit (PSU), referred to as the 2018 NDHS cluster, is established by the 2006 EA census system based on EAs.

To classify the list of EAs, assess the number of households and define EAs as urban and rural for the survey sample context, a mixture of geographical material demarcating each EA and LGA population figures from the census was used. Stratification was accomplished by grouping each of the 36 states into urban and rural areas as well as the Federal Capital Territory. A total of 74 strata of sampling were identified.

At the first stage, 1400 EAs were chosen proportionally to the size of the EA. In all the chosen EAs, a household listing process was conducted and the resulting household lists acted as a sampling frame for household classification in the second stage.

A fixed number of 30 households in each cluster were chosen in the recruitment of the second stage by rigorous sampling with equal probability, resulting in a total sample size of approximately 42,000 households. A more detailed version of the survey was published elsewhere (National Population Commission(NPC)[Nigeria] & ICF International, 2019).

3.6: Study Variables

The variables used in this study are stated below.

3.6.1: Dependent variable

Current Modern contraceptive use, represented in this study as a binary response variable classified as either Yes or No. The modern contraceptives considered in this survey are oral contraceptive pills, intrauterine contraceptive devices (IUDs), injectables, diaphragm, male condoms, female condoms, male sterilization, female sterilization, implants, foam/ jelly, emergency contraception pills. Any respondent who use at least one of the contraceptives within 12 months preceding the survey date was classified as a user (Yes) else non-user (No).

3.6.2: Independent variables

The choice of explanatory variables was based on literature and available data which consists of several socio-demographic and socio-economic factors.

Socio-demographic factors will be explored: Respondent's current age, Respondent's Age at first cohabitation/ marriage, Respondent's Age at first birth, Partners' age, Religion, Ethnicity, Number of children alive, Number of children had, Family size intention.

Socio-economic factors: Residential type, Wealth index, Respondent's level of education, Partner's level of education, Geopolitical zone, Respondent's working status; **Knowledge Indicators**: Knowledge of Family planning, Access to media.

3.6.3: Description of Variables

VARIABLES	DESCRIPTION
Dependent Variable	
Current Modern Contraceptive use	0 = No (Non-Modern), 1 = Yes
Independent Variables	
1. Age	0 = <15; 15-19, 1= 20-24, 2= 25-29, 3= 30-39; >=30, 4= 40-49
2. Religion	0= Christians, 1= Islam, 2=Traditionalist, 3=Others
3. Ethnicity	0 = Hausa, 1 = Igbo, 2 = Yoruba, 3 = Others
4. Number of children	The mean number of children is 3 and its coded as, 0 = <=3, 1= >3
5. Family size intention	0 = <= 4, 1 = 5-9, 2 = 10+
6. Residential type	1 = Urban, 2= Rural
7. Wealth index	1= Poorest, 2= Poorer, 3= Middle, 4= Richer, 5= Richest
8. Level of education	0 = No education, 1 = Primary, 2 = Secondary, 3 = Higher
9. Current employment status	0 = No, 1 = Yes
10. Exposure to family planning	0 = No, 1 = Yes

11. Access to media	The media sources are radio, TV, and newspaper access to no media (None: 0 = No) and access to at least one media Yes (one, two or three forms), 1 = Yes.
12. Geopolitical zone	1 = North Central, 2 = North East, 3 = North West, 4 = South East, 5 = South South, 6 = South West
13. Knowledge of Family planning	The knowledge sources are radio, TV, newspaper and text messages; no exposure to any source-(None: 0 = No) and knowledge through at least one source; (Yes: one, two or three forms), 1 = Yes

3.7: Data

For the 2018 NDHS questionnaires, the Woman's questionnaire used is tailored to represent population and health issues specific to Nigeria based on the regular Demographic and Health Survey (DHS-7) questionnaires of the DHS program.

The survey protocol was reviewed and approved by the National Health Research Ethics Committee of Nigeria (NHREC) and the ICF Institutional Review Board. After all, the questionnaire was finalized in English, they were translated into Hausa, Yoruba, and Igbo. The 2018 NDHS used computer-assisted personal interviewing (CAPI) for data collection.

Nigeria's National Health Research Ethics Committee (NHREC) and the ICF Institutional Review Board reviewed and approved the survey protocol. They were interpreted into Hausa, Yoruba, and Igbo after the questionnaire had been fully implemented in English. For data collection, the NDHS used computer-assisted personal interviewing (CAPI) in 2018.

3.8: Data Analysis and Management

For data analysis, IBM SPSS (version 20) and R-programming language with BayesX package installed were used for descriptive and analytical methods while variations in categorical data were presented with frequency tables and percentages. For the continuous data which is normally distributed, the mean and standard deviation were calculated and used. The analysis used structured additive regression to evaluate the spatial correlation of important parameters.

3.9: Model

The spatial analysis builds on the framework of Structured additive regression for a binary response but first, the Binary Logistic regression model is considered.

3.9.1 Binary Logistic Regression

Logit, which is the normal logarithm of an odds ratio, is the core mathematical principle underlying logistic regression. (Peng *et al*., n.d.). The binary logistic regression model is the best fit for a dichotomous outcome variable and it encourages the influence of multiple factors in explaining the outcome variable, all at the same time.

The model's dependent variable is represented by a binary variable, where one signifies the true (having the event), and the false is indicated by zero (no event). A collection of identified socio-demographic and socio-economic possible factors define the independent variables of the model.

The model uses independent variables as predictor values that are continuous or categorical variables to calculate the probability of an event occurring (Bo *et al*., 2014).

The advantage of using both categorical and continuous explanatory variables in the same model, is what distinguishes logistic regression as compared to linear regression and also its ability to handle more than two explanatory variables simultaneously (Stoltzfus, 2011).

For a logistic regression, the structure of the model is given by equation;

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_n x_{n,i} \quad (3.1)$$

where P_i is the probability of the occurrence of an event which is the expected value of the response variable y_i (such that $y_i = 1$ if a sample has the event of interest and $y_i = 0$, otherwise), x_i represents the explanatory variables, β is the regression coefficient, i is the index of the records, such as a geographical unit at 5% level of significance (Bo *et al*., 2014).

3.9.1.1: Assumptions of Binary Logistic Regression

1. The response variable is binary
2. Absence of multicollinearity among explanatory variables
3. The observations are independent of errors
4. There is a linear relationship between explanatory variables and the logit of the response variable
5. Lack of strongly influential outliers
6. The sample size is sufficiently large (n>=30)

3.9.2: Structured Additive Regression Models

Structured additive regression (STAR) models provide a robust structure for modelling potential nonlinear covariate results which include well-established structures of generalized linear models and generalized additive models as special cases, but also provide for a broader range of effects, e.g. for regional or Spatio-temporal details, facilitating the design of complex and practical models (Umlauf *et al*., 2015). Structured additive regression (STAR) models comprise of Generalized additive models (GAM) for cross-sectional data, Generalized additive mixed models (GAMM) for longitudinal data, Space-time main effect models − Geoadditive models, Varying coefficient models (VCM)- Geographically weighted regression, and ANOVA type interaction model (Fahrmeir & Tutz, 2001). Generalized additive models (GAM) for cross-sectional data will be adopted for this study.

3.9.2.1: Derivation of Generalized Additive Model from Generalized Linear Models

To illustrate the basic concept, the generalized linear model varies from the general linear model (of which multiple regression is a unique case) in two main respects: First, the distribution of the dependent or response variable may be (clearly) non-Gaussian and may be continuous for example, it may be binomial. Secondly, dependent variable values are estimated from a linear composition of explanatory variables linked through the use of a link function to the dependent variable. A particular case of the generalized linear model may be known as the generalized linear model for a single response variable: The values of the dependent variable are expected to follow the binomial distribution in the general linear model, and the link function is a basic identity function (i.e., the linear combination of values is not modified for the predictor variables).

For further illustration, a response variable Y is linearly correlated with values on the X variables in the general linear model while the association in the generalized linear model is presumed to be

$$Y = h(b_0 + b_1 * X_1 + \cdots + b_m * X_m) \quad (3.2)$$

Where $h(b_0 + b_1 * X_1 + \cdots + b_m * X_m)$ is a function. Formally, the inverse function of $h(\ldots)$, say $(h'(\ldots))$, is called the link function; so that:

$$h'(\mu Y) = b_0 + b_1 * X_1 + \cdots + b_m * X_m \quad (3.3)$$

Where μY stands for the expected value of Y.

The spatial analysis is based on the concept of the structured additive regression model for a binary response. The response variable $(y_{ijk}, w_k, v_k, r_j, s_i)y_{ijk}$ is the state of modern contraceptive use of the j^{th} person living in the i^{th} geo-political zone whereby y takes the value 1 if the respondent used a contraceptive and 0 otherwise. Bayesian generalized linear models assume that, given covariates μ and unknown parameters α, the distribution of the response variable y belongs to an exponential family, with mean $\mu = E(y/w, \alpha)$ which is linked to the semi-parametric predictor η (Fahrmeir *et al*., 2004) therefore:

$$\mu = h(\eta); \qquad \eta = \mu'\alpha \quad (3.4)$$

Where; h is the response function and α is an unknown regression coefficient.

