Effectiveness of Contraceptive Usage among Reproductive Ages in Nigeria Using Artificial Neural Network (ANN)

[1]Kazeem A. Dauda, [2]Akinbowale N. Babatunde, [3]Kabir O. Olorede, [4]Sulaiman O. Abdulsalam and [5]Oluwaseun R. Ogundokun

[1,3]Department of Statistics and Mathematical Sciences, Kwara State University, Malete, P.M.B 1530, Ilorin, Nigeria.
kazeem.dauda@kwasu.edu.ng and kabir.opeyemi@kwasu.edu.ng

[2,4]Department of Computer Sciences, Kwara State University, Malete, P.M.B 1530, Ilorin, Nigeria.
akinbowale.babatunde@kwasu.edu.ng and sulaiman.abdulsalam@kwasu.edu.ng

[5]Department of Computer Science, Landmark University, Omu-Aran, P.M.B 1001, Omu-Aran, Nigeria.
ogundokun.roseline@imu.edu.ng

ABSTRACT

Purpose: Contraceptive usage among women of reproductive age is a fertile area of research for the medical scientists, social scientists, and medical practitioners. However, not much work has been done in Nigeria to identify some of the contraceptive methods used in preventing unwanted pregnancy and sexually transmitted infection (STI) diseases, particularly to explicitly determine which of them are most effective. This paper tackles this task.

Methodology: In this paper, we examine different types of contraceptive methods used by Nigeria women to prevent unwanted pregnancy. Datasets on contraceptive usage among 28,647 women of reproductive age from the 2008 Nigerian Demographic Health Survey (NDHS) were analyzed using Artificial Neural Network (ANN) approach in the R language.

Finding/Results: The results of the analysis revealed that approximately 1%, 3% and 9% of the study population were using Folkloric, Traditional and Modern methods, respectively. Additionally, 12%, 3% and 9% of the women were found to be currently using the methods since last birth and before last birth. Furthermore, the ANN results through the Garson algorithm revealed that using the modern methods (IUD, Norplant and Female condom) and the traditional methods prevents the unwanted pregnancy negatively, while other modern methods (pill, male condom, female sterilizer, periodic abstinence, withdrawal, locational amenorrhea and foam or jelly) were found to be effective in preventing unwanted pregnancy positively. Interestingly, women that used the modern methods (i.e. Pill, IUD, Injection, Male condom, Female sterilization, Periodic abstinence, Withdrawal and Lactational amenorrhea) were found to be effective in preventing unwanted pregnancy.

Research Limitation: The main limitation of this study is the inability to access the current data from NDHS. Therefore, the conclusion of this study is only based on the 2008 NDHS data.

Originality/Value: This research work introduces artificial neural network (ANN) to determine and identify the effect of contraceptive methods usage among Nigeria women, and to determine their level of important using Garson's algorithm variable important. This introduction measures the nonlinear effect that exists between the methods and response variable (pregnant and no pregnant) which existing research approaches do not.

Keywords: *Contraceptive methods, Variable Important, Garson Algorithm, Artificial Neural Network (ANN) and Data mining.*

[1]*Corresponding Author: alt. email: qdauda@yahoo.com/qdauda70@gmail.com*

1 Introduction

Contraception is defined as the prevention of conception without abstinence (Ladipo and Akinso, 2005). There are traditional methods of contraception, which include withdrawal and rhythm, and there are modern contraceptive methods, which include the hormonal and non-hormonal methods. The hormonal methods include oral pills, injectable and subdermal implants and some intrauterine contraceptive devices whereas non-hormonal contraceptives include condoms, intrauterine devices like Copper-T and sterilization (Tubal Ligation in women and vasectomy in men (Hatcher et al., 1997). For most methods, effectiveness depends on user compliance, which may be improved by information provision, counseling and the support of health care providers. For some

methods, efficacy also depends on aspects of healthcare provision.

