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Fecundability Estimation from a Survey Data in Borno State

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Abstract: *A sensitive biological measure of fertility called fecundability (the probability of a woman in a menstrual cycle) has drawn the attention of population scientists who have estimated it precisely for specific populations by incorporating it into suitable probability models. Studies have shown that fecundability is affected by several factors. Some researchers have raised a doubt that it is affected by the blood group of the women too. In this article, an attempt has been made to examine this fact through an empirical study with the help of suitably collected data from Borno State of Nigeria. The study reveals that the blood group has nothing to do with fecundabilty, thus, contradicting the notion. Significant variables of the study are age at menarche, age at first marriage, respondents current age, husbands age, marital duration, use of contraceptive, spousal age difference, age at first birth, respondent education level, husband's education level, respondent work status, husband occupation, body mass index. The research findings reveal that the fertility pattern seems to be very high in the study area. This is because the average fecundability using simple compound type I geometric distribution compounded by transformed gamma distribution is estimated to be 0.27 as compared to other studies elsewhere. The average age at menarche and that of effective age at marriage in the study area were estimated to be 14.13 and 16.96 years respectively. The average duration of postpartum amenorrhea (PPA) also appears to be less than two months in the study area. This is significant finding of the survey. In various studies, it has been reported to vary between 3 months to even more.*

Keywords: *Age at menarche, Fecundability, Fertility, model Blood group and Postpartum amenorrhea*

1.0 Introduction

The human reproduction starts with the onset of marriage and timing of first conception signifies couples fertility at early stage of married life. The time, a woman takes to conceive for the first time after her marriage is called the first conception wait or conception delay. A conception delay is defined as the exposure months preceding, but not including, the month of conception, whereas the conception wait or the time required conceive includes that month as well (Potter and Parker, 1964).

The notion of fecundability is the monthly probability of conception in women is one of the principle factor of fertility and one of the most important parameters for study fertility patterns in different society (Roshidul et al, 2015).

Since 1960 the volume of research material being produced on reproductive decisionmaking has increased considerably. The research community now focuses on improving knowledge of specialized areas. On the other hand, unevenness of knowledge and capacity remains a major problem. Very little is known about population determinants in Northern Nigeria, where data on basic demographic indicators show growing differentials across regions in both fertility and health regimes. Very little insight has been shed on the determinants or consequences of regional differences in fertility regimes on women's lives and fertility transitions. It is becoming increasingly clear that women's position in the family and community has an important bearing on fertility regimes in Nigeria but the implications for policies and programmes remain unclear. Against this background there is need to undertake a study that will solve this problem. Fertility, being attributed to be the main cause behind it, has become the most fascinating area of research during the last four decades. A sensitive biological measure of fertility called fecundability (the probability of a woman in a menstrual cycle) has drawn the attention of population scientists who have estimated it precisely for specific populations by incorporating it into suitable probability models. Studies have shown that fecundability is affected by several factors. Some researchers have raised a doubt that it is affected by the blood group of the women too. In this research, an attempt was be made to examine this fact through an empirical study with the help of suitably collected data from Borno State of Nigeria.

In practice, fecundability is measured in women who are ovulating regularly, that is, pregnant, sterile or postpartum, anovulatory women are excluded. The term natural fecundability is used for non-contraception populations; total (or physiological) fecundability considers all conceptions regardless of out, including non-implanted fertilized ova and conceptions aborted spontaneously before the end of the cycle (Bongaarts 1975, Leridon 1977); while recognizable fecundabiliy relates to conceptions cycle by the non-occurrence of menstruation, and ‘effective’ fecundability includes only pregnancies ending in live births (Henry 1957).In this study the term ‘fecundability’ mainly refers to effective fecundability.

