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Current and Predicted Fertility using Poisson Regression Model: Evidence from 2008 Nigerian Demographic Health Survey

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Abstract

Nigeria with persistent high growth rate is among top ten most populous countries. Monitoring key mechanisms of population dynamics particularly fertility in Nigeria is long overdue. Periodical availability of data on fertility and other demographic indices is scarce, hence this study. Our objective was to build a non-linear model to identify fertility determinants and predict fertility using women's background characteristics. We used 2008 Nigeria Demography and Health Survey dataset consisting of 33,385 women with 31.4% from urban area. Fertility was measured using children ever born (CEB) and fitted into multi-factors additive Poisson regression models. Respondents mean age was 28.64±9.59years, average CEB of 3.13±3.07 but higher among rural women than urban women (3.42±3.16 vs 2.53±2.79). Women aged 20-24years were about twice as likely to have higher CEB as those aged 15-19years (IRR=2.06, 95% CI: 1.95-2.18). Model with minimum deviance was selected and was used to predict CEB by the woman. *(Afr J Reprod Health 2014; 18[1]: 71-83).*

Keywords: Fertility, Incidence rate ratio, Poisson prediction, children ever born, Nigeria,

Résumé

Le Nigeria avec un taux de croissance élevé et persistant est parmi les dix pays les plus peuplés. La surveillance des mécanismes clés de la dynamique des populations notamment la fécondité au Nigeria est attendue depuis longtemps. La disponibilité périodique des données sur la fécondité et d'autres indices démographiques sont rares, d'où cette étude. Notre objectif était de construire un modèle non - linéaire pour identifier les déterminants de la fécondité et de prédire la fécondité en utilisant les antécédents caractéristiques des femmes. Nous avons utilisé les données de l'Enquête nigériane démographique et de santé de 2008 qui comprenaient 33 385 femmes avec 31,4 % de la zone urbaine. La fécondité a été mesurée à l'aide des enfants déjà nés (EDN) et installée dans les additifs multi-facteurs des modèles de la régression de Poisson. L'âge moyen des interrogées était de 28,64 ± 9,59 ans, la moyenne des EDN était de 3,13 ± 3,07, mais plus élevé chez les femmes rurales que les femmes urbaines (3,42 ± 3,16 vs 2,53 ± 2,79). Les femmes âgées de 20 24 années étaient deux fois plus susceptibles d'avoir EDN plus que les femmes âgées de 15-19 ans (IRR = 2,06, IC 95%: 1,95 à 2,18). Un modèle avec la déviance minimum a été sélectionné et a été utilisé pour prédire la l'EDN chez la femme. *(Afr J Reprod Health 2014; 18[1]: 71-83).*

Mots-clés : fertilité, rapport des taux d'incidence, prédiction de Poisson, enfants nés, Nigeria

Introduction

Nigeria ranks among countries with highest population growth rate. The importance of monitoring the key mechanisms of population dynamics particularly fertility in Nigeria cannot be overemphasized. Sufficient data to track the direction of fertility and other demographic indices is scarce. There is need for mathematical modeling to track the fertility outcomes, but unfortunately such models are scarce in Nigeria. Our study which formulates a model to predict future fertility in Nigeria was basically conceived to fill the gap. Understanding population, its determinants, growth, dynamics and trends is essential in planning and achieving sustainable development. Fertility still remains a key determinant of population pattern, and researchers use fertility patterns to understand the population patterns.

Although literature has reported a decline in the number of births world-wide since 1960, the birth rate is still high in sub-Sahara Africa, especially in Nigeria[1,2]. Nigeria is Africa's most populous nation with an estimated population of 170 million[3,4]. Compared with the reported general decreasing fertility outcomes across the globe, sub-Saharan African countries continue to top the worlds' fertility charts. While the 2012 world's total fertility rate (TFR) is 2.4, it is 1.7 for more developed countries, 2.7 for less developed countries, 5.2 for sub-Saharan Africa, 5.5 for West Africa and 5.7 for Nigeria[3]. Elsewhere in west Africa sub-region, Nigeria ranked 5th in high TFR behind Guinea-Bissau (5.8), Liberia (5.9), Burkina Faso (6.0) and Mali (6.6)[4].

Total fertility rate as a measure of fertility in Nigeria has achieved a marked reduction over the years, from 6.6 in 1965 to 5.7 in 2008[5,6]. However, the pace of reduction is slow as population continues to increase rapidly from about 80 million in 1990 to approximately 170 million in 2012[3,4]. The pattern of fertility varies widely across different regions and by socio-demographic characteristics in Nigeria[6]. For instance, fertility peaks in age group 25-29 with 265 births per 1,000 women and declines thereafter. The general fertility rate is 194, which means that there were 194 births for every 1,000 women during the three-year period preceding the survey. The crude birth rate was 40.6 per 1,000 population for the same period[6]. Conscious of the relative consequence of fertility on population health and development indicators, the patterns of fertility in Nigeria has attracted attention of researchers for some time now both locally and internationally.

In different studies, researchers have been identified numerous factors that are determinants of fertility among which are increase in contraceptive use, increase in female enrolment at all levels of education as well as increasing participation of women in the labour force, etc[7-15]. Family economy, educational and labour market opportunities, globalization of fertility attitudes and behavior, family enhancement and society images are some of the main factors behind decline in fertility rates across the globe[16-18]. The high fertility in Africa could be traced to contextual factors and societal socioeconomic conditions. High levels of; infant and childhood mortality, maternal mortality, poverty, prevalence of communicable diseases (including HIV/AIDS) and emergence of non-communicable diseases constitute part of the reasons for high fertility in Africa etc[9,19-21]. Studies on fertility in sub-Saharan Africa have also dwelt on fertility implication on child and maternal health and overall family well-being[1,2,22-26]. These earlier studies mainly focused on either fertility determinants or its consequence, but very few had ever proffered a model to predict fertility as evidenced in our study. A robust model of factors affecting fertility may go in no small extent in designing effective interventions leading to improved child and maternal well-being and economic growth[25].