1.1 The risk of pregnancy versus the risk of the method

The relative risks associated with the use of a particular contraceptive need to be balanced against the risks of pregnancy.

When a woman has a condition that makes unplanned pregnancy an unacceptable health risk, the sole use of methods with a relatively high typical use failure rate, including barrier methods and Fertility Awareness-Based Methods (FABMs) may not be appropriate (Cavazos-Rehg et al., 2015). Some of these conditions include recent breast cancer, complicated valvular heart disease, ischaemic heart disease (IHD) or stroke, malignant gestational trophoblastic disease and malignant liver tumors severe (decompensated) cirrhosis.

1.2 Effectiveness

The average pregnancy rate, when no contraception is being used, is approximately 20% per cycle, with rates depending on the age of the couple and frequency of sexual intercourse. The effectiveness of a contraceptive method is most easily defined as the number of unintended pregnancies occurring in a year for every 100 women using the method. For example, if a method has an effectiveness of 99% this can be explained as either: 99 women out of 100 women using the method in a year being protected against an unintended pregnancy or 1 woman out of every 100 women using the method becoming pregnant in a year.

The effectiveness of the method for an individual woman will depend on the inherent method characteristics, the woman's own fertility status and her adherence to the method, e.g. the ability to remember a daily contraceptive pill or the ability to correctly use a male or female condom. Contraceptive effectiveness is also described by the Pearl Index, which is derived by dividing the number of unintended pregnancies occurring with a method, by the number of years of exposure to the risk of unintended pregnancy during a study (Bradshaw and Brook, 2014).

1.3 Worldwide Contraceptive Prevalence

Worldwide contraceptive prevalence (the percentage of married women currently using contraception) was estimated to be 58% in, with contraceptive use in the developed regions at 70% and in the developing regions at 55% (WHO, CCP, USAID, 2011). Among the developing areas, contraceptive prevalence is lowest in Africa where on average only one out of five married couples is currently using a contraceptive (WHO, 2015). In Asia and Latin America and the Caribbean, contraceptive use is similar. However, data at the regional levels reveal greater divergence than is implied by the overall averages (WHO, CCP, USAID, 2011**).**

Monjok et al. (2010) estimated that of the 210 million pregnancies that occur annually worldwide, about 80 million (38%) are unplanned and 46 million (22%) end in abortion. More than 200 million women in developing countries would like to delay their next pregnancy or even stop bearing children altogether (Diaz, 2002), but many of them still rely on traditional and less effective methods of contraception or use no method at all. Those who do not use any contraceptive method may lack access or face barriers to using contraception (Diaz, 2002). These barriers include lack of awareness, lack of access, cultural factors, religion, opposition to use by partners or family members, and fear of health risks and side effects of contraceptives (DeRose et al., 2004).

In many developing countries (also termed low- and middle-income countries), official family planning programmes began during the 1960s with the aim of reducing high fertility i.e. high numbers of births per woman (Diaz, 2002). However, in recent years, various Demographic and Health Surveys (DHS) report that women in developing countries have lower desired fertility than actual fertility, i.e. women are having more children than they want. This indicates that there is still an unmet need for family planning i.e. there is the proportion of women of reproductive age who prefer to avoid or postpone childbearing but who are not using any method of contraception. In 2000, an estimated 17% of married women (105 million) had an unmet need for family planning in the developing world (USAID, 2013), and there is considerable variation across countries, for example, 5% in Vietnam and 40% in Haiti.

1.4 Nigeria Contraceptive Prevalence Perspective

In Nigeria, unintended intercourse is the primary cause of unwanted pregnancies, and many women with unwanted pregnancies decide to end them by abortion (Otoide et al., 2001). Since abortion is illegal in Nigeria (unless medically recommended to save a mother's life) many abortions are carried out in an unsafe environment (Abiodun and Balogun, 2009). The consequences of these clandestine abortions are grave and can be life-threatening, often leading to maternal death. Abortions account for 20% to 40% of maternal deaths in Nigeria (Oriji et al., 2009).