Although the theoretical importance of fecundability is beyond question, there are several difficulties in estimating it from direct observation. Fecundability is frequently estimated from the distribution of waiting time of conception (Bongaarts 1975; Potter Parker 1964; Sheps 1946; Jain 1969; Majumdar and Sheps 1970; Sheps and Menken 1973).It is becoming increasingly clear that women's position in the family and community has an important bearing on fertility regimes in Nigeria but the implications for policies and programmes remain unclear. Against this background there is need to undertake a study that will solve this problem. Fertility, being attributed to be the main cause behind it, has become the most fascinating area of research during the last four decades. A sensitive biological measure of fertility called fecundability (the probability of a woman in a menstrual cycle) has drawn the attention of population scientists who have estimated it precisely for specific populations by incorporating it into suitable probability models. Studies have shown that fecundability is affected by several factors. Some researchers have raised a doubt that it is affected by the blood group of the women too. In this research, an attempt will be made to examine this fact through an empirical study with the help of suitably collected data from Borno State of Nigeria.

Estimation of Fecundabiliy

Other techniques for estimating fecundability involve the following methods.

1. Calculation based on coital frequency and the viability of the ovum and sperm (Class and Grebenik 1954; Lachenbruch 1967).
2. Observations on proportion of women conceiving during a one month period of exposure to risk of conception (Henry 1980).
3. Models fitted to the distribution of birth interval, or partial attained within a certain period of time by a group of women (Brass 1958; Singh 1963).

Porter and Parker (1964) have suggested the type I geometric distribution to describe the data on the conception times under the following assumptions;

(a) The fecundability of each couple remains constant from month to month until pregnancy.
(b) Among couples, fecundability is distributed as a Pearson Type I curve i.e. a beta distribution with parameters a and b.
(c) Conception is a random event, conditional on fecundability.
(d) The number of couples is large.
(e) The model applies only to those women who conceive.

In order to estimate the parameters 'a' and 'b' in the model Potter and Parker applied the method of moments using the first two moments about origin of the conception months. Majumdar and Sheps (1970), along with moment estimates, applied the method of maximum likelihood, to estimate these parameters and observed some improvement in the goodness of fit but in both the cases the fit was found to be almost poor, while giving explanation for this poor fit they have raised a doubt on the appropriatness of the beta distribution for fecundability parameter 'p'

In the present research alternative distribution to describe the nature of 'P' has been proposed. The distribution is as follows;

$$f(p) = \frac{c^l}{\Gamma(l)} p^{C-1} (\log \frac{1}{p})^{l-1} \qquad 0 < p < 1, \qquad l, c > 0 \qquad (1.1)$$

$= 0$ otherwise

This distribution has been used by Grassia (1976) by using a transformation

$$t = \log_e (\frac{1}{p}) \qquad (1.2)$$

In the gamma distribution

$$g(t,c,l)=\frac{c^l}{\Gamma(l)}e^{-ct}t^{l-1} \qquad l,c>0 \text{ and } 0<t<\infty \qquad (1.3)$$

$$=0 \quad \text{otherwise}$$

And used in some other context.

2.0 The Revised Model

Using the alternative model, as given in (1.1), for 'P' the unconditional distribution g(x) of x, the random month of conception can be written as

$$g(x)=p\mid X=x\mid=\frac{c^l}{\Gamma(l)}\int_0^1 p^c(\log\frac{1}{p})^{l-1}(1-p)^{x-1}dx \qquad 0<p<1, \qquad l,c>0 \qquad (2.1)$$

$$=0 \quad \text{otherwise} \qquad x=1,2,3---$$

Solving the integral on the right hand side (2.1) the expression for g(x) reduces as

$$g(x)=\begin{cases}\dfrac{c^l}{(c+1)^l} \\ \dfrac{c^l}{(c+1)^l}-\begin{pmatrix}x-1\\1\end{pmatrix}\left(\dfrac{c}{c+2}\right)+\begin{pmatrix}x-1\\2\end{pmatrix}\left(\dfrac{c}{c+3}\right)----+(1)^{x+1}\begin{pmatrix}x-1\\x-1\end{pmatrix}\dfrac{c}{c+x}\end{cases} \qquad (2.2)$$

$$x\geq 2$$

The first four moments of x about the origin, conditional on p, as given by the simple geometric distribution ie.