As compared to classical regression models, structured additive regression models replace the linear predictor by a structured additive predictor (Rigby *et al*., 2005);

$$\eta_{ij} = \sum_{j=1}^{p} f_{ij}\,(x_{ij}) + f_{spat}\,(s_i) + \ldots + v_{ij}\alpha \quad (3.5)$$

f is the smoothing function that describes the nonlinear relationship between the explanatory variables (x) and logit probability of the response variable, these functions will be estimated using Bayesian cubic Penalized regression spline, f_{spat} is the nonlinear spatial effect (s), and α is the

regression coefficients for the categorical covariates (*v)*. The spatial effects f_{spat} may be further split into spatially correlation (structured) and uncorrelated (unstructured) effects such as:

$$f_{spat}(s_{ij}) = f_{str}(s_i) + f_{unstr}(s_j) \quad (3.6)$$

3.9.2.2: Prior Assumptions

Due to ease of analysis and the probability of measuring a posterior odds ratio (which is a calculation of the degree of correlation in logistic regression) directly from the performance of Markov chain Monte Carlo (MCMC), the Bayesian structured additive regression of the logit model is chosen. The fitting of Bayesian models using MCMC includes treating all parameters as spread randomly according to some prior distribution. The posterior distribution is intractable, and MCMC algorithms are used to produce samples from this prior distribution so that the parameters can be measured and inferred (Diggle, P. J., Tawn, J. A., & Moyeed, 1998).

The term P-spline (penalized B-spline) refers to the use of the representation B-spline (basis spline) where the coefficients are calculated partly by the data to be equipped and partly by an additional penalty feature which aims to enforce smoothness to prevent over fitting. Through combining the different penalties with their stochastic analogs, Bayesian P-spline is obtained e.g. Gaussian (intrinsic) random walk priors acting as smooth priors for the undefined coefficients in regression. Further clarification on this can be gotten from Lang and Brezger, (2004) and Brezger and Lang, (2006).

All the regression coefficients and smooth f_j functions are considered as random variables in Bayesian analysis and are given prior distributions. Without any prior knowledge, diffuse priors are assigned to the coefficients α of continuous covariates;

$$p(\alpha_i) \propto const. \quad (3.7)$$

The unknown smooth functions $f_j(x_j)$ are assigned Bayesian penalized splines priors (Brezger, 2006). The functions are assumed to be approximated by a polynomial of degree l which is defined over a set of equally spaced knots of the form:

$$x_{min} = \zeta_0 < \zeta_1 < \cdots < \zeta_{m-1} < \zeta_m = x_{max} \tag{3.8}$$

The spline is expressed as a linear combination of B-spline basis functions. This approach is similar to fitting second-order random walk priors of the form:

$$\beta_k = 2\beta_{k-1} - \beta_{k-2} + \mu_k \tag{3.9}$$

with Gaussian errors, μ_k, assigned to the smooth terms. The spatial random terms are also fitted as splines, particularly as a two-dimensional tensor product. The unknown β_j are assigned priors of the general form:

$$p(\beta_j/{\tau^2}_j) \propto \frac{1}{({\tau^2}_j)^{rank(K_j/2)}} \exp(-\frac{1}{2{\tau^2}_j}{\beta'}_j K_J \beta_j) \tag{3.10}$$

where K_j is the penalty matrix and τ_j is the variance parameter that controls the tradeoff between flexibility and smoothness. The ${\tau^2}_j$ is assigned non-informative dispersed inverse Gamma priors $p\left({\tau^2}_j\right) \sim IG(a_j, b_j)$ (Fahrmeir, L., & Kneib, 2009) where

$${\tau^2}_j \propto \frac{1}{(\tau_j)^{a_j+1}} \exp(\frac{-b_j}{\tau_j}). \tag{3.11}$$

We considered stationary Gaussian method with constant mean and variance to achieve the spatial effects; $\Sigma_{ij} = \sigma^2 corr(d_{ij}, \rho)$, where σ^2 is the variance and $corr(d_{ij}, \rho)$ is the spatial correlation. The spatial correlation is said to be a function of distance, d_{ij}, between the spatial locations s_i and s_j.

3.9.2.3: Model Building

Model 1: η = time +f_{spat} (s_{ij})

Model 2: η = time + f_{spat} (s_{ij}) + f (age of respondents)

Model 3: η = time + f_{spat} (s_{ij}) + f (age of respondents) + geopolitical zones

Model 4: η = time + f_{spat} (s_{ij}) + f (age of respondents) + geopolitical zones + demographic characteristics

Model 5: η = time + f_{spat} (s_{ij}) + f (age of respondents) + geopolitical zones + demographic characteristics + knowledge indicators

Model 6: η = time + f_{spat} (s_{ij}) + f (age of respondents) + geopolitical zones + demographic characteristics + knowledge indicators + socio-economic status

3.9.2.4: Assumptions of the model

1. It does not require a linear relationship between the outcome and explanatory variables.
2. The outcome variable does not need to be normally distributed.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF FINDINGS

4.1: Descriptive Analysis of the Univariate Data

This section explains the distribution of socio-demographic factors, socio-economic factors and indices of awareness about the use of modern contraceptives in Nigeria.

4.1.1: Socio-demographic and Socio-economic characteristics of ever-in-union women

The table 1 below shows the descriptive analysis of various Socio-demographic characteristics among ever-in-union women in Nigeria with a total of 31,152 women and an average current age of 32 years. It describes the majority of women had their first marriage and first birth at an early age of less than 20 years. Among these women, a large majority are Hausa's (37.1%) and in the Islamic religion (55.0%) with the highest family size intention being (50.1%) of about 5-9 children in a family.

Table 1: Distribution of the studied ever-in-union women by their socio-demographic characteristics

Variable	Levels	Frequency	Percentage
Respondent's Age (years)	15-19	1866	6.0
	20 – 24	4515	14.5
	25 - 29	6205	19.9
	30 – 39	10791	34.6
	>= 40	7775	25.0
	Mean ± SD		**32.28 ± 8.76**
Respondent's Age at first marriage (years)	< 15	6514	20.9
	15-19	13955	44.8
	20 – 24	6624	21.3
	25 - 29	2872	9.2
	>=30	1187	3.8
	Mean ± SD		**18.53 ± 5.10**

Variable	Levels	Frequency	Percentage
Respondent's Age at first birth (years)	< 15	2096	7.2
	15-19	14382	49.5
	20 – 24	8422	29.0
	25 - 29	3109	10.7
	>=30	1071	3.7
	Mean ± SD		**19.68 ± 4.50**
Partner's Age (years)	15-19	26	0.1
	20 – 24	584	2.0
	25 - 29	2347	8.1
	>=30	25931	89.8
	Mean ± SD		**42.29 ± 11.20**
Religion	Christians	13750	44.1
	Islam	17144	55.0
	Traditionalist	128	0.4
	Others	130	0.4
Ethnicity	Hausa	11563	37.1
	Igbo	4402	14.1
	Yoruba	3752	12.1
	Others	11410	36.7
Number of children alive	<= 3	17025	54.7
	> 3	14127	45.3
Number of children ever had	<= 3	15085	48.4
	>3	16061	51.6
Family size intention	<= 4	8334	27.6
	5-9	15141	50.1
	>=10	6763	22.4
Total		31152	100

The table 2 below describes the socio-economic status of ever-in-union women with the majority of these women living in the rural area (63.1%), having most of them with no education (42.8%). Although 70.9% of these women are presently working, most are still in the poorer class of the wealth index (21.6%) followed by the poorest class (21.5%) and a higher percentage of women with no knowledge of family planning (66.6%).

Table 2: : Distribution of the studied ever-in-union women by their socio-economic characteristics

Variable	Levels	Frequency	Percentage
Residential type	Urban	11504	36.9
	Rural	19648	63.1
Wealth index	Poorest	6687	21.5
	Poorer	6724	21.6
	Middle	6476	20.8
	Richer	6093	19.6
	Richest	5172	16.6
Respondent's Level of education	No education	13328	42.8
	Primary	5448	17.5
	Secondary	9584	30.8
	Higher	2792	9.0
Partner's level of education	No education	9803	33.9
	Primary	4436	15.4
	Secondary	9769	33.8
	Higher	4487	15.5
Respondent's working status	No	9052	29.1
	Yes	22100	70.9
Knowledge of family planning	No	20739	66.6
	Yes	10413	33.4
Total		31152	100

4.1.2: Modern Contraceptive Use

The table 3 below shows that a huge minority 3582 (11.5%) among ever-in-union women are users of modern contraceptive compared to those who are non-users 27570 (88.5%) out of 31,152 ever-in-union women.

Table 3: Distribution of the studied ever-in-union women by their use of Modern Contraceptives

Modern Contraceptive	Frequency	Percentage
Users	3582	11.5
Non-users	27570	88.5
Total	31152	100

4.1.3: Distribution of the studied ever-in-union women by their access to different forms of media

The figure 2 below describes the access of ever-in-union women to any form of media such as access to newspaper/ magazine, radio or television with none signifying no form of access to media (37.3%), one signifying access to one form of media (24.5%), two signifying two forms (27.8%) and three signifying access to all the forms of media available (10.4%). Therefore, we can classify access to media in two major forms; for those who have no access at all are seen to be in the No category and those who have access to at least a form of media are in the Yes category.

