

Fertility Level, Trend and Differentials in Nigeria: A Multivariate Analysis Approach

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Abstract We present an empirical approach to changes in some fertility measures using multivariate profile analysis to determine level, trend and differences in fertility measures in Nigeria. ASFR, TFR and MNCEB was studied with respect to residency for three time points. Results obtained showed strong evidence of mean differences in TFR across zones with both ASFR, TFR and MNCEB showing no interaction with respect to residency. Various profile plots and tests showed evidences of parallelism for all the fertility measures considered. Some implications and suggestions with regards to policy formulation were also given.

Keywords: *profile, changes, rates, profile analysis, fertility*

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1. Introduction

Population change results from the interaction of three components namely; fertility, mortality and migration. With improved health facilities, nutrition and environmental conditions, mortality levels in most developing countries have been drastically reduced but fertility levels seem to have remained high due to some several factors responsible for fertility [1]. It is the combined effects of declining mortality and high fertility rate that has kept the rate of population growth very high in most developing countries. Some of the socio-economic and cultural factors that influence fertility level are place of residence (rural/urban), level of education, occupation, employment status, income, religion and ethnic nationality [2]. These factors influence fertility through the intermediate variables (proximate determinants). The four main fertility-reducing proximate determinants, according to Bongaarts [3] are marriage, abortion, contraception and postpartum infecundability while, coital frequency, primary and secondary sterility and separation of spouses are considered secondary proximate determinants [4]. In a society where marriage is early universal and stable and where contraceptive use is low, fertility level is usually high.

According to [5], developing countries of the world accounted for about 81 percent of the world populations in 2017. Among the developing regions, Africa has the highest annual population growth rate of about 2.6 percent. Among the sub-regions in Africa, West Africa has the second highest growth rate of about 2.7 percent per annum. Within the sub-region, Nigeria is one of the most populous countries and has one of the most rapidly

growing populations in Africa. The rate of population growth is currently put about 2.6 percent per year. The 2008 and 2013 Nigerian Demographic and Health Survey (NDHS) reported a total fertility rate (TFR) of about 5.7 and 5.5 children per women respectively. The 2008 (and 2013) NDHS also reported the total fertility rate (TFR) for the six geopolitical zones as follows: North Central has about 5.4 (and 5.3) children per women, North East has 7.2 (and 6.3) children per women, North West has 7.3 (and 6.3) children per women, South East has 4.8 (and 4.7) children per women, South South has 4.7 (and 4.3) children per women and South West has 4.5 (and 4.6) children per women respectively.

Many developing countries experiencing the problem of rapid population growth, have adopted a number of measures to control their fertility levels. In 1988, the Nigerian Government inaugurated the National Population Policy (NPP). The policy is aimed at improving the quality of life of the population and achieving lower population growth rates through reduction of birth rates by voluntary fertility regulation methods. Some of the set targets of the policy are: (i) to reduce the proportion of women bearing more than four children by 50 percent by 1995 and by 80 percent by the year 2000 and (ii) to reduce the total fertility rate per woman from over six to four children by the year 2000 and the population growth rate from about 3.3 percent to 2.0 percent per year by the year 2000 among others. To achieve the set goals and targets, some of the strategies adopted are: -making family planning services easily affordable, safe and culturally acceptable, mobilizing relevant agencies both private and public for effective service delivery and pursuing aggressive population information, education and communication programmes among others. The country has also invested a lot of resources towards achieving the

set targets. Some non-governmental organizations like International Planned Parenthood Federation (IPPF), Planned Parenthood Federation of Nigeria (PPFN), and the United Nations Fund for Population Activities (UNFPA) have also made a lot of contributions towards achieving these goals.

Although fertility reduction is speculated in some quarter, there is no empirical evidence of fertility decline. It is equally not clear whether the rapid population growth is the result of the decline in mortality levels accompanied by constant fertility or a tendency to over –estimate fertility levels. The questions that follow are; what level of achievement has Nigeria made on fertility reduction? Is there enough evidence to show that fertility level is reducing or will reduce? Are there differences in the fertility level among the regions (geo-political zones) of the country? This work therefore seeks to adopt a multivariate profile analysis approach to address these questions objectively.

2. Methodology

The data used for this study are secondary data obtained from [13], [14] and [15] Nigeria Demographic and Health survey (NDHS). The fertility level measures used are Total Fertility Rate (TFR), Age Specific Fertility Rate (ASFR) and Mean Number of Child Ever Born (MNCEB). The fertility trend was examined within the years under study while the differentials were made between residence (Urban and Rural) and Region (the six geo-political zones). The age group as well as states of the nations including Federal Capital Territory(FCT) served as experimental subjects.