Many Nigerian women of reproductive age experience unwanted pregnancies and resort to abortion (Otoide et al., 2001). According to a DHS survey of women in southwestern and northern Nigeria, at least 20% reported having experienced an unwanted pregnancy (Nigeria Demographic and Health Survey, 2008). The 2008 DHS found that of the total live births reported in the three years prior to 2008, 15% were also reported to be unplanned.

Contraception has been identified as an effective means of combating the problem of unwanted pregnancy and unsafe abortion. It is equally an effective means of family planning and fertility control and therefore very important in promoting maternal and child health. Access to quality reproductive health and family planning services remain poor in Nigeria (Abiodun and Balogun, 2009).

1.5 Choice of contraceptive methods

Four pieces of information about contraceptive efficacy would help couples to make an informed decision when choosing a contraceptive method: Pregnancy rates during typical use show how effective the different methods are during actual use (including inconsistent or incorrect use). Secondly, pregnancy rates during perfect use show how effective methods can be, where perfect use is defined as following the directions for use.

Thirdly, pregnancy rates during imperfect use show how ineffective methods would be if they are used incorrectly or inconsistently. Pregnancy rates can be computed separately for different categories of imperfect use to reveal which types of imperfect use are most risky. Lastly, the percentage of perfect users or percentage of months during which a method is used perfectly reveals how hard it is to use a method correctly and consistently.

1.6 Data Mining

The process of discovering interesting knowledge, which includes patterns, associations, changes and significant structures from a large amount of data set from statistical perceptive is regarded as *Data Mining* (Fayyad, 1996). It is also seen as nontrivial extraction of implicit, previously unknown, and potentially useful information from data using machine learning, statistical and visualization techniques (Frawley, 1991). Data mining has proved to be valuable in numerous application, due to increase in technology around the globe (Vapnik, 1998; Hastie et al., 2001; Witten and Frank, 2005; Felici and Vercellis, 2007). The majority of the problems studied in the data mining community can be categorized as Decision Trees, Neural Networks, Rule Induction, Nearest Neighbors, and Genetic Algorithms (Hastie et al., 2001).

Data mining is noted for its pattern recognition ability that ensures that information is obtained from vague data. In particular, unique or valuable relationships between and within the data can be identified and used proactively to categorize or anticipate additional data. Through the use of exploratory graphics in combination with advanced statistics, machine learning tools, and artificial intelligence, critical "nuggets" of information can be mined from large repositories of data.

Many techniques have been developed for data mining and the methods for analyzing and modeling data can be divided into two groups: supervised learning and unsupervised learning. Supervised learning requires input data that has both predictor (independent) variables and a target (dependent) variable whose value is to be estimated. By various means, the process learns how to model (predict) the value of the target variable based on the predictor variables. Unsupervised learning does not identify a target (dependent) variable but rather treats all of the variables equally. In this case, the goal is not to predict the value of a variable but rather to look for patterns, groupings or other ways to characterize the data that may lead to an understanding of the way the data interrelates.

Data mining can be used to generate a hypothesis and it uses modeling techniques. In the past, data mining processes were summarized as a collection of statistical analysis. However, the addition of machine learning and intelligent processes such as Artificial Neural Networks, Genetic Algorithms, Fuzzy Logic,

and modified cluster analyses have considerably increased the capabilities and utilities offered by data mining. Data mining uses machine learning, statistical and visualization techniques to discover and present knowledge in a form that is easily comprehensible to humans. The most common data mining tasks are based on classification, clustering, and discovery of association rules. Others include prediction, characterization, deviation analysis and outlier analysis. Data mining is more oriented towards applications than the basic nature of the underlying phenomena. It is relatively less concerned with identifying the specific relations between the involved variables. Instead, the focus is on producing a solution that can generate useful predictions. Therefore, data mining accepts among others a "black box" approach to data exploration or knowledge discovery (Felici and Vercellis, 2007).