$$\Pr ob[X=x/p]=p(1-p)^{x-1} \qquad 0<p<1,\ x=1,2,3--- \qquad (2.3)$$

$$=0 \quad \text{otherwise}$$

Are

$$\frac{1}{P}=\frac{1}{p} \qquad (2.4)$$

$$\frac{2}{P}=\frac{2}{p^2}-\frac{1}{p} \qquad (2.5)$$

$$\frac{3}{P}=\frac{6}{p^3}-\frac{6}{p^2}+\frac{1}{p} \qquad (2.6)$$

$$\frac{4}{P}=\frac{24}{p^4}-\frac{36}{p^3}+\frac{14}{p^2}-\frac{1}{p} \tag{2.7}$$

On the assumption that 'P' follows the distribution given in (1.1), the expected value of $\frac{1}{p^r}$ is

$$E(\frac{1}{p^r})=\frac{c^l}{\Gamma(l)}\int_0^1 \frac{1}{p^r}p^{c-1}(\log)^{l-1}dp \tag{2.8}$$

$$=\frac{c^l}{(c-1)^l} \tag{2.9}$$

Using the expression (2.9) for the expected values of $\frac{1}{p^r}$, the various unconditional moments can obtained as

1. $=\left(\frac{c}{c-1}\right)^l$ (2.10)

2. $=2\left(\frac{c}{c-2}\right)^l-\left(\frac{c}{c-1}\right)^l$ (2.11)

3. $=6\left(\frac{c}{c-3}\right)^l-6\left(\frac{c}{c-2}\right)^l+\left(\frac{c}{c-1}\right)^l$ (2.12)

4. $=24\left(\frac{c}{c-4}\right)^l-36\left(\frac{c}{c-3}\right)^l+14\left(\frac{c}{c-2}\right)^l-\left(\frac{c}{c-1}\right)^l$ (2.13)

3.0 Estimation of Fecundability

Let m_1 and m_2 denote the first two sample moments of x about origin. Equating m_1 and m_2 with their population counterparts as defined in (2.10) and (2.11) we

$$\left(\frac{c}{c-1}\right)^l=m_1 \tag{3.1}$$

And

$$\left(\frac{c}{c-2}\right)^l=\frac{m_1+m_2}{2} \tag{3.2}$$

The equations (3.1) and (3.2) can be solve for c and l in terms of m_1 and m_2. These estimated values of c and l can be used to find the probabilities for the various values of x as given in (2.2).

The maximum likelihood estimates for c and l also be obtained using the scoring methods of Rao (1952). In the present case only the method of moments has been considered because of its simplicity. The estimates of the parameters c and l using the conception data have been obtained.

The equation (3.1) and (3.2) can be used to obtain the values of 'c' and 'l' observing the values of m_1 and m_2 from the empirical data. These estimated values of 'c' and 'l' can be used to find the probabilities for the various values of x using (2.2). The average fecundability can be computed by the formular.

$$E(p) = \left(\frac{\hat{c}}{\hat{c}+1} \right)^{\hat{l}} \qquad (3.3)$$

To solve the equation (3.1) and (3.2) for 'c' and 'l' interms of m_1 and m_2 the following techniques as suggested by Misra (1982) can be adopted. The equation (3.1) and (3.2) can respectively be written as

$$l[\log c - \log(c-1)] = \log m_1 \qquad (3.4)$$

$$l[\log c - \log(c-2)] = \log \frac{m_1 + m_2}{2} \qquad (3.5)$$

From (3.4) and (3.5)

$$\frac{\log c - \log(c-1)}{\log c - \log(c-2)} = \frac{\log m_1}{\log \frac{m_1 + m_2}{2}} = \lambda$$

$$\therefore \log c - \log(c-1) = \lambda[\log c - \log(c-2) \qquad (3.6)$$

Using a suitable numerical technique the value of 'c' can be found to any derived degree of accuracy from equation (3.6) and substituting the value of x in (3.1) the value of 'l' can be computed. Equation (3.3) can be used to compute the average value of fecundability for women of that region. The research design used in this study is ex-post-factor. This design was appropriately chosen because it is not possible for the researcher to directly manipulate the independent variables (demographic factors), Asika(1991). In other words data were collected after the phenomenon under investigation has taken place. A sample size of eight hundred and fifty five (855) was selected. Which was of mixed nature as no proper frame could be available to use an adequate sampling scheme (disproportionate stratified sampling). However, every attempt was made to make this sample as a representative for the State.