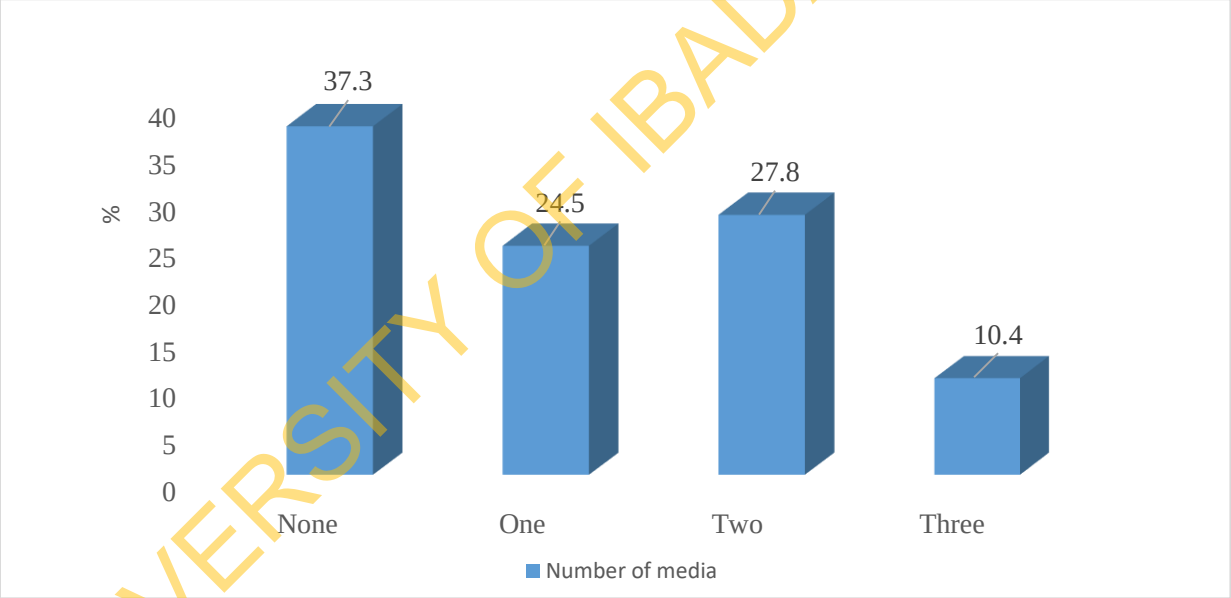

Figure 2: Chart showing the distribution of the studied ever-in-union women by their access to different forms of media

4.1.4: Distribution of the studied ever-in-union women by their Geopolitical zones

The figure 3 below describes the spread of ever-in-union women across the six geopolitical zones showing more of these women in the northern region with a majority in the North-Western Region (27.1%).

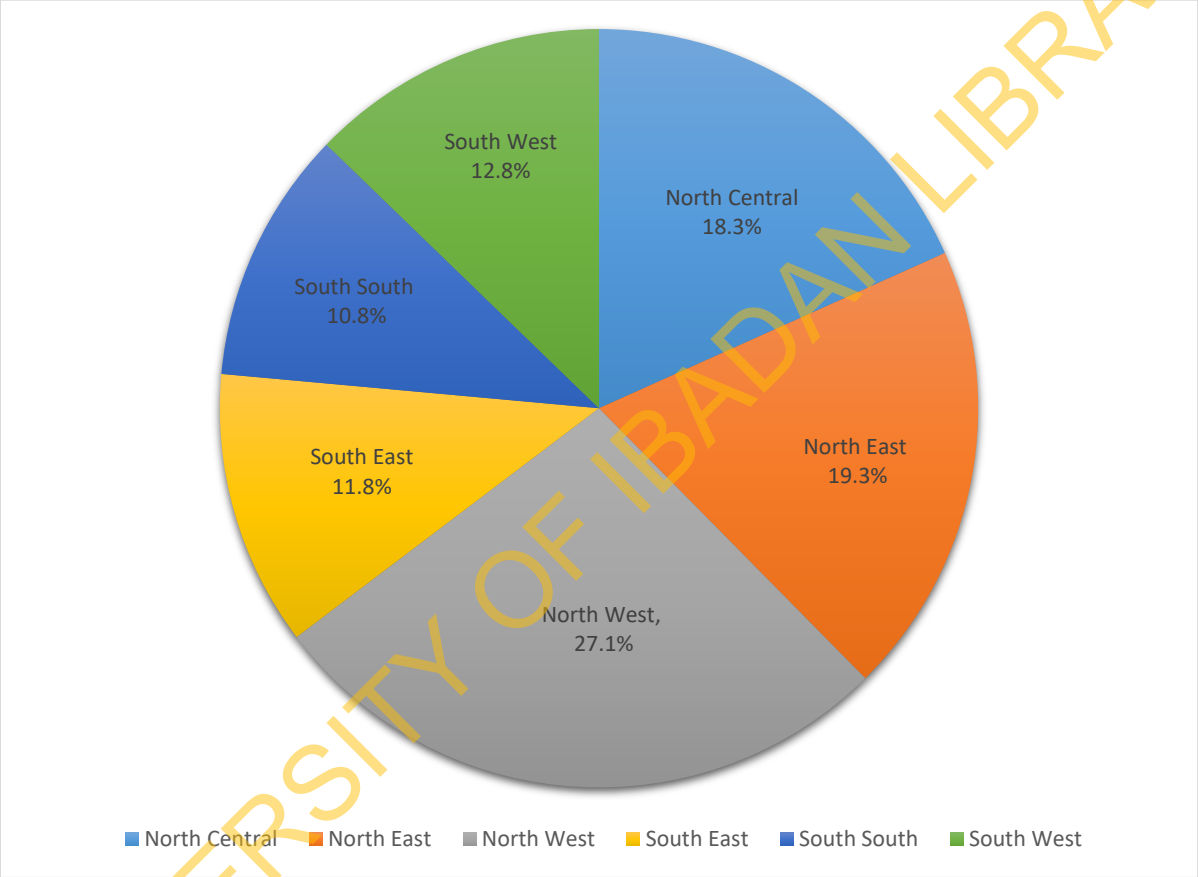

Figure 3: Chart showing the distribution of the studied ever-in-union women by their Geopolitical zones

4.2: Geographical differences in the use of modern contraceptives among ever-in-union women in Nigeria

The table below shows the rate at which ever-in-union women use modern contraceptives across the six geopolitical zones. There seems to be a poor rate of modern contraceptive use generally, especially in the Northern region compared to their southern counterpart with North West being the region with most sampled ever-in-union women having the lowest use of modern contraceptives (5.6%) followed by the North East (8.6%), then the North Central (14.2%). Whereas in the Southern region of Nigeria, South East has the highest number of sampled ever-in-union women but the least use of modern contraceptives (11.4%), followed by South South (13.9%) and the South West with (22.7%) which is the highest rate of use across the zones.

Table 4: Geographical differences in the use of modern contraceptives among ever-in-union women in Nigeria

Characteristics	Number of women	Percentage of users	Percentage of non-users
All	**31,152**	**11.50**	**88.50**
North central	5696	14.2	85.8
North East	6019	8.6	91.4
North West	8433	5.6	94.4
South East	3662	11.4	88.6
South South	3364	13.9	86.1
South West	3978	22.7	77.3

4.3: Bivariate analysis showing the association between Socio-demographic and Socio-economic characteristics of ever-in-union women and Modern Contraceptive use.

Table 5 below shows the association between socio-demographic characteristics and the use of modern contraceptive using bivariate analysis. There is evidence of a significant association between the age of respondents and use of modern contraceptives. The percentage of ever-in-union women who use modern contraceptives increased as age increases except with the last category (from 40 years) which took a downward turn. There is also evidence of a significant association between age at first marriage and modern contraceptive use with these women between the ages 30-39 years using modern contraceptives more than the other age categories (14.7%), this is also similar to those who had their first birth within the ages 25-29 years with the highest rate of modern contraceptive use (15.9%). The partner's age of these respondents has evidence of a significant association with modern contraceptive use with those between ages 15-19 years using it more (19.2%) compared to other categories. There is evidence of a significant association between the use of modern contraceptives and the total number of children ever had, number of children alive, and ideal family size intention. Those having a total number of three children ever born and above with 13.1% and those with more than three children alive 13.7%. Ever-in-union women with the desired family size of at most four children use modern contraceptives more (17.2%) than others who want more children. Religion and Ethnicity both have significant associations with Modern contraceptive use with Christians (17.0%) using modern contraceptive the most and Yoruba's (23.7%) being the ethnic group with the greatest percentage of use amongst ever-in-union women.

Table 5: Bivariate analysis showing the association between Socio-demographic characteristics of ever-in-union women and Modern Contraceptive use

Variable	Number of women	Levels	Modern Contraceptive use		X^2	p-value
			Yes %	No %		
Respondent's age group (years)	1866	15-19	2.6	97.4	299.715	0.001
	4515	20 – 24	8.2	91.8		
	6205	25 - 29	11.6	88.4		
	10791	30 – 39	14.7	85.3		
	7775	40 - 49	11.0	89.0		
Respondent's age at first marriage (years)	6514	< 15	7.0	93.0	373.766	0.001
	13955	15-19	10.5	89.5		
	6624	20 – 24	17.1	82.9		
	2872	25 - 29	14.2	85.8		
	1187	>= 30	9.8	90.2		
Respondent's age at first birth (years)	2096	< 15	8.8	91.2	241.758	0.001
	14382	15-19	9.8	90.2		
	8422	20 – 24	15.8	84.2		
	3109	25 - 29	15.9	84.1		
	1071	>= 30	12.1	87.9		
Number of children alive	17025	<=3	9.6	90.4	128.397	0.001
	14127	> 3	13.7	86.3		
Number of children ever had	15085	<=3	9.8	90.2	83.993	0.001
	16061	>3	13.1	86.9		
Partner's age (years)	26	15-19	19.2	80.8	57.550	0.001
	584	20 – 24	5.8	94.2		
	2347	25 - 29	8.0	92.0		
	25931	>= 30	12.2	87.8		
Religion	13750	Christians	17.0	83.0	745.203	0.001
	17144	Islam	7.2	92.8		
	128	Traditionalist	3.1	96.9		
	130	Others	5.4	94.6		
Ethnicity	11563	Hausa	5.5	94.5	1003.524	0.001
	4402	Igbo	12.9	87.1		
	3752	Yoruba	23.7	76.3		
	11410	Other	13.1	86.9		

Variable	Number of women	Levels	Modern Contraceptive use		X^2	p-value
			Yes%	No%		
Family size intention	8334	<= 4	17.2	82.8	620.234	0.001
	15141	5-9	11.2	88.8		
	6763	>=10	4.3	95.7		
Total	31152					

Table 6 below shows the association between socio-economic characteristics of ever-in-union women and the use modern contraceptives using bivariate analysis and it all shows evidence of a significant association. With most of these women who use the modern method of contraception staying in Urban areas (16.5%) and they are mostly the Richest (20.7%) with the highest level of education (21.1%), same as their partners (19.3%). Respondents who have access to media (14.7%) are seen to use modern contraceptives more than those who do not (6.0%), also similar to those who are currently working with (13.2%) of use compared to those not working (7.4%). Those that know about family planning (16.0%) use more modern contraceptives than those who do not (9.2%).