In this work, we apply Artificial Neural Networks (ANN) to NDHS survey data conducted in 2008.

1.6.1 Artificial Neural Network (ANN)

An Artificial Neural Network (ANN) is a mathematical model that tries to simulate the structure and functionalities of biological neural networks. The basic building block of every artificial neural network is an artificial neuron, that is, a simple mathematical model (function). Such a model has three simple sets of rules: multiplication, summation, and activation. Every input is weighted which means that every input value is multiplied by individual weight at the initial state of Artificial Neuron. The sum function that adds up all weighted inputs and biases of Artificial Neuron occur in the middle section. At the final state of artificial neuron, the previously sum weighted inputs and bias are passing via activation function that is also called transfer function (Figure 1.) (Andrej et al., 2011).

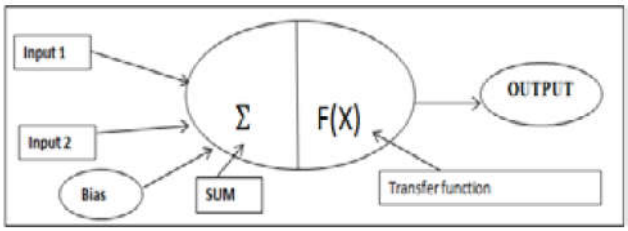


Figure 1: Artificial Neuron Design

2 Methodology

The data used for this research was obtained from the Nigerian Demographic and Health Survey (NDHS), and it covers 28,647 women of reproductive age (respondents), throughout the nation. The minimum and maximum ages of the respondents are 13 years and 45 years, respectively. Yahya et al. (2012) used a similar age range.

The response variable is pregnant status, which is categorized into distinct groups. The first group is those that answered “Yes” and the second group is those that answered “No”. This makes it a dichotomous response variable. The scale of 0 for the category "No" and 1 if another category that is "Yes".

Apart from the Response variable, the categorical variables were also involved and regarded as independent variables. These are currently used, used since, used before, using modern, using traditional, pill, IUD, injection, condom, female sterilizer, periodic, withdrawal, other, Norplant, lactation, female condom, and form or jelly.

The original function of neural network (NN) was the computer-based model used to mimic the human brain. The most widely used NN is called the Multi-layer perceptron (MLP) system, which consists of a set of input features, a number of interactive layers, in between the inputs and output layers and specifically one output layer (Yahya et al, 2012). The simplest multilayered perceptron is given in the equation below

$$o(x) = f(w_0 + \sum_{i=1}^{n} w_i x_i) \quad (1)$$

Where w_0 denotes the intercept, $w_i = (w_1, w_2, \dots, w_n)$ the vectors consisting of all synaptic weight without the intercept, and $x = (x_1, x_2, \dots, x_n)$ the vector of all independents variable (Frauk and Steven, 2010). Since the response variable is binary, sigmoid function (transfer function) is suitable for our ANN construction.

After experimenting with the equation (1) on the real-life data set discussed earlier, the contribution of the independent (contraceptive methods) variables on the response variable was measured using Garson Algorithm (1991) technique. The algorithm partitions the hidden layer weights into components associated with each input node. Subsequently, the percentage of all hidden node weight associated with the input node was used to measure the relative importance of that attribute. In general, for each input j, where

$j = 1,2,\dots,i$, the relative importance (RI_j) can be calculated using the equation (2).

$$RI_j = \frac{\sum_{m=1}^{N_h}\left[\left[\frac{|w_{jm}^{ih}|}{\sum_{k=1}^{N_i}|w_{km}^{ih}|}\right]\times|w_{jm}^{ho}|\right]}{\sum_{n=1}^{N_i}\left[\sum_{m=1}^{N_h}\left[\left[\frac{|w_{nm}^{ih}|}{\sum_{k=1}^{N_i}|w_{km}^{ih}|}\right]\times|w_{jm}^{ho}|\right]\right]} \quad (2)$$

In equation (5), N_i and N_h are the numbers of inputs and hidden neurons respectively, w is the connection weight, the superscripts $"i","h"\ and\ "o"$ refer to input, hidden and output layers, respectively and subscripts $"k","m"\ and\ "n"$ refer to input, hidden and input neurons used. In our case, there is only one output neuron. In this algorithm, each input node j, the relative contribution of j to the outgoing signal of each hidden neuron, is calculated and presented in percentage, which then serves as a measure of importance for each node of the given variable. Additionally, the entire input variables with the smallest contribution to the final output of the network are eliminated (Garson Algorithm., 1991).