4.0 Results and Discussions

The research findings reveal that the fertility pattern seems to be very high in the study area. This is because the average fecundability using simple compound type I geometric distribution compounded by transformed gamma distribution is estimated to be 0.27 as compared to other studies elsewhere. The average age at menarche and that of effective age at marriage in the study area were estimated to be 14.13 and 16.96 years respectively. This is higher than that of Brooks-Gunn and Eliot (1992). The average duration of postpartum amenorrhea (PPA) also appears to be less than two months in the study area. This is significant finding of the survey. In various studies, it has been reported to vary between 3 months to even more.

From the analysis of human fertility it reveals that the socio economic variable is an important factor in human fertility. The age at marriage has a vital role in human fertility. The R^2 value is only 65% in fertility. Other than these variables such as biological, economic and demographic variables put together could contribute only 44% for human fertility. Using the Poisson distribution the age at marriage shows close relation to the human fertility.

Random samples of 855 households were selected. In each, one married couple was selected and from each selected couple the information pertaining to fertility (Y), Education of Wife (Xi), Education of Husband (X2), Occupation of Wife (X5) Occupation of Husband (X4), Place of residence (X5), Religion (X6), Age at Marriage (X7) and Type of house (X8) were obtained. The data were initially subjected to multiple regression analysis. The Step-wise regression analysis revealed that the maximum Contribution for Fertility is the age at marriage. The highly significant negative association of age at marriage with fertility was reasonable to isolate it and fits the Poisson distribution.

Table 1 Statistical details pertaining to the estimated fertility equation

S/No			
1.	Education of Wife	X_1	-0.123
2.	Education of husband	X_2	-0.093
3.	Occupation of wife	X_3	-0.123
4.	Occupation of husband	X_4	-0.088
5.	Place of residence	X_5	-0.156
6.	Religion	X_6	0.138
7.	Age at marriage	X_7	-0.342
8.	Type of house	X_8	-0.083
9.	Regression (constant)	B_0	0.325

In this study fertility is related to all possible Social – economic factors. Random samples of 855 households were selected. In each, one married couple was selected and from each selected couple the information pertaining to fertility (Y), Education of Wife (Xi), Education of Husband (X2), Occupation of Wife (Xa) Occupation of Husband (X4), Place of residence (X5), Religion (X6), Age at Marriage (X7) and Type of house (X8) were obtained. The data were initially subjected to multiple regression analysis. The Step-wise regression analysis revealed that the maximum Contribution for Fertility is the age at marriage. The highly significant negative association of age at marriage with fertility was reasonable to isolate it and fits the Poisson distribution.

The above analysis shows that the major factor affecting the fertility of women is the age at marriage. As the raw data indicates the marriages between 19 and 23 years of age yields better results. Next in the order is the religion. This might be due to the fact that even now among the Muslim Community in Northern Senatorial District education is not given any importance and their marriages take place at a very early age. The step-wise multiple regressions performed admitted the variable age at marriage as the first inside the function with co-efficient of determination equal to 0.387 and the first regression equation is

$$Y = 0.325 - 0.123 X, \qquad (3.7)$$

This helped in isolating the variable Women's education separately. The graph of fertility with age at the marriage showed a sudden downward trend and in the raw data it was observed that mean variance are almost equal and hence the Poisson distribution suits it and the equation is

$$Y = \frac{e^{-1.68(1.68)^{n}}}{n!} \qquad (3.8)$$

Table 2 Observed and Expected frequencies of conception under both the Distribution for ‘p’