Table 6: Bivariate analysis showing the association between Socioeconomic characteristics of ever-in-union women and Modern Contraceptive use

Variable	Number of Women	Levels	Modern Contraceptive use		X^2	p-value
			Yes %	No %		
Residential type	11504	Urban	16.5	83.5	454.372	0.001
	19648	Rural	8.6	91.4		
Wealth index	6687	Poorest	4.5	95.5	1012.085	0.001
	6724	Poorer	7.2	92.8		
	6476	Middle	11.3	88.7		
	6093	Richer	16.3	83.7		
	5172	Richest	20.7	79.3		

Variable	Number of Women	Levels	Modern Contraceptive use		X^2	p-value
			Yes %	No %		
Respondent's level of education	13328	No education	4.5	95.5	1254.999	0.001
	5448	Primary	13.1	86.9		
	9584	Secondary	17.5	82.5		
	2792	Higher	21.1	78.9		
Partner's level of education	9803	No education	4.0	96.0	1014.221	0.001
	4436	Primary	11.3	88.7		
	9769	Secondary	16.3	83.7		
	4487	Higher	19.3	80.7		
Respondent's working status	9052	No	7.4	92.6	210.442	0.001
	22100	Yes	13.2	86.8		
Knowledge of family planning	20739	No	9.2	90.8	310.029	0.001
	10413	Yes	16.0	84.0		
Access to media	11606	No	6.0	94.0	543.292	0.001
	19546	Yes	14.7	85.3		
Total	31152					

4.4: Binary Logistic Regression of modern contraceptive use among the studied ever-in-union women

This section shows the result of the binary logistic regression with a combination of all the explanatory variables predicting the response variable. Model 6 is seen to be with the least log-likelihood which infers that it is the most efficient.

Table 7: Values for the Model diagnostics of the Binary Logistic Regression

Models	Log-likelihood
Model 1	22230.788
Model 2	21875.883
Model 3	21154.842
Model 4	17769.462
Model 5	17516.771
Model 6	17007.148

4.4.1: Full model for Binary Logistic regression of modern contraceptive use among the studied ever-in-union women

The table 8 below shows that respondents within the ages of 30-39 year have a higher odds (OR=1.49, p-value = 0.036) of using modern contraceptives than those in the age category of 15-19 years, also, those whose partners are within the ages of 25-29 have lower odds (OR= 0.090, p-value= 0.001) of using it compared to the reference category. Respondents who are traditionalist are less likely (OR= 0.186, p-value=0.021) to use modern contraceptives compared to Christians. Based on ethnicity, Yoruba's have higher odds (OR= 1.433, p-value= 0.001) of using modern methods compared to Hausas and, respondents with more than three children alive have higher odds (OR=1.720, p-value= 0.001) of using modern methods of contraception compared to those that have about three children or less. Those whose family size intention is equal or above ten have lower odds (OR= 0.502, p-value= 0.001) of using modern methods compared to those whose intention is for a family size of at most four. Respondents in the South East have lower odds (OR=0.461, p-value= 0.001) of using modern methods of contraception compared to those in the North Central region of Nigeria. Urban residents seem to be more likely to use modern contraception as they have higher odds of (OR= 1.188, p-value= 0.001). Respondent's level of education is seen to have an impact on the use of these modern methods as those in the highest level of education have higher odds (OR= 2.237, p-value= 0.001) compared to those without education and same goes for their partner with higher odds of (OR=1.632, p-value= 0.001) at the highest level of education. Ever-in-union women who are in the Richest level of wealth index have higher odds (OR= 1.988, p-value= 0.001) of using these methods compared to those who fall in the poorest category. It is important to note also that those who know about family planning through a method or more, have higher odds (OR= 1.280, p-value= 0.001) of using these modern methods compared to those who do not know at all.

Table 8: Full model estimates from Binary Logistic regression of modern contraceptive use among the studied ever-in-union women's socio-demographic characteristics

Variables	Levels	OR	p-value	95% CI Interval	
				Lower	Upper
Respondent's age (years)	15-19 (Ref)				
	20-24	1.429	0.048	1.003	2.037
	25-29	1.467	0.039	1.020	2.109
	30-39	1.490	0.036	1.027	2.162
	>= 40	1.099	0.629	0.749	1.612
Respondent's age at first marriage (years)	< 15(Ref)				
	15-19	1.108	0.152	0.963	1.276
	20-24	1.124	0.186	0.945	1.338
	25-29	0.856	0.170	0.686	1.069
	>= 30	0.637	0.004	0.469	0.863
Respondent's age at first birth (years)	< 15 (Ref)				
	15-19	1.042	0.682	0.855	1.270
	20-24	1.115	0.325	0.897	1.386
	25-29	1.011	0.932	0.783	1.305
	>= 30	1.069	0.698	0.763	1.498
Partner's age (years)	15-19 (Ref)				
	20-24	0.089	0.001	0.026	0.310
	25-29	0.090	0.001	0.027	0.300
	>= 30	0.085	0.001	0.025	0.284
Religion	Christians (Ref)				
	Islam	0.557	0.001	0.495	0.628
	Traditionalist	0.186	0.021	0.045	0.776
	Others	0.343	0.007	0.157	0.749
Ethnicity	Hausa (Ref)				
	Igbo	1.014	0.916	0.787	1.306
	Yoruba	1.433	0.001	1.156	1.776
	Other	1.217	0.018	1.034	1.433
Number of children alive	<=3 (Ref)				
	> 3	1.720	0.001	1.426	2.075
Number of children ever had	<=3 (Ref)				
	> 3	1.358	0.071	1.117	1.651
Family size intention	< 4 (Ref)				
	5-9	0.809	0.001	0.736	0.889
	>= 10	0.502	0.001	0.425	0.593

Table 9: Full model estimates from Binary Logistic regression of modern contraceptive use among the studied ever-in-union women's socio-economic characteristics

Variables	Levels	OR	p-value	95% CI Interval	
				Lower	Upper
Geopolitical Zone	North Central(Ref)				
	North East	1.220	0.009	1.052	1.416
	North West	0.993	0.932	0.836	1.178
	South East	0.461	0.001	0.367	0.578
	South South	0.515	0.001	0.446	0.596
	South West	0.897	0.196	0.760	1.058
Residential type	Rural (Ref)				
	Urban	1.188	0.001	1.081	1.306
Wealth Index	Poorest (Ref)				
	Poorer	1.176	0.061	0.993	1.393
	Middle	1.428	0.001	1.205	1.691
	Richer	1.753	0.001	1.466	2.097
	Richest	1.988	0.001	1.637	2.416
Respondent's Level of Education	No education (Ref)				
	Primary	1.737	0.001	1.503	2.008
	Secondary	1.954	0.001	1.685	2.267
	Higher Institution	2.237	0.001	1.846	2.711
Partner's Level of Education	No education (Ref)				
	Primary	1.475	0.001	1.249	1.743
	Secondary	1.638	0.001	1.403	1.912
	Higher Institution	1.632	0.001	1.370	1.944
Respondent's working status	No (Ref)				
	Yes	1.066	0.230	0.960	1.184
Access to Media	No (Ref)				
	Yes	1.113	0.071	0.991	1.250
Knowledge of Family planning	No (Ref)				
	Yes	1.280	0.001	1.172	1.398

4.5: Generalized Additive Regression Model with Spatial Effect

This section deals with the factors affecting the risk of modern contraceptive use in Nigeria. We use a fully Bayesian estimation based on Markov Chain Monte Carlo (MCMC) simulations. Making inferences based on a full Bayesian approach is preferred because the functionality of the posterior can be computed without relying on large Gaussian justification. In this study, burn-in is 2000 and 12000 iterations were performed. The risk of modern contraceptive use is shown in Tables 10 and 11.

4.5.1: Bivariate analysis of the Parametric Variables for Generalized Additive Regression Model

Table 10 below shows the effect of socio-demographic factors on the risk of modern contraceptive utilization among ever-in-union women. The table suggests that with a one-unit increase in age at first birth, there was 0.5% expected odds of using modern contraceptives compared to the use of non-modern contraceptive keeping all other variables constant. The ever-in-union women that were surveyed who are in the categories of Islam and Traditionalist had 79.59% and 39.64% respectively lower odds of using modern contraceptive compared to those women surveyed who are Christians but women that are from other religion had 10.55% higher odds of using modern contraceptives compared to Christians.

The table further shows that Igbo women and other ethnic groups had 39.42% and 93.76% lower chances of using modern contraception relative to Hausa women respectively, but Yoruba women had 10.18% higher chances of using modern contraceptives relative to Hausa women. Also, ever-in-union women who have more than three children alive have 28.01% higher odds of using modern contraceptives compared to those who have children less than or equal to three. Ever-in-

union women who ever had more than three children have 9.67% higher odds of using modern contraceptives compared to those whoever had less than or equal to three children.

The ever-in-union women that were surveyed and whose ideal number of children were 5-9, >=10 had 94.43%, 86% lower odds of using modern contraceptive respectively compared to ever-in-union women whose ideal number of children was less than or equal to four, but ever-in-union women who had an ideal number of more than twenty children have 1.66% higher odds of using modern contraceptive compared to those whose ideal number of children was less than or equal to four.