This paper aimed at modeling individual woman's fertility level and predicts the number of children she would have bearing in mind of differential in their socio-demographic characteristics. The total number of children ever born (CEB) per woman was used as a measure of fertility since it is often used in various demographic studies as a proxy for fertility estimation[26-29]. Naturally, CEB is a count outcome. We used Poisson regression model which belongs to the family of generalized linear models (GLM)[30]. Besides contributing to the body of knowledge on fertility issues in Nigeria and beyond, this study will help individuals and policy makers in encouraging and promoting characteristics that are favorably disposed to lowering fertility in the country.

Method

Brief Description of the Study Area

Nigeria is a country in West Africa and the most populous black nation with estimated population of about 170 million[3]. The country has a birth rate of 40 per 1000 population, Infant mortality rate of 77 per 1000 live births, total fertility rate of 5.6 and 2.6% rate of natural increase[4]. There is an evidence of increasing use of modern contraceptive in Nigeria but the pace is relatively low compared to some other countries in sub-Saharan Africa[3].

Study Design and Data collection Procedure

The study was retrospective cross-sectional in design and utilized 2008 Nigeria Demographic Health and Survey (NDHS) conducted by ICF Macro Calverton, Maryland, USA, in conjunction with the National Population Commission (NPC)[6]. The data was downloaded from the website of the data originator after formal approval was granted for its utilization for this study. The data collection procedures and method have been exclusively provided in the 2008 NDHS report. Therefore, interested readers should visit the measure DHS website for this information (www.measure.dhs). The study focused on all women (n=33855) who have duly completed individual women questionnaires at the time of the survey. All women were included because, we aim at predicting fertility of women irrespective of their background characteristics.

Description of the variables

Children ever born was our dependent variable while the independent variables included respondents' location, region, age, age at first marriage, modern contraceptive use, paid employment status, marital status, marital duration, education attainment, husbands education attainment, residence, zones, wealth quintiles. Children ever born in the context of this study refers to the number of children a woman previously born alive as at the time of the study.

Data analysis

Before we began data analysis, the dataset was weighted by creating a new variable using the variable sampling weight already existing in the dataset to ensure representativeness since cluster sampling was used to select the study subject. This has tendency for proper re-distribution of the studied subjects.

We used descriptive statistics and analysis of variance (ANOVA) to analyze the data. Thereafter, Poisson regression was used to explore bivariate relationship between the independent and the outcome variable and also to model the fertility outcomes. We predicted the fertility levels among women and estimated the probabilities of a woman having exactly the CEB declared, less than the declared CEB and between 1 and 4 births respectively. Data was analyzed using STATA software version 12 and missing data were appropriately treated, although no missing value was recorded for the dependent variable.

Poisson regression has the advantage of fitting nonlinear models over the linear regression models including situations involving the number of occurrences (counts) of an event. This regression model was recommended by previous researchers such as; Little (1978), Rogers (1991) and Poston (2002) and has been used in studies by Fahrmeir et al (2001) and Kazembe (2009)[25,29,31-33]. The model assumes that; the incidence rate can be multiplied by exposure to obtain the expected number of observed events, the probability of finding more than one event is small compared to the exposure and non-overlapping exposures are mutually independent.

Poisson regression deals with situations in which the dependent variable is a count and the expected value is similar to the variance. Poisson distribution is a limiting case of the binomial distribution when the number of trials becomes large while the expectation remains stable, i.e., the probability of success is very small. An important additional property of the Poisson distribution is that sums of independent Poisson variates are themselves Poisson variates, i.e., if Y_1 and Y_2 are independent with Y_i having a P(μ_i) distribution, then

$$Y_1 + Y_2 \sim P(\mu_1 + \mu_2) \quad \text{.............(1)}$$

The key implication of equation (1) is that individual and grouped data can both be analyzed with the Poisson distribution[32].

The Poisson regression model assumes that the sample of n observations x_i are observations on independent Poisson variables Y_i with mean μ_i, if this model is correct, the equal variance assumption of classic linear regression is violated, since the Y_i have means (μ_i) equal to their variances (μ_i).

A generalized linear model,

$$\log(\mu_i) = x_i'\beta + offset_i \text{................(2)}$$

can then be fitted.

This is similar to $P(\text{Children Born}) = \frac{e^{-\lambda}\lambda^x}{x!}$..... (3)

Where $\lambda = \propto + \sum_{i=1}^{j} \beta_i x_i + \varepsilon$.............(4)

α is the constant B*is* are the coefficients and x_i are the independent variables.

Therefore,

$$Log(No\ of\ Children) = \propto + \sum_{i=1}^{j} \beta_i x_i + \varepsilon \text{.............(5)}$$

Alternatively,

$$No\ of\ Children = exp\ (\propto + \sum_{i=1}^{j} \beta_i x_i + \varepsilon) \text{......(6)}$$

Which means the Poisson regression model is a generalized linear model with Poisson error and a log link and implies that one unit increase in an x_i is associated with a multiplication of μ_i by $\exp(\beta_i)$.
For a grouped data, we defined Y_{ijkl} to be the number of children borne by the *l-th* woman in the *(i,j,k)*-th group, where *ijk* denotes some categorical independent variables. Let $Y_{ijk.} = \sum_l Y_{ijkl}$ be the group total for the model. Therefore, if each of the observations in this group is a realization of an independent Poisson variate with mean μ_{ijk}, then the group total will be a realization of a Poisson variate with mean $n_{ijk}\mu_{ijk}$, where n_{ijk} is the number of observations in the *(i,j,k)-th* cell.