3 Experimental Results

Table 1 describes the dataset using simple percentages.

Table 1: Description of the dataset using simple percentages

Determinants	**Factor levels**	**Currently Pregnant**		**Total 28,647 (100%)**
		No (0) 24,953 (87.1%)	Yes (1) 3,694 (12.9%)	
Current methods used	No method	21,258 (85.2%)	3,694 (14.8%)	24,952 (87.1%)
	Folkloric method	187 (100%)	0 (0.0%)	187 (0.65%)
	Traditional method	885 (100%)	0 (0.0%)	885 (3.09%)
	Modern method	2,623 (100%)	0 (0.0%)	2,623 (9.16%)
Pattern of use	Currently using	3,695 (100%)	0 (0.0%)	3,695 (12.9)
	Used since last birth	473 (50.4%)	466 (49.6%)	939 (3.28)
	Used before last birth	2,309 (86.2%)	370 (13.8%)	2,679 (9.35)
	Never used	18,476 (86.6%)	2,858 (13.4%)	21,334 (74.47%)

However, for the currently used methods, the analyses show that out of the 24,952 respondents that used "No method", 3,694 (14.8%) have the chance of having a pregnancy of which 21,258 (85.2%) are pregnant free. Also for the “folkloric method”, out of 187 women who practice this method none of them had a pregnancy. Likewise for “Traditional method”, 885 women who practiced this method were pregnant free. So also for the “Modern method”, 2,623 women who practice this method are also pregnant free (i.e. Folkloric, Traditional and modern method are very efficient).

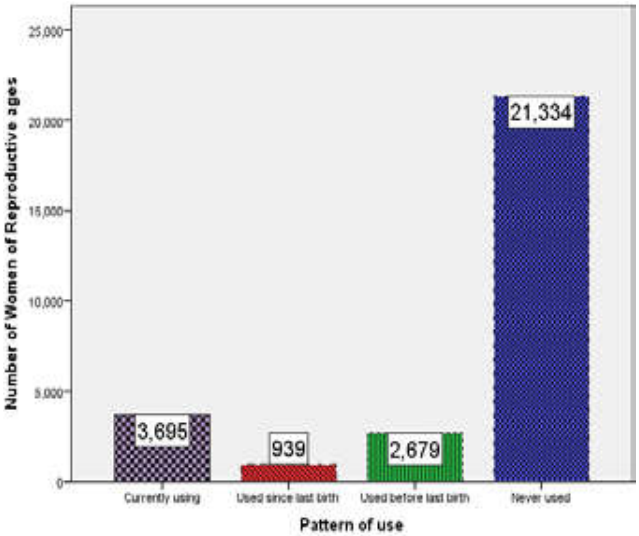


Figure 2: Virtual display of the pattern of use

Furthermore, the pattern of use for those that are currently using the method (contraceptive method) shows that 3,695 women currently practicing (contraceptive methods) are pregnant free. Out of 939 women who used since last birth 466 (49.6%) have pregnancy and 473 (50.4%) are pregnant free, also out of 2,679 who used before last birth, 370 (13.8%) were pregnant and 2,309 (86.2%) were free from having pregnant, and out of 21,334 women that never used any means of contraceptive methods, 2,858 (13.4%) have pregnancy and 18,476 (86.6%) are pregnant free.