Table 10: Posterior means, odds ratio and 95% Credible Intervals for the Parameter estimates of socio-demographic factors

Variables	Levels	Posterior Mean	OR	95% Cr. Interval	
				Lower	Upper
Intercept		-9.893			
Age at first birth		0.006	1.006	0.975	1.031
Religion	Christians(Ref)		1	1	1
	Islam	-0.228	0.796	0.678	0.941
	Traditionalist	-0.925	0.396	0.057	1.923
	Others	0.100	1.106	1.283	3.646
Ethnicity	Hausa (Ref)		1	1	1
	Igbo	-0.931	0.394	0.303	0.522
	Yoruba	0.097	1.102	1.015	1.412
	Other	-0.064	0.938	0.754	1.185
Number of Children Alive	<=3 (Ref)		1	1	1
	> 3	0.247	1.280	1.087	1.662
Number of Children ever had	<=3 (Ref)		1	1	1
	> 3	0.092	1.097	0.837	1.436
Family size intention	< 4 (Ref)		1	1	1
	5-9	-0.057	0.944	0.829	0.998
	>= 10	-0.171	0.860	0.627	0.905

Ref Reference Category. Cr. Credible Interval

Table 11 below shows the effect of socio-economic factors on the risk of modern contraceptive utilization among ever-in-union women. The table suggests that ever-in-union women that were from urban place of residence have 4.2% higher odds of using modern contraceptives compared to from rural place of residence. Furthermore, those whose wealth index are poorer, middle and richer have higher odds of using modern contraceptives; 89.9%, 88.4% and 97.7% respectively compared to those who are from poorest wealth index. While ever-in-union women whose wealth index are in the richest category are 2 times more likely to use modern contraceptives compared to those whose wealth index are in the poorest category.

Ever-in-union women whose highest educational level was primary, secondary and higher institution had 5.3%, 9.5% and 31.8% respectively higher odds of using modern contraceptives compared to those who had no education. Also, those whose partner's highest educational level was secondary and higher institution had 70.4% and 94.7% higher odds of using modern contraceptives compared to those whose partner had no education. While ever-in-union women whose partner's highest educational level was primary had 0.3% higher odds of using modern contraceptives compared to those whose partner had no education.

Also, ever-in-union women who were currently working had 23.4% higher odds of using modern contraceptives compared to those who were not currently working. Ever-in-union women who had access to media had 32.1% higher odds of using modern contraceptives compared to those who do not have access to media. Those who have the knowledge of family planning have 27.9% higher odds of using modern contraceptives compared to those who do not have knowledge of family planning.

Table 11: Bivariate analysis of Posterior means, odds ratio and 95% Credible Intervals for the Parameter estimates of Socio-Economic Factors

Variables	Levels	Posterior Mean	OR	95% Cr. Interval	
				Lower	Upper
Residential type	Rural (Ref)		1	1	1
	Urban	0.041	1.042	1.021	1.500
Wealth Index	Poorest (Ref)		1	1	1
	Poorer	0.024	1.899	1.675	2.173
	Middle	0.014	1.884	1.687	2.132
	Richer	0.106	1.977	1.757	2.271
	Richest	0.123	2.014	1.769	2.301
Highest Educational Level	No education (Ref)		1	1	1
	Primary	0.052	1.053	1.002	1.250
	Secondary	0.091	1.095	1.015	1.262
	Higher Institution	0.276	1.318	1.108	1.412
Partner's Educational Level	No education (Ref)		1	1	1
	Primary	0.003	1.003	1.001	1.503
	Secondary	0.054	1.704	1.701	1.714
	Higher Institution	0.351	1.947	1.946	1.996
Work Status	No (Ref)		1	1	1
	Yes	0.210	1.234	1.214	1.236
Access to Media	No (Ref)		1	1	1
	Yes	0.278	1.321	1.311	1.353
Knowledge of Family planning	No (Ref)		1	1	1
	Yes	0.243	1.279	1.009	1.605

Ref Reference Category. Cr. Credible Interval

4.5.2: Bivariate analysis of the Non-Categorical Variables of the Generalized Additive Regression Model

Table 12 below shows the importance of the non-parametric variable in determining the risk of using modern contraceptives. The table suggests that the geographical location had the highest importance in predicting the risk of using modern contraceptives with a mean of 0.0296, followed by the age at first marriage and current age of the respondents. The partner's age of the respondent had the least important among the non-parametric variables considered in this study.

Table 12: Parameter estimates for Non Categorical Variables of the studied ever-in-union women

Variable	Posterior Mean	95% Cr. Interval			
		Lower	Upper	Min	Max
Geographical location	0.0296	0.0006	0.1493	0.0002	0.3277
Respondent's Current Age	0.007	0.0007	0.0287	0.0002	0.1308
Respondent's Age at first Marriage	0.0099	0.0005	0.0577	0.0003	0.1858
Partner's Age	0.0053	0.0004	0.0301	0.0002	0.1008

4.5.3: Model Diagnostics

The values for the model diagnostics in the table below shows that model performance becomes better with increased model complexity. Discussion of results is based on Model 6 being the best model showing the least Deviance Information Criterion (DIC) among all the models which comprises of time, f_{spat} (s_i), f (age of respondents), geopolitical zones, demographic characteristics, knowledge indicators and socio-economic status.

Table 13: Values of model diagnostic criteria, DIC

Models	*pD*	DIC
Model 1	4.519	187.181
Model 2	9.985	160.712
Model 3	19.973	159.932
Model 4	25.192	139.973
Model 5	31.761	119.985
Model 6	46.781	110.152

Table 14: Full model estimates for the Full Model of the studied ever-in-union women

Variables	Levels	Posterior Mean	OR	95% CI	
				Lower	Upper
Intercept		-6.5621	0.0014	0.0004	0.0081
Age at first birth		-0.5333	0.5867	0.5351	0.8821
Religion	Christians (Ref)		1	1	1
	Islam	-7.2986	0.0007	0.0002	0.0039
	Traditionalist	-8.7927	0.0002	0.00004	0.0013
	Others	-2.3176	0.3738	0.23813	0.5117
Ethnicity	Hausa (Ref)		1	1	1
	Igbo	0.3224	1.4884	1.3029	1.5221
	Yoruba	0.7166	1.7244	1.6479	2.3910
	Other	0.7095	1.4919	1.3957	2.1854
Number of Children Alive	<= 3 (Ref)		1	1	1
	> 3	0.3926	1.4808	1.2394	1.6618
Number of Children ever had	<= 3 (Ref)		1	1	1
	> 3	0.3903	1.6769	1.5609	1.7905
Family size intention	<= 4 (Ref)		1	1	1
	5-9	-1.5500	0.7361	0.1728	0.8173
	>= 10	-0.2286	0.2568	0.1310	0.3789
Residential type	Rural (Ref)		1	1	1
	Urban	0.0145	1.0146	1.0115	1.3663

Variables	Levels	Posterior Mean	OR	95% CI	
				Lower	Upper
Wealth Index	Poorest (Ref)		1	1	1
	Poorer	0.9139	1.4010	1.3572	2.2712
	Middle	0.4145	1.6607	1.5872	2.1316
	Richer	0.2532	1.7763	1.6959	2.3008
	Richest	0.2255	1.7981	1.6747	2.1726
Respondent's Level of Education	No education (Ref)		1	1	1
	Primary	0.3503	1.2592	0.1693	1.3181
	Secondary	0.5517	1.5760	1.47081	2.2620
	Higher Institution	0.7975	1.7427	1.6586	2.2496
Partner's Level of Education	No education (Ref)		1	1	1
	Primary	1.2904	1.2752	1.1571	1.7039
	Secondary	0.6412	1.5267	1.4809	2.0031
	Higher Institution	0.6090	1.5439	1.4703	1.9471
Work Status	No (Ref)		1	1	1
	Yes	0.9042	1.9101	1.8860	2.2342
Access to Media	No (Ref)		1	1	1
	Yes	0.6289	1.1961	1.1535	2.3210
Knowledge of Family Planning	No (Ref)		1	1	1
	Yes	1.1100	1.7877	1.6608	2.2507

4.5.3.2: Map showing the spatial effect of Modern Contraceptive usage risk by the states of the studied ever-in-union women

This section gives the effect of each of the non-parametric variables on the spatial effect of modern contraceptive utilization which is being illustrated in figures below. The darkest areas indicate the areas that are most disadvantaged and the lightest areas indicating low disadvantage towards the utilization of modern methods of contraception based on their spatial effect. Figure 4 shows the spatial effect of modern contraceptive use, with the North Central (black) showing the highest disadvantaged spatial effect, followed by North-Eastern part and North Western part of Nigeria. While the spatial effect of modern contraceptive use (light grey) was found to be lower in the southern part of Nigeria namely; South West, South South and South East in an ascending order of disadvantage in the use of modern contraceptive. The highest spatial effect of modern contraceptive use was found in Benue, followed by Borno, Bauchi, Jigawa and Kano states while the lowest spatial effect of modern contraceptive use was found in Lagos state.