A log-linear model can then be postulated for the individual means, like

$$Log(ijkl) = Log\ E(Y_{ijkl}) = x'_{ijk}\beta \quad \ldots\ldots\ldots.(7)$$

Then the log of the expected value of the group total is

$$Log\ E(Y_{ijkl}) = Log\left(n_{ijk}\,\mu_{ijk}\right) = Log(n_{ijk}) + x'_{ijk}\beta \quad \ldots(8)$$

The group totals follow a log-linear model with exactly the same coefficients as the individual means in the equation, except for the fact that the linear predictor includes the term *log(*n_{ijk} *)*which is the offset.
In the Poisson regression model, the incidence rate (r_j) for the *jth* observation is assumed to be given by

$$r_j = e^{\beta_0+\beta_1 x_{1,j}+\beta_2 x_{2,j}+\cdots\ldots+\beta_k x_{k,j}} \ldots\ldots.(9)$$

If E_j is the exposure, the expected number of events, C_j is

$$C_j = E_j e^{\beta_0+\beta_1 x_{1,j}+\beta_2 x_{2,j}+\cdots\ldots+\beta_k x_{k,j}} \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

$$= e^{\log(E_j)+\beta_0+\beta_1 x_{1,j}+\beta_2 x_{2,j}+\cdots\ldots+\beta_k x_{k,j}} \ldots\ldots..(11)$$

The incidence rate ratio (IRR) for a one-unit change in x_i is given by

$$e^{\beta_i} = \frac{e^{\log(E_j)+\beta_0+\beta_1 x_1+\cdots+\beta_i(x_i+1)+\cdots\ldots+\beta_k x_k}}{e^{\log(E_j)+\beta_0+\beta_1 x_1+\cdots\beta_i x_i+\cdots\ldots+\beta_k x_k}} \ldots\ldots\ldots(12)$$

If variables $x_1,\ldots\ldots..x_j$ are held constant[32,33].

Results

Socio-demographic characteristics of respondents

The NDHS 2008 consisted of 33855 women with 19.45% ages 15-19 years, 18.37% aged 20-24 years and 18.90% aged 25-29 years. Almost a quarter (24.03%) of the respondents is from the North West zone while a fifth (20.34%) is from the South West. Over a third (35.75%) of the respondents live in the urban area while only 8.91% and 13.97% had higher education and were married to men with higher education respectively. About three quarters (76.0%) of the respondents had never used a modern family method and 70.63% was currently married against 25% who had never married. The average CEB by respondents aged 15-19 years was 0.23(0.22-0.25) while it is almost seven 6.86(6.74-6.98) for those aged 45-49 years. Average CEB in North Central is 2.98(2.90-3.05), 3.94(3.84-4.02) in North East, 2.27(2.20-2.34) in South West, 2.43(2.37-2.48) in the Urban and 3.40(3.36-3.45) in the rural area. The data further showed significant differences between CEB and age, regions, residence, highest education level, employment status, marital status, marital duration, religion, ethnicity, and wealth quintiles (Table1).

Table 1: Social-demographic and Reproductive characteristics of respondents and summary of their children ever born (CEB),NDHS 2008

Characteristics		**Weighted % of N=33855**	**Mean CEB (Standard Error)**	**95% CI**	**Analysis of Variance of CEB across characteristics**	
Age (years)	15-19	19.45	0.23(0.007)	0.22-0.25	6597.67	0.000
	20-24	18.37	1.19(0.018)	1.16-1.23		
	25-29	18.90	2.51(0.026)	2.46-2.56		
	30-34	13.88	3.95(0.037)	3.87-4.01		
	35-39	11.72	5.26(0.047)	5.17-5.35		
	40-44	9.08	6.17(0.585)	6.06-6.28		
	45-49	8.60	6.86(0.621)	6.74-6.98		