Figure 2 shows the virtual display of the pattern of contraceptive usage among women. It was observed that "Never used" (contraceptive method) has the highest number of reproductive ages with a total of 21,334 and number of reproductive ages that has the lowest pattern of use is the "Used since last birth" with total of 939, while currently using and used before last birth has number of reproductive ages of totals 3,695 and 2,679 respectively.

Table 2: Variable Important by Garson Algorithm

Covariate	**Relative important**	**Remarks on the pregnancy status**
Currently, use	-0.3544	Weak Negative relationship
Used since	1.0000	Strongest Positive relationship
Used before	0.0000	No substantial importance
Using modern	-0.0723	Very weak Negative relationship
Using traditional	-0.1449	Very weak Negative relationship
Pill	0.4690	Strongest Positive relationship
IUD	-0.1543	Very weak Negative relationship
Injection	0.0809	Very weak Positive relationship
Condom	0.2099	Strongest Positive relationship
Female sterilizer	0.0614	Very weak Positive relationship
Periodic	0.2329	Strongest Positive relationship
Withdrawal	0.2084	Strongest Positive relationship
Other	0.1318	Very weak Positive relationship
Norplant	-0.1479	Very weak Negative relationship
Lactation	0.1186	Very weak Positive relationship
Female condom	-0.1014	Very weak Negative relationship
Foam or Jelly	0.0900	Very weak Positive relationship

The Table 2 above shows that "Currently used" which is among the pattern of use method by the women of reproductive ages has a weak negative relationship to the response variable. This implies that women who "Currently used" contraceptive methods have -0.3544 association towards the pregnant status. While "Used since" which indicates a pattern of contraceptive usage among women since last birth has the strongest positive relationship to the response variable. This also implies that women who make use of the "used since" method have 100% correlation towards the pregnant status. Moreover, "Used before" which indicates a pattern of a used method before the last birth has no relationship to the response variable and implies that women who practice "used before" method have 0% association towards the pregnant status.

Nevertheless, “Using modern and traditional methods” which indicate the current methods used by the women has a weak negative relationship to the response variable and implies that women who are “using modern and traditional” methods have -0.0723 and -0.1449 associations towards the pregnant status. The Pill, Condom, Periodic and Withdrawal among the contraceptive methods have strong positive relationships to the response variable. This implies that women who use these methods have 0.4690, 0.2099, 0.2329 and 0.2084 correlation towards the pregnant status.

Finally, other contraceptive methods which include "Injection, Female sterilizer, Other, Lactation, and Foam or Jelly, IUD, Norplant, and Female condom” suffer from a very weak positive and negative relationship with the response variable. These also imply that women who practice these methods have weak degrees of association towards the pregnant status.