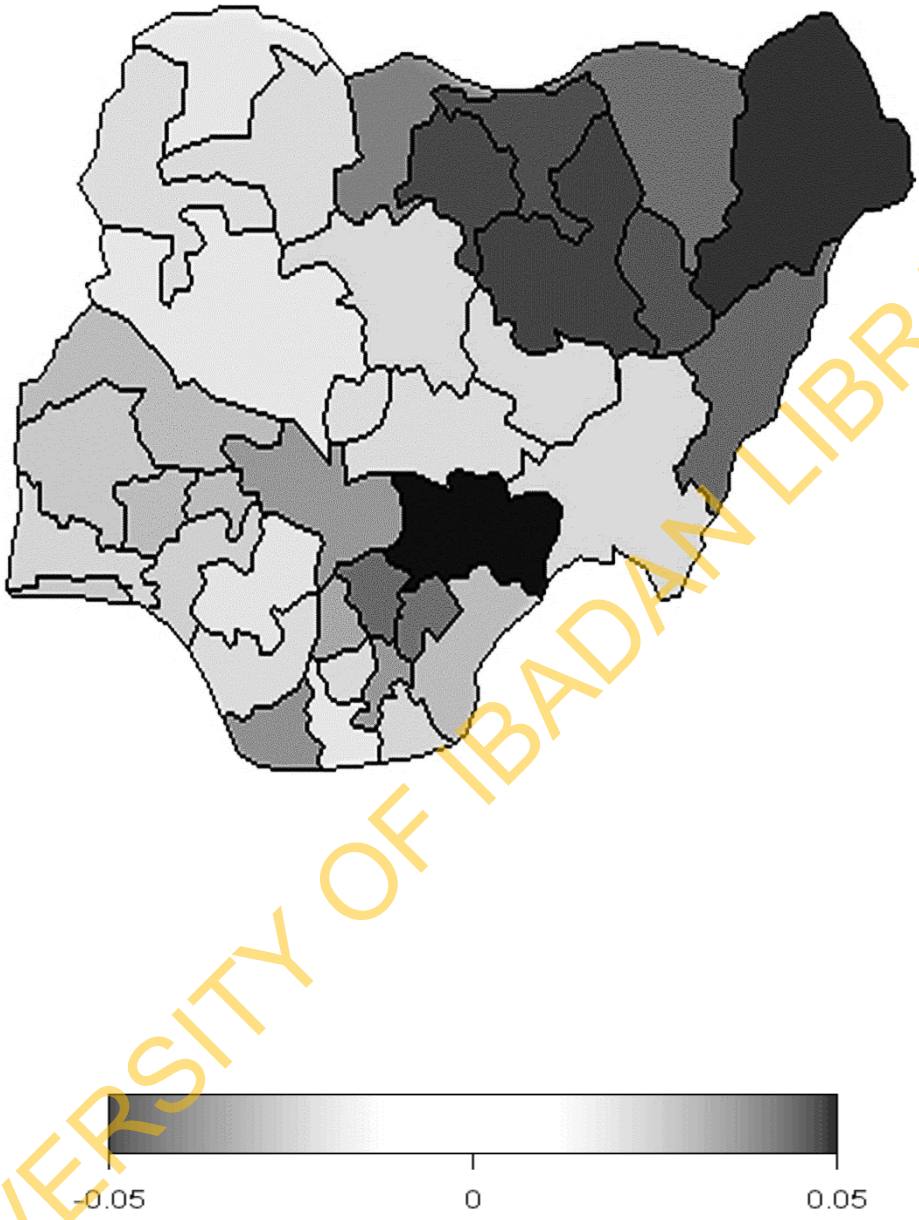

Figure 4: Map of Nigeria showing the 95% Posterior Means Spatial Effect for the use of Modern Contraceptives

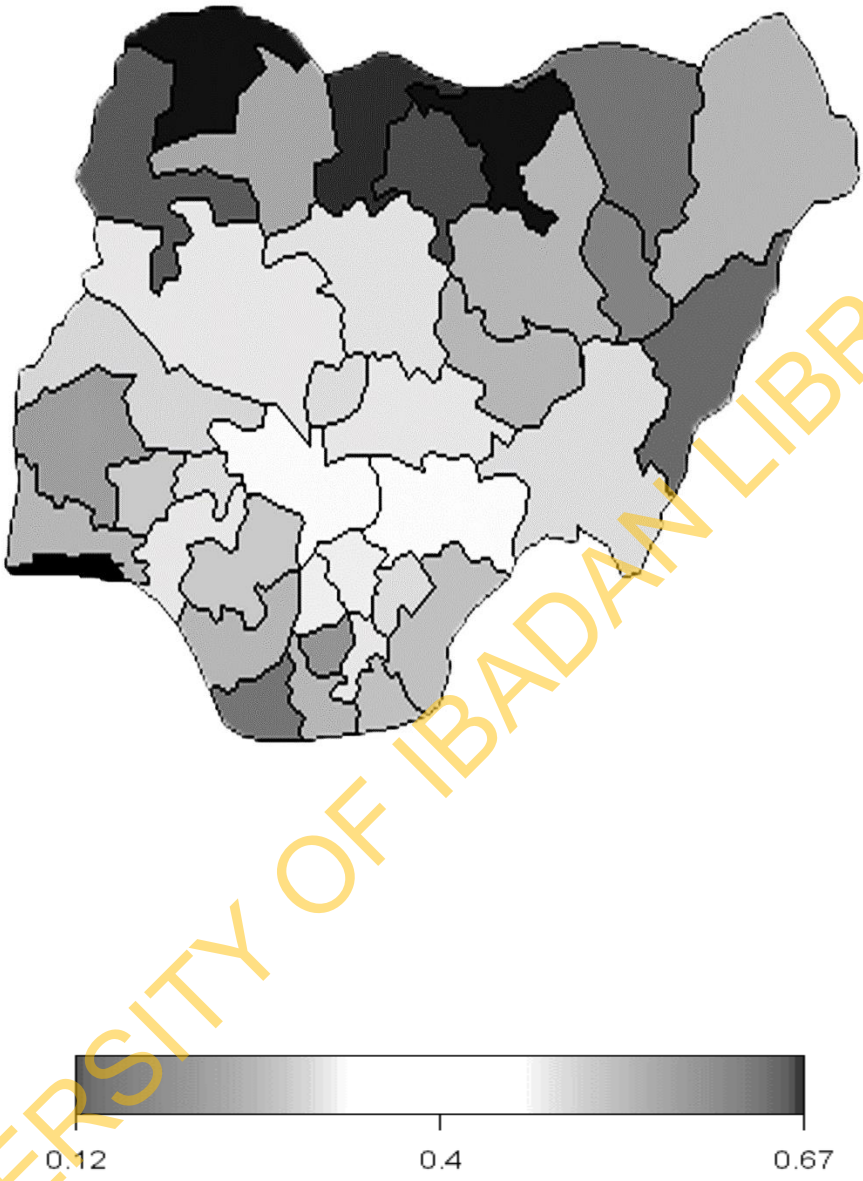

Figure 5: Map of Nigeria showing the 97.5% C.I Spatial effect for the use of modern contraceptives

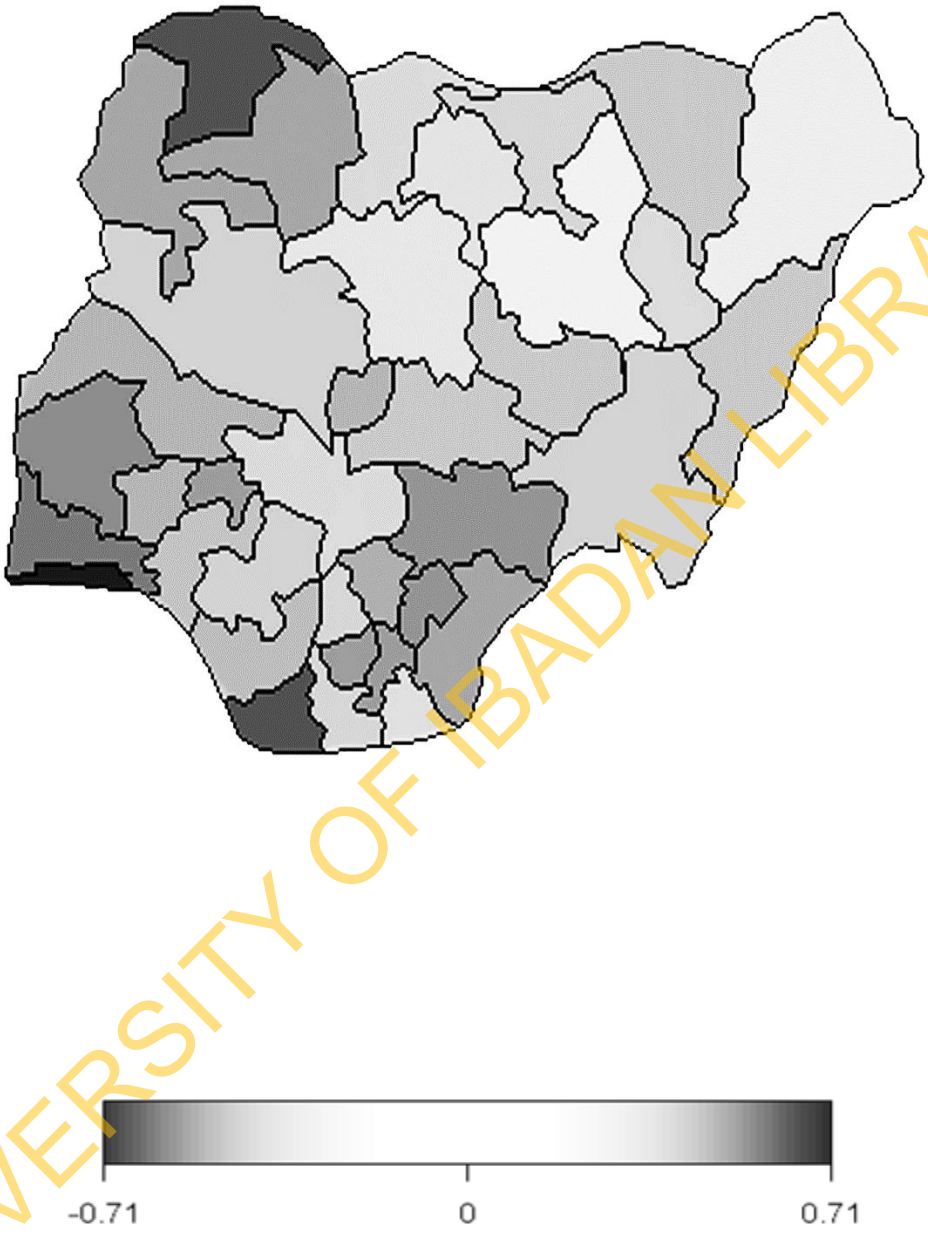

Figure 6: Map of Nigeria showing the 2.5% C.I Spatial effect on the use of modern contraceptive.