Region	North Central	14.22	2.98(0.038)	2.90-3.05	429.92	0.000	South West V South South
	North East	12.77	3.94(0.045)	3.84-4.02			South West V South South
	North West	24.03	4.03(0.041)	3.95-4.11			North West and North East
	South East	12.25	2.43(0.049)	2.33-2.52			
	South South	16.39	2.44(0.044)	2.35-2.53			
	South West	20.34	2.27(0.034)	2.20-2.34			
Residence	Urban	35.75	2.43(0.028)	2.37-2.48	807.22	0.000	
	Rural	64.25	3.40(0.022)	3.36-3.45			
Highest Education Level	No Education	35.77	4.45(0.030)	4.39-4.51	2575.70	0.000	Secondary V Higher
	Primary	19.67	3.81(0.039)	3.73-3.88			
	Secondary	35.66	1.59(0.023)	1.55-1.64			
	Higher	8.91	1.64(0.042)	1.56-1.72			
Partners' Highest Education Level	No Education	37.87	4.67(0.034)	4.61-4.74	252.20	0.000	Secondary V Higher
	Primary	21.28	4.36(0.042)	4.28-4.45			
	Secondary	26.87	3.31(0.032)	3.24-3.37			
	Higher	13.97	3.24(0.046)	3.14-3.33			
Currently working	No	40.14	2.14(0.026)	2.08-2.19	1090.95	0.000	
	Yes	59.13	3.68(0.023)	3.63-3.73			
	No Response	0.73	2.92(0.232)	2.46-3.37			
Ever used modern FP	No	76.04	3.06(0.021)	2.08-2.19	2.07	0.149	Used and Never Used
	Yes	23.96	3.01(0.034)	3.64-3.73			
Marital Status	Never	25.15	0.09(0.005)	0.08-0.10	5161.87	0.000	
	Currently	70.63	4.03(0.020)	3.99-4.08			
	Formerly	4.22	4.27(0.082)	4.11-4.43			
Ethnicity	Yoruba	1.66	2.61(0.113)	2.39-2.83	184.82	0.000	Yoruba V Igbo/Ibiobio
	Hausa/Fulani	46.62	3.40(0.028)	3.34-3.45			
	Igbo/Ibibio	51.72	2.76(0.023)	2.72-2.81			
Religion	Catholic	10.73	2.49(0.050)	2.39-2.58	338.66	0.000	Catholic V Other Xtian
	Other Xtian	40.70	2.42(0.025)	2.37-2.47			Others V Islam
	Islam	46.28	3.76(0.028)	3.71-3.82			Others V Traditional
	Traditionalist	1.60	4.18(0.139)	3.90-4.45			
	Other	0.69	3.73(0.463)	2.83-4.64			
Marital Duration	never married	25.15	0.09(0.005)	0.08-0.10	10935.1	0.000	
	0-4	15.98	1.04(0.015)	1.01-1.07			
	5-9	15.23	2.67(0.019)	2.63-2.70			
	10-14	12.78	4.13(0.027)	4.07-4.18			
	15-19	11.07	5.14(0.037)	5.07-5.21			
	20-24	8.35	6.29(0.050)	6.19-6.39			
	25-29	6.63	6.90(0.064)	6.78-7.03			
	>29	4.81	7.87(0.081)	7.72-8.04			
Wealth Quintile	Poorest	18.55	3.96(0.041)	3.89-4.05	546.84	0.000	
	Poorer	16.67	3.82(0.042)	3.73-3.90			
	Middle	18.99	3.23(0.041)	3.15-3.31			
	Richer	20.78	2.55(0.037)	2.48-2.63			
	Richest	23.00	2.01(0.031)	1.95-2.07			
Age at 1st Marriage	never married	25.15	0.09(0.005)	0.08-0.10	3809.80	0.000	
	<15 years	20.02	5.08(0.041)	4.50-5.16			
	15-17 years	22.46	4.18(0.035)	4.11-4.24			
	18-20 years	14.20	3.70(0.039)	3.62-3.78			
	21-23 years	8.43	3.31(0.047)	3.21-3.40			
	Over 23 years	9.73	2.79(0.044)	2.70-2.87			
Total		100.00	3.13(0.017)	3.11-3.17			

The distribution of CEB among all respondents is shown in Figure 1. It showed that 9634 of the 33855 respondents had had no child while CEB ranged from 1 to 18. Figure 2 showed distribution of CEB by the respondents' according to rural/urban locations while Figure 3 depicts the same statistics on regional basis.

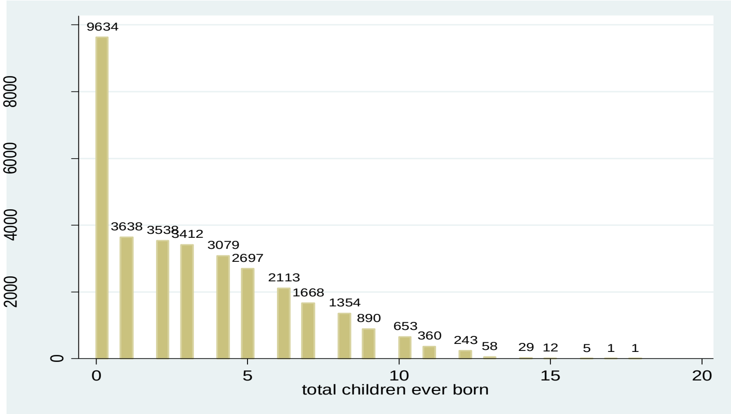

Figure 1: Children ever born per women, based on 2008 Nigeria Demographic and Health Survey data

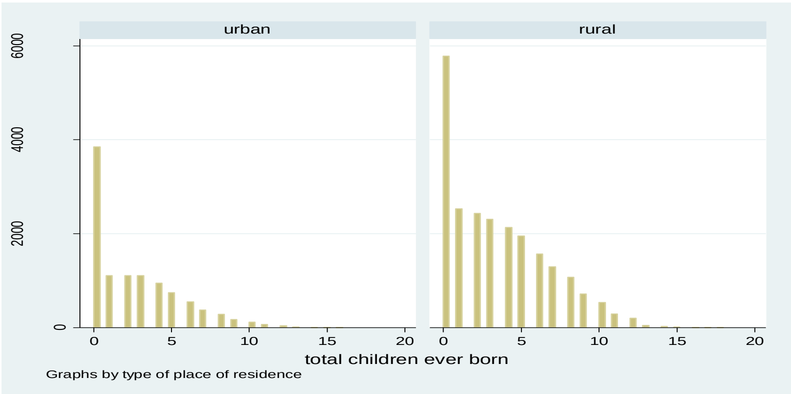

Figure 2: Children ever born per women, based on 2008 Nigeria Demographic and Health Survey data by location of residence

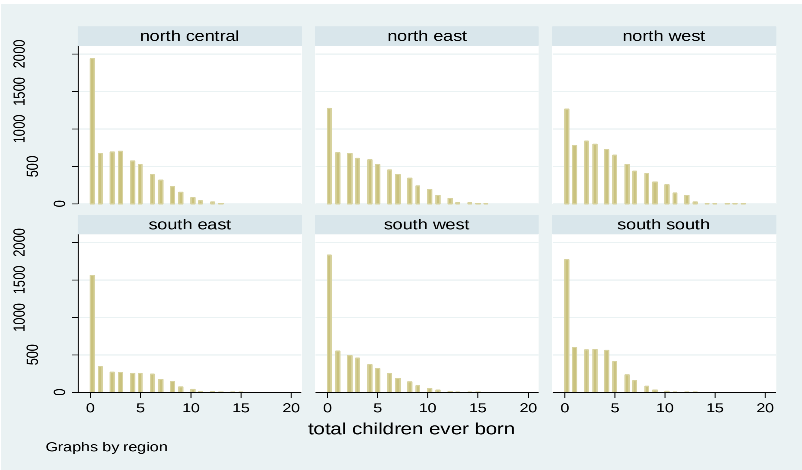

Figure 3: Children ever born per women, based on 2008 Nigeria Demographic and Health Survey data by zones