Month	Observed Frequency	Expected Frequency		
		Using Beta Distribution for ‘p’		Using transformed gamma distribution for ‘p’ and moment method for estimation
		Under Method of Moments	Under Method of Likelihood Estimation (MLE)	
1	258	28.75	230.75	209.75
2	133	151.5	156	151.5
3	108	111.75	109	111.25
4	68	83.25	78.25	83
5	75	63	57.5	62.5
6	23	46	43.25	43.75
7	30	35.5	33	37
8	23	27.5	25.5	28.75
9	15	21.75	20	22.5

1 0 2	0 1 7 . 2 5 1 6 1 8
1 1 2	5 1 3 . 7 5 1 3 1 4 . 2 5
1 2 1	3 1 1 1 0 . 5 1 1 . 5
1 3 - 1 5 2	3 2 2 2 1 . 7 5 2 3
1 6 - 1 8 1	8 1 2 . 2 5 1 2 . 7 5 1 3
1 9 - 2 4 1	8 1 1 . 5 1 3 . 2 5 1 2 . 5
2 5 + 1	0 1 8 . 2 5 1 4 . 5 1 3
T o t a l 8 5	5 8 5 5 . 0 8 5 5 . 0 8 5 5 . 0
Fecundability	a = 5 . 9 9 a * = 3 . 4 0 c = 1 0 . 1 3 9
Parameters	b = 1 8 . 5 6 b * = 9 . 1 9 l = 1 4 . 9 4 6
Chi-square value	$\chi^2_{13} = 20.43$ $\chi^2_{13} = 17.2$ $\chi^2_{13} = 17.72$

From Table (2) we observe that under the transformed gamma model for 'p' the fitting has improved approximately of the same order as has been obtained under the maximum likelihood methods. If c and l are estimated using MLE the fitting may improve a little more but even then the fitting is not expected very close to the observed values. A critical examination of table (1) reveals that the frequency in the first cell is comparatively high, a situation, generally, not observed in the Nigerian data. It is possible that some women might have conceived before marriage and for the sake of some social reason or the other they might have reported the conception in the first month after marriage. Thus, it appears that the parent population in this case consist of two types of units,

i. those who always respond to the first cell and

ii. those who respond to the month as and when the conception occur.

Under such a situation an inflated distribution with inflation in the first cell may describe the data more closely in comparison to the distribution used in the present case. The study of an appropriate inflated distribution is under study and will be reported shortly

Table 3 : showing the first and second moments, estimated parameters as well as the average fecundability of the various blood groups

Blood groups	First moment (M_1)	Second moment (M_2)	Estimate of c	Estimate of l	Estimate of average fecundability
O	6.96	88.89	5.74	8.53	0.25
A	7.02	84.89	6.41	9.64	0.24

B	7.16	88.43	6.41	9.64	0.24
AB	8.60	115.74	8.71	15.06	0.19

The first and the second moments about the origin were computed for the various blood groups. These moments were used in estimating the fecundability parameters ‘c’ and ‘l’ which were substituted in the compounded distribution, hence the value of fecundability is obtained for these groups as shown in table 3 above.

The data were classified with respect to the four blood groups namely: blood O, blood A, blood B and blood AB. However, the nature of the frequency distribution of the random months of conception was seen under these blood groups. There was no significant change. The distribution appears almost the same as found for total sample size. The fecundability estimates were also computed under all these groups and it was found that the blood group has no effect on the value of fecundability.

5.0 Conclusion

Demography had become a strong, well-established empirical discipline, badly in need of theoretical guidance. The stochastic model satisfied this need by arguing that fertility is a result of conscious decision and deliberate purpose action.

In this research, we were able to examined whether blood groups has influence on fecundabilty or not. However, the study was able to establish through empirical evidence that there was no significant effect .The study also used some probability models to describe the stochastic nature of human fertility behaviors and estimate the inherent fertility parameters among women in Borno State.

In the present study the fecundabilty has been estimated for the different blood groups, utilizing the data for the duration of first conception. It can also be estimated by utilizing the data on various orders of birth. i.e. closed birth and open birth intervals. A study utilizing these data for that region is under progress and will be reported elsewhere.

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