4.5.3.3: Smoothing Component of modern contraceptive use

These smoothing maps show the posterior means of the non-linear effect of respondent's age, respondent's age at first cohabitation/marriage and respondent's age at first birth in the Figures below.

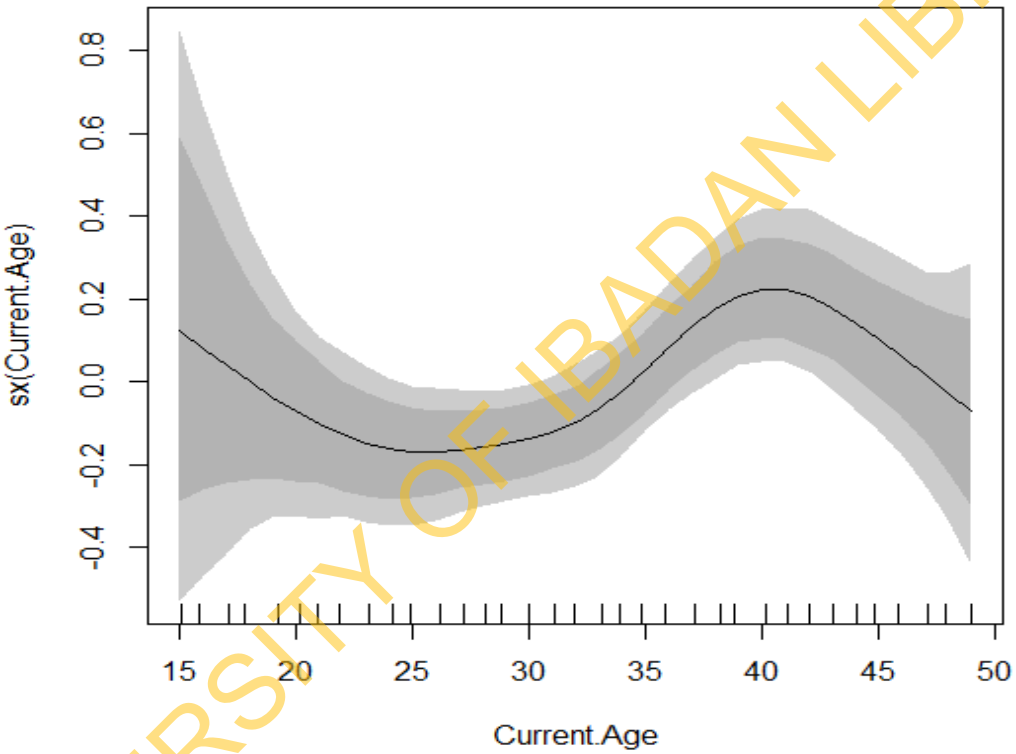

Figure 7: Smoothing Component of modern contraceptive use showing the non-linear effect of Respondent's age

Figure 7 suggests that there was a decrease in modern contraceptive use among respondents in the age category of 15-24 years but shows an increase in modern contraceptive use from respondents who are in the age category of 25-40 years with a sharp drop in modern contraceptive use from age 41 and above.

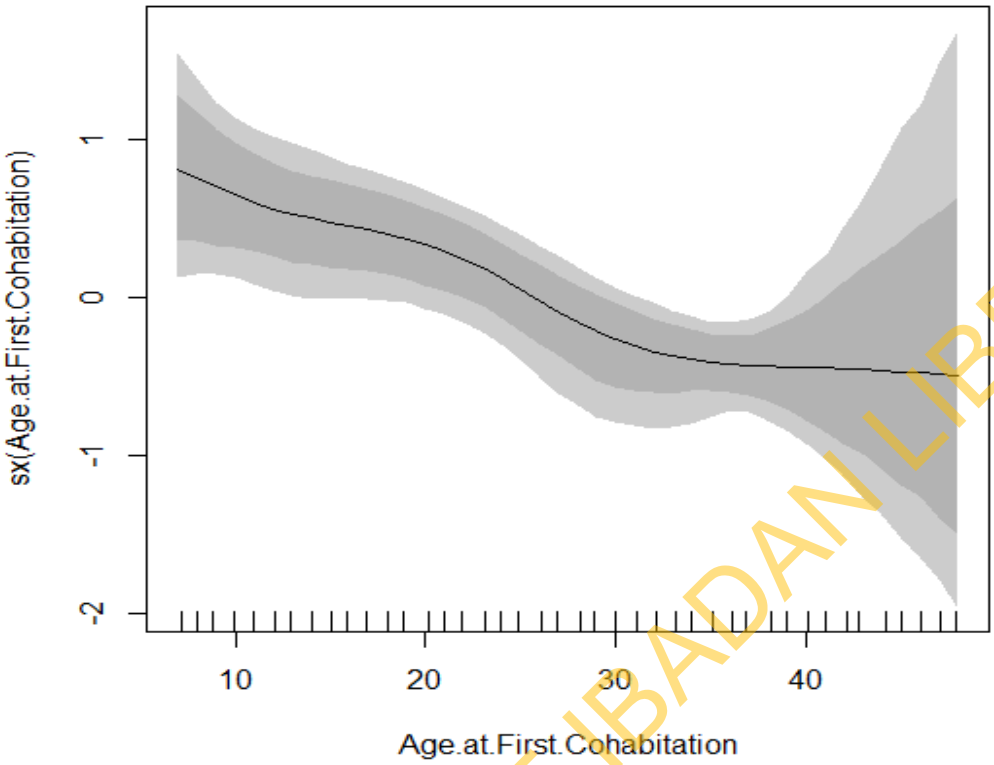

Figure 8: Smoothing Component of modern contraceptive use showing the non-linear effect of age at first cohabitation/marriage of the respondents

Figure 8 suggests that as the age of respondents increase at their first marriage, the use of modern contraceptive decreases.

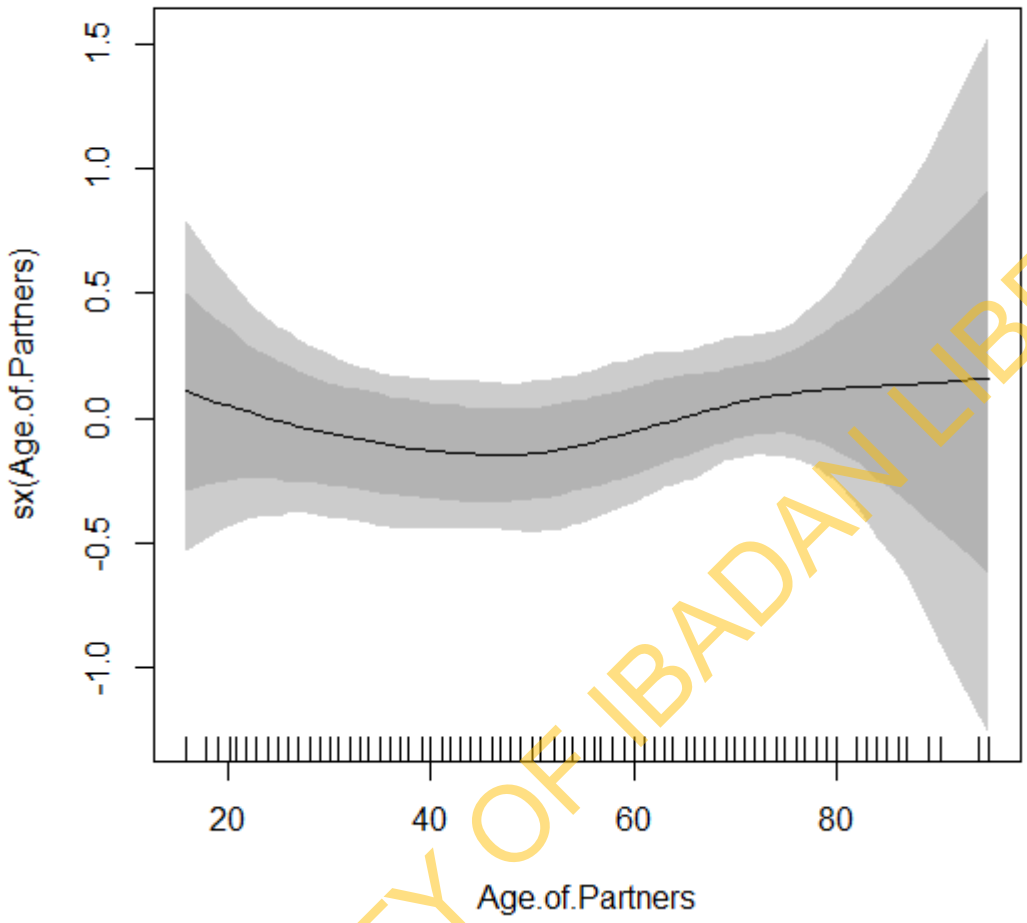

Figure 9: Smoothing Component of modern contraceptive use showing the non-linear effect of Partner's age

Figure 9 suggests that as the Partner's age increases, there is a slight increase in modern contraceptive use.