The range of CEB was 0-18, with median at 2. As shown In figure 4 classifying CEB into four groups is evidenced that 29.90% of the respondents had had no child, 21.51% had either 1 or 2 children, 19.5% had 3-4 children while others had already had more than 4 children

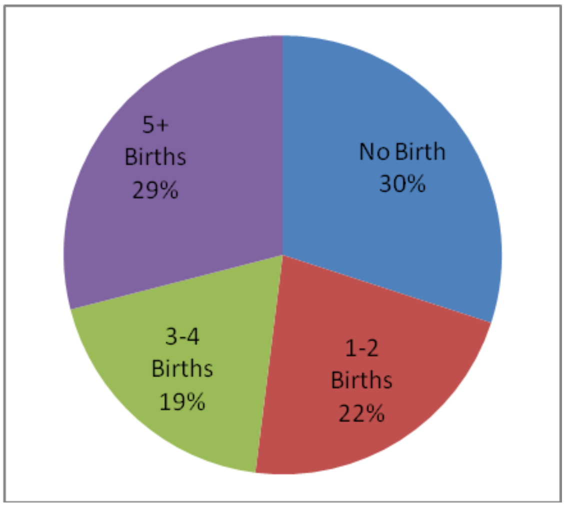

Figure 4: Distribution of children ever born among Nigeria Women NDHS 2008.

The Poisson regression model

Table 3: Choosing the best Poisson regression model

Models	Variables	deviance
I	Region, Education, Currently Working, Marital Duration, Wealth quintile, Marital status	27434.98
II	Region, Education, Currently Working, Marital status, Wealth quintile, Age at 1st marriage,	30248.34
III	Region, Education, Currently Working, Marital Duration, Wealth quintile, Age at 1st Marriage	26433.92
IV	Region, Education, Currently Working, Marital Duration, Wealth quintile, Marital status, Age at 1st Marriage	26208.54
V	Region, Education, Currently Working, Marital Duration, Wealth quintile, Marital status, Age,	26479.67
VI	Region, Education, Currently Working, Marital Duration, Wealth quintile, Age, Age at 1st Marriage,	26158.49

We fitted five models of various specifications. Conditional on the independent variables ($x'_{ijk}y$), the number of children (y_{ijk}) born by kth woman were modeled using the Poisson model through the predictor n_{ijk}. In Table 3 we presented only the combinations of factors that were significant in the respective regression model alongside the deviance of the fitted regression and we chose the Poisson regression model VI with the smallest deviance as the best prediction model. The fitted Poisson regression model included age, region, respondents' education attainment, employment status, marital duration, wealth quintile and age at first marriage. The fitted model for expected CEB by the woman was

$$E_j = e^{-2.49+B_1 age_{1,j}+B_2 Zone_{2,j}+B_3 locality_{3,j}+B_4 education_{4,j}+B_5 employ\ st_{5,j}+B_6 Marital\ st_{6,j}+B_7 Marital\ dur_{7,j}}$$
……………….(14)

The bivariate Poisson regression of CEB by respondents on their ages showed that respondents aged 35-39 years are 6.2 times more likely to have more children than those aged 15-19 years. Similarly, respondents from South west are about 24% less likely (IRR=0.76 95% CI: 0.75-0.78) than the North central respondents to have children but it is 1.3 times higher in North East (IRR=1.30, 95% CI: 1.28-1.33) and North West (IRR =1.32 95% CI: 1.30-1.34) higher than the fertility in North Central. Also respondents with secondary and higher educations were about 50% (IRR =0.49, 95% CI: 0.49-0.50) and 0.4 times less likely (IRR=0.38, 95% CI: 0.37-0.40) less likely to have children as their uneducated counterparts (Table 4).

The multiple Poisson regression of CEB on all the independent variable showed that the Adjusted Incidence Rate Ratio (AIRR) of a woman aged 35-39 years having children compared to woman aged 15-19 years if all other variables are kept constant was 1.63. This implies that women aged 35-39 years would have children 1.632 times as those aged 15-19 years with similar conditions. Also respondents from South west were about 10% less likely (AIRR=0.91; 95% CI: 0.89-0.93) than the North central respondents to have children but it is 1.09 times higher in North East (AIRR=1.085, 95% CI: 1.06-1.11) and 1.05 times in North West (AIRR =1.05 95% CI: 1.03-1.07) higher than the fertility in North Central. Also respondents with secondary and higher education were about 5%

(AIRR =0.94, 95% CI: 0.92-0.96) and 25% times less (AIRR=0.77, 95% CI: 0.75-0.80) less likely to have children as the respondents with no formal education. The currently working respondents were 1.03 times likely to have children than respondents who were not currently working (AIRR =1.03, 95% CI: 1.01-1.04). Respondents in richest wealth quintile were 0.92 times less likely to have as many children as the poorest respondents 0.92(0.89-0.95) if all other conditions are kept constant (Table 4).