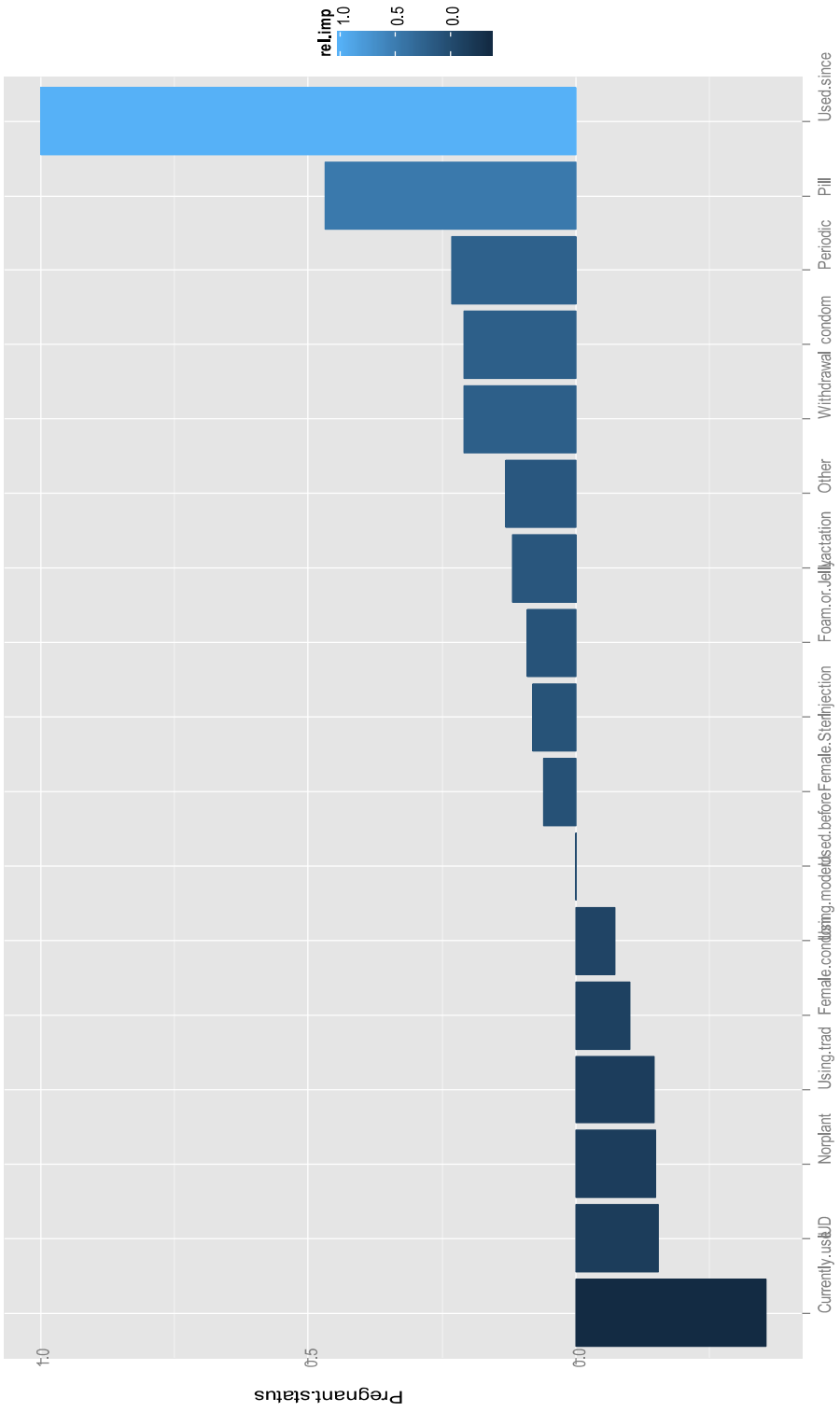


Figure 3: Relative important of the seventeen contraceptive methods against the response (pregnant status) variable

The relative important value in Table 2 and Figure 3 was determined using the method of Garson (1991). The results tell us that the covariates "used since" have the highest relative importance. Pill, condom, periodic and withdrawal methods have the strongest positive relationship, individually with the response (pregnant status). Correspondingly, covariates that have relative important to be zero such as the "used before" method do not have any substantial importance for response variable. Nevertheless, this covariate with zero relative importance most likely has some marginal effect on the response variable, but its effect is irrelevant in the context of the other covariates. Other covariates were found to have either very weak positive or negative relationships with the response variable as shown in Table 2.