4.6: Comparison of the Binary logistic regression and STAR models

Based on the principles of model selection, the deviance explains how much of unexplained information present after model has been fitted (Spiegelhalter *et al*., 2002), therefore the lesser the value of the deviance the better the model. In comparing the two models; the Frequentist logistic regression in Table 7 and the Bayesian structured additive regression in Table 13, it is observed based on the results of the Deviance Information Criteria(DIC) that the Frequentist approach is weaker for model selection with values ranging in thousands from 22230.788 to 17007.148. Although, they both yielded the same model choice but the measure of unexplained variation differs as the DIC for the Bayesian approach had lesser values ranging from 187.181 to 110.152. For the Frequentist logistic regression, the best model turned out with a deviance of 17007.148 while in the Bayesian approach, the deviance is seen to be 110.152. As deviance is a measure of overall fit of a model, the model with the least deviance shows the best fit, we conclude that the Bayesian approach works best for fitting the best model in this study and this can be attributed to pD that was added to the posterior mean deviance giving a measure of fit that is penalized for complexity(Spiegelhalter *et al*., 2002).

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1: Summary of Major Findings

This study was designed to compare the performance of STAR and binary logistic regression in the identification of the factors associated with modern contraceptive use in the six geo-political zones among couples due to a rise in birth rates and subsequently a substantial annual population increase. The description of socio-cultural and socio-demographic variables was firstly explored, then moved on to a bivariate analysis where the association between Socio-demographic / Socio-economic characteristics of ever-in-union women against Modern Contraceptive use was examined and only the significant variables for interpretation was used. A Model Diagnostics was done to examine the model that explains the factors that affect the use of modern contraceptive techniques among these women in the six geo-political zones, where two methods were compared to know which best fits the model.

The results showed that a huge majority of 27570 (88.5%) among 31,152 ever-in-union women were currently not using modern contraceptive compared to the minority 3582 (11.5%) who use it. It also suggests that the Northern region was the most affected region with the North West having the largest number of women with the least percentage of users of modern contraceptives (5.6%), followed by the North East (8.6%), then the North central (14.2%). Whereas in the southern region, the South East had the highest number of ever-in-union women with the least use of modern contraceptives (11.4%), followed by South South (13.9%) and the South West (22.7%).

We can also note that majority of these women had their first marriage and first birth at an early age of less than 20 years at a rate of 44.8% and 49.5% respectively, among which a large majority

were Hausa's (37.1%) and in the Islamic religion (55.0%) with the highest family size intention being 50.1% of about 5-9 number of people in a family which can be seen to have a great impact on the rate of modern contraceptive use.

Fixed Effects: The social-economic status of these women were also seen to have a contribution to their usage of modern contraceptives, those women who lived in rural areas mostly stopped their education at the Secondary education level and they had the least exposure to modern contraception due to these factors. Compared to those in urban areas (16.5%), who reached the top cadre in the education plain and due to that enabled them to stay as the Richest (20.7%) among others in the wealth index categories. Respondents who had access to media (14.7%) were seen to use modern contraceptives more than those who did not (6.0%), also similar to those who were currently working with (12.4%) of use compared to those not working (6.2%). Those that knew about family planning (16.0%) used more modern contraceptives than those who did not (9.2%).

Non-Linear Effects: A decrease in modern contraceptive use is seen among respondents in the age category of 15-24 years (Figure 7) but showed an increase in modern contraceptive use from respondents who were in the age category of 25-40 years with a steady drop in modern contraceptive use from age 41 and above. The use of modern contraceptive decreased as the age of respondents at their first marriage increased (Figure 8), and as that of their Partners increased, there was a slight increase in the modern contraceptive use (Figure 9).

Spatial Effects: The spatial maps of modern contraceptive use (Figure 4) revealed that North Central part was the most disadvantaged area based on the utilization of modern contraceptives followed by North Eastern and North Western part of Nigeria. While the southern part of Nigeria

was seen to have a lower disadvantage to the utilization of modern contraceptives, namely; South West, South South and South East in ascending order of level of use of modern contraceptive. The state with the lowest level of modern contraceptive use was found in Benue, followed by Borno, Bauchi, Jigawa and Kano states while the state with the highest level of modern contraceptive use was found in Lagos state.

Based on the two methods; the binary logistic regression and the structured generalized additive regression, the sixth model is seen to be the best model among others with the fitting of time, f_{spat} (s_i), f (age of respondents), geopolitical zones, demographic characteristics, knowledge indicators and socio-economic status all in that model (Table 7 & 13).

5.2: Discussion

Recognizing the factors that contribute to the use of modern methods of contraception serves a significant role in designing successful strategies that can lead to increased use and subsequently to a reduction in the rate of population growth (Adebayo *et al*., 2013). Also, it will assist policymakers in making important decisions on resource distribution. This study found a substantial difference in the usage of modern contraceptive techniques, showing that the majority of ever-in-union women are non-users of these modern techniques compared to those in Nigeria who use them. It was discovered that those who are currently within 30-39 years use modern contraceptives more and this can be based on women trying to stop birthing at this age after they might have given birth to their desired number of children.

Further analysis was conducted to know what the major concerns were and it was found that those that got married between the ages 20-24 years used modern methods most compared to other age categories. Those above this age range used it less and it could be as a result of wanting children during those years of reproduction. This study showed that those that got married between the ages of 15-19 used modern contraceptives lesser than those within 20-24 years, this could be due to factors like lack of maturity, low level of education or none at all (National Population Commission(NPC)[Nigeria] & ICF International, 2019).

The use of these modern methods was found to be more among women with more children either currently alive or ever had and also among those whose family size intention was less than or equal to four. This explains that the more children a married woman has the more she tries to prevent having more and the more the intention of the family size is the less they use modern contraceptive methods and similar situations have been reported earlier (National Bureau of Statistics, 2017).

Ethnicity and Religion were seen to also be major factors contributing to the use of modern contraceptive methods. It was observed that Hausa's were the least users of these modern methods which could be linked to their belief systems about polygamy especially among the Muslims and traditionalists. Respondent's level of education and that of their partner was seen to have a major effect to the use of MCs, the more educated these women got, the more they knew the importance and benefits of these methods and it led to their increased usage. This study also showed that those in urban areas used it more, also, those who were down the ladder of the wealth index used it less compared to those up the ladder and currently working. These findings have also been reported in earlier studies (Azuike *et al*., 2017; Okigbo *et al*., 2017).

There was a strong north-south difference, with the usage of MC methods in the northern states being widely lower than the southern states. Further investigations were done and it was discovered that knowledge of MCs and access to media had a great impact on the usage of these methods but unfortunately, those in the Northern region were the least exposed to these. The results showed that it was not only a factor of these two things but also a number of others such as their level of education, wealth index, age of the women at their first birth and first marriage, their partner's age and level of education, religion, ethnicity, family size intention, number of children ever born and presently alive, work status and residential type. All of these contributed to the reason for their lack of use or low use of modern contraceptives which has remained so from past studies (Adebayo *et al*., 2013; Alo *et al*., 2020).

It is of great importance to note that the highest risk of modern contraceptive usage was found in the North-Eastern part, followed by North Central and North Western part of Nigeria. While the lowest risk of modern contraceptive use was found in the southern part of Nigeria namely; South West, South South and South East in ascending order of risk in the use of modern contraceptive. However, after controlling for other variables, it was only in two states in the North – namely Benue, Borno, Bauchi, Jigawa, Kano – that had significant spatial effects on use of modern MC methods among ever-in-union women while the lowest risk of modern contraceptive use in the South was found in Lagos state

Modern contraceptives have been studied over the years on different grounds of implementation (Babazadeh *et al*., 2018), but it is interesting to note that many of these studies used the frequentist approach in solving the challenges faced. Unfortunately, after comparing the frequentist approach

with that of Bayesian in this study, Bayesian was proven to be more excellent in fitting models for factors related with modern contraceptive use as opposed to the frequentist approach.

This method gave us the allowance to discover specifically the major states where we have the highest risk and lowest risk of the usage modern contraceptive.

5.3: Conclusion

Based on the methods employed in this study, it was clear that binary logistic regression was a straight forward method which did not require a prior information to make an inference but, that did not exempt the presence of larger values of deviance in the model fitting stage. The STAR approach was more rigourous as a prior information was needed before inference could be generated yet, it turned out to be a better method as the deviance values were far lesser than that of the binary logistic regression. This reveals to us that the STAR which can also be referred to as the Bayesian approach was well suited for this study compared to the frequentist logistic regression.

It is important to also note that, amongst other social-economic, socio-demographic, knowledge indicators, the location of a woman has a great impact on the use of modern contraceptives. With our results, we can see that even with several interventions that had gone forward in the past years regarding this subject, there has still not been a decline in the rate of growth in the country. This can be subjected to the wrong channelling of these interventions.

5.4: Recommendations

With this result, the following recommendations are given, researchers should work more with the Bayesian approach as it has proven to be more efficient with lesser errors. Also, the government

or non-governmental organizations are advised to channel every form of modern contraceptive initiatives to the locations that lack it the most, most especially the Northern region of Nigeria. There should not only be a free supply of these MCs but there should be a proper education system put in place for the women in those regions because the more educated these women get, the more they are open-minded to use these modern methods for their health preservation, that of their children and to help the population at large.

5.5: Study strengths and limitations

This study poses some limitations because of the emphasis on only the factors influencing the use of modern contraceptives on the part of the respondent. Further studies can focus on the role that the government plays in enforcing policies to improve health coverage quality and incorporate frameworks on the use of these modern methods. Also, the focus was only on the effect of modern contraceptive use on population growth and there are other major benefits that the use of modern contraceptive poses but those were not explicitly studied in this research.

Despite the limitations, this research has significant strengths that have made it possible to distinguish particular areas; states that have a higher and lower prevalence for the purpose of information and intervention in the right places.

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