Table 4: Poisson regression of children ever born by women according to socio-demographic characteristics

Variables	Bivariate Poisson Regression		Multiple Poisson Regression	
	IRR (95% CI)	p-value	AIRR (95% CI)	p-value
Ages in 5-year groups				
15-19	1.000	Reference	1.000	Reference
20-24	3.120(2.958-3.291)	0.000	1.498(1.415-1.585)	0.000
25-29	4.737(4.503-4.984)	0.000	1.547(1.504-1.642)	0.000
30-34	5.804(5.518-6.105)	0.000	1.606(1.505-1.714)	0.000
35-39	6.264(5.957-6.587)	0.000	1.632(1.518-1.754)	0.000
40-44	6.208(5.902-6.529)	0.000	1.606(1.482-1.739)	0.000
45-49	5.875(5.586-6.178)	0.000	1.556(1.423-1.700)	0.000
Region				
North Central	1.000	Reference	1.000	Reference
North East	1.302(1.277-1.327)	0.000	1.085(1.063-1.107)	0.000
North West	1.319(1.295-1.344)	0.000	1.047(1.027-1.068)	0.000
South East	0.839(0.819-0.861)	0.000	1.050(1.024-1.078)	0.000
South South	0.863(0.844-0.883)	0.000	1.022(0.999-1.047)	0.065
South West	0.762(0.745-0.780)	0.000	0.910(0.888-0.933)	0.000
Highest Education Level				
No Education		Reference	1.000	Reference
Primary	1.000	0.000	1.021(1.004-1.039)	0.014
Secondary	0.880(0.867-0.893)	0.000	0.942(0.921-0.963)	0.000
Higher	0.494(0.485-0.502)	0.000	0.774(0.747-0.803)	0.000
	0.383(0.372-0.395)			
Currently Employed				
No	1.000	Reference	1.000	Reference
Yes	1.184(1.168-1.199)	0.000	1.027(1.012-1.042)	0.000
Marital Duration				
Never Married	1.000	Reference	1.000	Reference
0-4	8.706(8.080-9.380)	0.000	6.290 (5.812-6.807)	0.000
5-9	17.52(16.31-18.82)	0.000	10.552 (9.72-11.45)	0.000
10-14	21.80(20.31-23.41)	0.000	12.096(11.08-13.20)	0.000
15-19	22.83(21.26-24.52)	0.000	12.137(11.04-13.34)	0.000
20-24	23.59(21.97-25.34)	0.000	12.180(10.99-13.49)	0.000
25-29	22.95(21.37-24.65)	0.000	11.457(10.26-12.80)	0.000
>29	23.01(21.41-24.72)	0.000	10.805(9.586-12.18)	0.000
Wealth Quintile				
Poorest	1.000	Reference	1.000	Reference
Poorer	0.974(0.957-0.990)	0.002	1.040(1.023-1.058)	0.000
Middle	0.844(0.829-0.859)	0.000	1.022(1.002-1.041)	0.027
Richer	0.701(0.687-0.714)	0.000	0.991(0.971-1.013)	0.438
Richest	0.533(0.522-0.544)	0.000	0.921(0.897-0.945)	0.0000
Age at 1st Marriage				
Never Married	1.000	Reference	1.000	Reference
<15 years	25.43(23.70-27.29)	0.000	1.620(1.550-1.692)	0.000
15-17 years	22.22(20.71-23.85)	0.000	1.479(1.423-1.536)	0.000
18-20 years	18.36(17.10-19.72)	0.000	1.283(1.240-1.327)	0.000
21-23 years	15.70(14.60-16.89)	0.000	1.172(1.135-1.217)	0.000
Over 23 years	12.19(11.33-13.11)	0.000	1.172(1.135-1.217)	0.000

CI: Confidence interval, IRR: Incidence rate ratio, AIRR: Adjusted incidence rate ratio

Using the fitted model (VI) in Table 3, we predicted fertility outcomes among different women as shown in Table 5. A never married woman aged 15-19 years from North central, currently working with secondary education belonging to the middle wealth quintile would have had no children on the average (Predicted births = 0.06). A woman married for 20-24 years, aged 35-39 years from North central, currently working with primary education belonging to the middle wealth quintile, married before age 15 who claimed to have had 7 children would have had 7.44 children on the average (Predicted births = 7.44). However, a woman married for 25-29 years, aged 45-49 years from South West, currently working with no education belonging to richer wealth quintile, who married at age 21-23 who claimed to have had 7 children are expected to have 5.47 children on the average (Predicted births = 5.47). Similarly, a woman married for 25-29 years, aged 45-49 years from South South, not currently working, with secondary education, belonging to richest wealth quintile, who married at age 18-20 who claimed to have had 7 children are expected to have 5.42 children on the average (Predicted births = 5.42). In Table 5, columns labeled (c), (d) and (e) showed the probability of a woman having exactly the CEB declared, probability of a woman having less than the declared CEB and probability of a woman having between 1 and 4 births respectively.