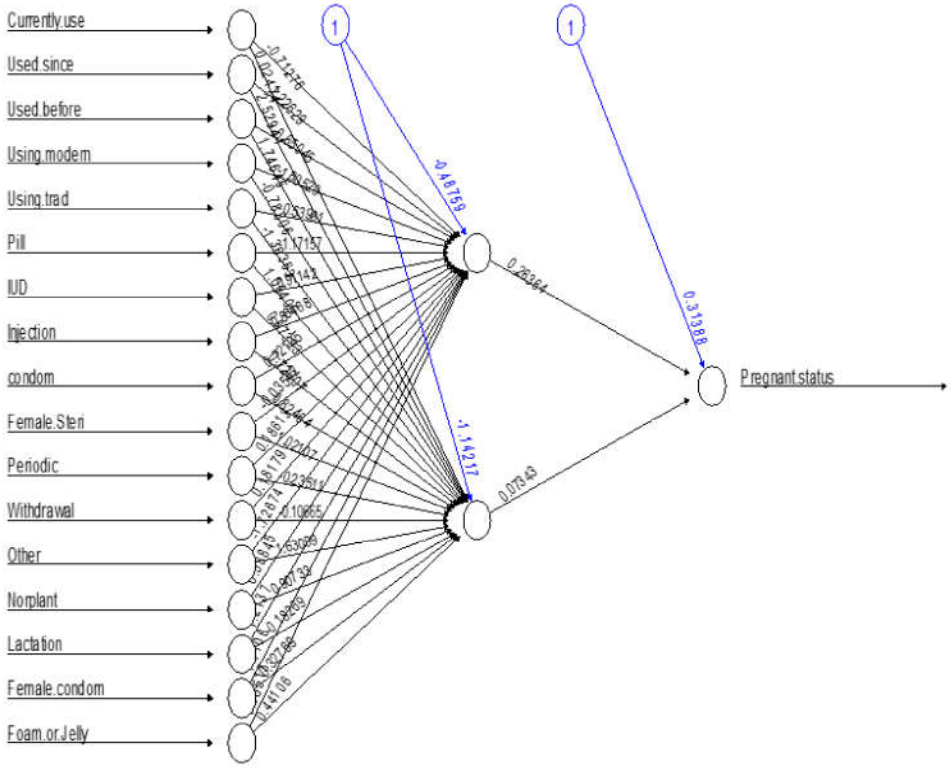


Figure 4: Plot of a trained neural network including trained synaptic weights and basic information about the training process.

Here, we present the virtualization of the results of the training process of MLP model with 2 hidden layers as shown in Figure 4. The plot includes the trained synaptic weights, different intercept and basic information about the training process such as the overall error and number of steps which produce one response (pregnant status).

4 Discussion of Results

Various facility factors were considered, among which are the quality of family planning services. This study was conducted with the aim of examining the effectiveness of contraceptive usage among women of reproductive age in Nigeria, because several contraceptive methods have been put in place, and all claim to be effective in preventing unwanted pregnancy and STI. Based on the NDHS 2008 survey, contraceptive methods are classified as modern or traditional methods. Modern methods include female sterilization, the pill, intra-uterine device (IUD), injectables, implants, female condom, foam/jelly, lactational amenorrhea method (LAM), and emergency contraception. Methods such as periodic abstinence and withdrawal are grouped as traditional methods. Women of reproductive ages in Nigeria who

practice contraceptive methods have the total of 28,647 respondents, and 3,694 have the chance of getting pregnant, and this shows that some methods are not effective as claimed. Nevertheless, 87.1% are those who are not practicing any form of contraceptive methods and the main reason for non-usage of contraceptive methods was fear of side effects and the desire to have more children.

Lastly, we proceed to the artificial neural network (ANN) through the use of "Neuralnet" package in R to identify some important variables (contraceptive methods) using Garson algorithm (1991). The results reveal the relative importance of the seventeen covariates (contraceptive methods) and we observed that "used since" (i.e., women that has been using the contraceptive method for a long time) has the strongest positive relationship with the pregnant status follow by "currently used" (i.e., women that are just using the contraceptive method) with a weak negative relationship. Finally, "used before" (i.e., women that stopped using contraceptive method) has no any substantial relationship with pregnant status.

5 Conclusions

This study has been useful in identifying some of the contraceptive methods that are effective in preventing unwanted pregnancy and sexually transmitted infection (STI) among women of reproductive ages in Nigeria and the findings should help in monitoring the reproductive status of the family. However, there was also a large portion of those who were not using contraceptive methods and this can increase the population of a country. Different types of birth control methods have large differences in effectiveness, action required of users, and side effects. Thus, different methods require different actions of users.

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