Table 5: Prediction of fertility outcomes among the respondents

CEB	Zone	Education	Currently Working	Marital Duration	Wealth Quintile	Age group	Age at 1st marriage	**Predicted Births**	(c)	(d)	(e)
0	NC	Secondary	yes	NM	Middle	15-19	Unmarried	**0.06**	.94	.94	.06
10	NC	None	no	20-24	Middle	40-44	18-20	**5.90**	.04	.96	.30
6	NC	None	yes	15-19	Middle	30-34	15-17	**5.17**	.15	.74	.41
0	NC	None	no	NM	Poorer	15-19	Unmarried	**0.05**	.95	.94	.05
2	NC	None	yes	15-19	Richer	35-39	18-20	**5.19**	.08	.11	.40
9	NC	None	no	25-29	Richest	40-44	15-17	**6.33**	.08	.89	.24
6	NC	None	yes	5-9	Middle	35-39	>23	**3.62**	.08	.92	.67
6	NC	None	yes	10-14	Poorest	25-29	<15	**4.39**	.12	.85	.54
12	NC	None	no	25-29	Poorer	45-49	15-17	**7.74**	.04	.95	.11
7	NC	Primary	yes	20-24	Middle	35-39	<15	**7.44**	.14	.53	.14
4	NC	Secondary	yes	5-9	Middle	35-39	>23	**3.41**	.19	.74	.71
6	SW	Primary	yes	25-29	Middle	45-49	18-20	**5.97**	.16	.61	.29
1	SW	Primary	yes	0-4	Richer	20-24	15-17	**1.08**	.37	.71	.66
0	SW	Secondary	yes	NM	Richer	20-24	Unmarried	**0.11**	.90	.89	.10
2	SW	Secondary	yes	0-4	Richest	30-34	>23	**1.40**	.24	.83	.74
2	SW	Secondary	yes	5-9	Richest	30-34	>23	**2.14**	.27	.64	.81
0	SW	Secondary	no	NM	Richest	25-29	Unmarried	**0.15**	.86	.86	.14
0	SW	Secondary	yes	NM	Richer	20-24	Unmarried	**0.12**	.89	.89	.11
7	SW	None	yes	25-29	Richer	45-49	21-23	**5.47**	.12	.81	.36
7	SW	None	yes	5-9	Middle	35-39	>23	**3.17**	.03	.98	.74
3	SW	Secondary	yes	10-14	Middle	35-39	21-23	**4.02**	.19	.42	.61
1	SW	Secondary	yes	0-4	Richer	20-24	18-20	**1.11**	.37	.70	.66
4	SW	Higher	yes	15-19	Richest	40-44	>23	**3.38**	.19	.75	.71
0	SW	Secondary	no	NM	Richest	15-19	Unmarried	**0.04**	.97	.97	.03
8	SW	Secondary	yes	20-24	Poorer	40-44	18-20	**5.64**	.09	.88	.33
0	SW	Secondary	no	NM	Poorer	15-19	Unmarried	**0.05**	.95	.95	.05
9	SW	Primary	yes	20-24	Poorer	35-39	15-17	**6.08**	.07	.91	.27
4	SW	None	yes	15-19	Poorest	30-34	15-17	**4.41**	.19	.55	.54
9	SW	Higher	yes	30+	Poorer	45-49	15-17	**5.29**	.05	.96	.39
10	SW	Primary	yes	10-14	Poorer	35-39	>23	**3.79**	.00	.99	.64
0	SS	Primary	no	NM	Middle	25-29	Unmarried	**0.23**	.79	.79	.21
1	SS	Primary	yes	5-9	Richest	25-29	15-17	**2.84**	.16	.22	.78
4	SS	Primary	yes	10-14	Richest	35-39	21-23	**4.42**	.19	.55	.54
3	SS	Secondary	yes	5-9	Richer	25-29	18-20	**2.90**	.22	.67	.78
7	SS	Secondary	no	25-29	Richest	45-49	18-20	**5.42**	.12	.82	.37

0	SS	Secondary	no	NM	Richer	20-24	Unmarried	**0.12**	.87	.87	.12
8	SS	Primary	yes	25-29	Richer	40-44	15-17	**7.31**	.14	.69	.15
0	SS	Secondary	no	NM	Richer	15-19	Unmarried	**0.06**	.94	.94	.06
6	SS	Primary	yes	10-14	Richer	30-34	15-17	**4.77**	.13	.79	.47
0	SS	Higher	no	NM	Richer	25-29	Unmarried	**0.14**	.86	.87	.13
6	SE	Primary	yes	15-19	Middle	25-29	<15	**4.58**	.13	.82	.51
0	SE	Secondary	yes	NM	Middle	15-19	Unmarried	**0.05**	.95	.95	.05
2	SE	Secondary	yes	5-9	Richer	20-24	15-17	**2.10**	.27	.65	.82
0	SE	None	yes	0-4	Middle	25-29	>23	**1.43**	.24	.24	.75
7	SE	Primary	yes	10-14	Middle	30-34	18-20	**5.21**	.11	.84	.41
3	SE	Primary	yes	0-4	Poorer	30-34	>23	**1.89**	.17	.88	.81
3	SE	Secondary	no	5-9	Richer	35-39	>23	**3.64**	.21	.51	.67
1	SE	Secondary	yes	NM	Richer	25-29	Unmarried	**0.19**	.15	.98	.17
0	SE	Higher	yes	0-4	Richer	35-39	>23	**1.77**	.17	.17	.79
6	SE	Secondary	yes	20-24	Richer	30-34	<15	**5.93**	.16	.62	.29
10	SE	Primary	yes	25-29	Richer	45-49	18-20	**7.24**	.08	.88	.15
11	SE	Primary	yes	25-29	Richest	35-39	<15	**6.62**	.04	.96	.21
10	NW	None	yes	30+	Poorer	45-49	15-17	**7.85**	.10	.83	.11
1	NW	None	no	0-4	Poorer	15-19	15-17	**0.75**	.35	.83	.53
3	NW	Secondary	yes	5-9	Richest	20-24	18-20	**2.11**	.19	.84	.82
9	NW	None	no	20-24	Middle	35-39	<15	**6.65**	.09	.86	.21
2	NW	None	yes	0-4	Richest	20-24	18-20	**1.24**	.22	.87	.70
6	NW	None	yes	15-19	Richer	30-34	<15	**5.25**	.15	.72	.39
10	NW	None	yes	30+	Richer	45-49	<15	**8.41**	.11	.77	.08
10	NW	None	yes	20-24	Poorer	40-44	15-17	**7.45**	.08	.87	.14
2	NW	None	no	5-9	Poorer	20-24	<15	**2.28**	.27	.60	.82
4	NW	Higher	yes	15-19	Richest	35-39	15-17	**4.34**	.19	.56	.55
1	NE	None	yes	5-9	Poorest	15-19	<15	**1.28**	.36	.64	.71
9	NE	None	yes	25-29	Poorest	35-39	<15	**7.28**	.11	.80	.15
10	NE	None	yes	30+	Poorest	45-49	<15	**8.80**	.12	.73	.06
4	NE	None	yes	5-9	Poorest	20-24	<15	**2.97**	.17	.82	.77
8	NE	None	yes	15-19	Poorest	30-34	15-17	**5.74**	.09	.87	.32
6	NE	None	no	10-14	Poorer	25-29	<15	**4.84**	.14	.79	.46
4	NE	None	no	5-9	Middle	25-29	15-17	**3.38**	.19	.75	.71
3	NE	None	no	5-9	Richer	20-24	15-17	**2.80**	.23	.69	.79
12	NE	None	yes	30+	Poorest	45-49	<15	**8.12**	.05	.93	.09

CEB = Children ever born NC=North Central, NE=North East, NW=North West, SE=South East, SS=South South, EW=South West, (c) Probability of having exactly the CEB declared (d) Probability of having between 0 and the declared CEB (e) Probability of having between 1 and 4 births NM= Never Married

Discussion

We developed six Poisson regression models in this paper from which we selected best regression model and predict expected fertility among Nigeria women of child bearing age using nationwide representative survey[6]. Model (VI) was chosen for the prediction of expected fertility because it has the least deviance of all the fitted regression models. The choice of this model was in line with Fahrmeir et al and Kazembe studies[25,31] except that the model did not use spatial effects. Kazembe had estimated the residual variation not accounted for by the individual characteristics and also assessed the spatial variation in fertility at district levels. We utilized some background information of the respondents in fitting our model. Our study found that the respondents' age, region, education attainment, employment status, marital duration, wealth quintile and age at first marriage affect fertility levels in Nigeria. This finding is in accordance with previous studies conducted in some parts of Nigeria[34,35] and Africa[25,36].

As expected, respondents' age was a significant determinant of fertility levels as older women had higher fertility levels than younger women. In Nigeria context, the mean age at first marriage is usually less than 20 years. This means older women married earlier than the younger and as such may be susceptible to the risk of childbearing than the younger women. We found that as level of education increased, the number of children born per woman reduced. Respondents who had secondary or higher education had lower fertility than the respondents without education or those with primary education. These findings are similar with reports in some previous studies[1,2,25]. Delay in marriage among educated women could be a reason for the mark differential. Also, studies have identified higher education as a factor influencing use of modern contraceptives[25,34-36] and fertility is known to be lower among women where prevalence of contraceptive use is high[4,6].

Interestingly, respondents' location (whether rural or urban) and marital status which independently had significant bivariate relationships with fertility levels were not significant determinants of fertility among the respondent in the fitted regression model. This finding is in consonance with the findings of a Malawian study[25] but at variance with the outcome of Kibirige study in 1997[37] who reported that rural women tend to have more children than urban women. The insignificance of marital status may be connected with other contextual factors which were not available in the dataset. Kibirige had early connected his finding to the overwhelming low socio-economic conditions in rural areas where he carried out his study[37]. He stated that rural dwellers often have higher fertility rates which results in large family needed for socioeconomic activities including farming. Several researchers have focused on the relationship between economic power and fertility level[1,2,23]. Closely related to their submission is our finding that an individual's wealth quintile affects her eventual fertility with respondents in the richer and richest wealth quintile having less children than poorer and poorest women. This finding is also supported by findings of Adebimpe et al (2011) and Foote et al (1993), where they established that economic reasons led to increased fertility in poor economies[24,34].

Respondents' age at first marriage was found to be an important determinant of the number of children that women will have. Similar findings have been reported by a previous study, where they affirmed that early marriage and the onset of childbearing at young ages are strongly associated with high fertility. Also, respondents' marital duration was found to be associated with fertility level as being married for a longer period increases the risk of exposure to childbearing. The geographical area of Nigeria where a respondent comes from was found to be a predictor of respondents' fertility level. While respondents from North Central have lower fertility level than those from North East, North Central fertility was higher than it is in South West, however respondents from North central and South East had similar fertility levels.

The Poisson regression fitted into the CEB showed clearly that relationship between CEB and region, marital duration, age at first marriage was not linear. Our model was able to establish this non-linear relationship, determined the significant factors and predicted number of children expected of women of different social, demographic, sexual and reproductive characteristics. The model has predicted higher births among women from Northern Nigerian having other similar characteristics with women from Southern Nigeria, similarly women in poorer wealth quintiles will have higher number of births. The outlier (10-18 births) number of births declared in 2008 NDHS report[6] was curtailed by the model as no woman irrespective of her background or characteristics was expected to have more than 9.39 births through her child bearing age in extreme cases.

In conclusion, it is evident from this study that Poisson regression model is an applicable tool for predicting number of children a woman is expected to have in Nigeria. This will ease the yearning of policy makers and researchers for fertility data for up to date planning. Also, government and non-governmental organizations should take conscious effort at encouraging women to reduce number of children they would have in their lifetime through use of modern contraceptive methods. Early marriage prominent in Northern regions should be discouraged while the girl child who becomes a future woman should be motivated to have good education and also empowered to increase their economic status thereby curtailing excessive births.

Limitations

The respondents may have underreported CEB when asked to give the total number of children they ever born (CEB). This is because in African context, women find it difficult to report their dead children among their previously born alive children and as such can lead to under-reporting of births. The CEB usually consists of all children either living or dead including perinatal and neonatal deaths. There is usually recall bias in answering questions of this nature as most people consider incident of losing a child a healing injury which they will not like to remember. Also, problems associated with the use of secondary data cannot be completely overruled from the outcome of this study. The original survey was not purposefully designed for this study; however, large number of subjects included in the sample can reduce such bias.

Contribution of Authors

FAF conceived and designed the study and analysed the data, AAS wrote the methodology, FAF and AAS wrote the result and the discussion and read and approved the final manuscript.

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