The data was analyzed using Profile Analysis, where each region/residence area serves as profile. The term profile comes from the practice in applied work in which scores on a test battery are plotted in terms of graph or profile [6]. It has found wide application in psychology and education, often such that profile analysis at a point was considered by educationist as simply the practice of depicting scores. Profile analysis is primarily used to identify patterns, and, some techniques have been employed in this situation. Examples include cluster analysis approach [7], model profile analysis [8], factor analysis [9], profile analysis via multidimensional scaling [10], and criterion-related profile analysis [11]. It is a multivariate equivalent of mixed ANOVA most commonly used in (i) comparing same dependent variable between groups over several time points, and (ii) when there are several measures of the same dependent variable, as such, it makes same assumption as those of the MANOVA. Data used in profile analysis must be on the same scale, otherwise, z-score or any other transformation may be required. Since sample size can affect power and homogeneity of variance/covariance test, it is required that there be more subjects than the number of dependent variables. The major tests of Profile Analysis includes (i) Parallelism Test, (ii) Level or Separation Test, and (iii) Flatness Test. These enable us to ascertain if there is a significant trend in the mean value of the variable under study.

Let the data matrix for n observation vectors be given by

$$Y = \begin{pmatrix} y_{11} & y_{12} & \dots & y_{1j} & \dots & y_{1p} \\ y_{21} & y_{22} & \dots & y_{2j} & \dots & y_{2p} \\ \vdots & \vdots & & \vdots & & \vdots \\ y_{i1} & y_{i1} & \dots & y_{ij} & \dots & y_{ip} \\ \vdots & \vdots & & \vdots & & \vdots \\ y_{n1} & y_{n2} & \dots & y_{nj} & \dots & y_{np} \end{pmatrix} = \begin{pmatrix} y'_1 \\ y'_2 \\ \vdots \\ y'_i \\ \vdots \\ y'_n \end{pmatrix} \quad (1)$$

where,

- the column represents the p variables or the same variable at p time points.
- The rows are the units (objects or subjects) upon which the measurement are carried out.

Assuming that **Y** in Equation (1.1) is partitioned into K independent groups with each group having n_i observations such that $\sum_{i=1}^k n_i = n$, then **Y** could be represented thus:

$$Y = \begin{pmatrix} y'_{11} \\ y'_{12} \\ \vdots \\ y'_{1n_1} \\ \\ y'_{21} \\ y'_{22} \\ \vdots \\ y'_{2n_2} \\ \vdots \\ \\ y'_{k1} \\ y'_{k2} \\ \vdots \\ y'_{kn_k} \end{pmatrix} = \begin{pmatrix} y_{111} & y_{112} & \dots & y_{11p} \\ y_{121} & y_{122} & \dots & y_{12p} \\ \vdots & \vdots & \dots & \vdots \\ y_{1n_11} & y_{1n_12} & \dots & y_{1n_1p} \\ \\ y_{211} & y_{212} & \dots & y_{21p} \\ y_{221} & y_{222} & \dots & y_{22p} \\ \vdots & \vdots & \dots & \vdots \\ y_{2n_21} & y_{2n_22} & \dots & y_{2n_2p} \\ \dots & \dots & \dots & \dots \\ \\ y_{k11} & y_{k12} & \dots & y_{k1p} \\ y_{k21} & y_{k22} & \dots & y_{k2p} \\ \vdots & \vdots & \dots & \vdots \\ y_{kn_k1} & y_{kn_k2} & \dots & y_{kn_kp} \end{pmatrix} \quad (2)$$

2.1. Test for Parallelism

Given a k independent groups each with n_i observations with p variables or the same variables at p time point, the null hypothesis for the test of parallelism for the k groups is given by:

$$H_{01}: C\mu_1 = C\mu_2 = \dots = C\mu_k$$

Where μ_k is k^{th} group mean vector, and C is any (p-1)×p matrix of rank p-1 such that $Cj = 0$ (i.e each row of C sums to zero). Example of such matrix thus:

$$C = \begin{pmatrix} -1 & 1 & 0 & \dots & 0 \\ 0 & -1 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \dots & 1 \end{pmatrix} \quad (3)$$

If Y are one variable at p time points and the time points are equal or approximately equal, C in Eq. (3) can be replaced with an orthogonal polynomial contrast which are often test for linear, quadratic, cubic and higher-order trend line. Example of such can be found in [12] which is given by:

$$C = \begin{pmatrix} -2 & -1 & 0 & 1 & 2 \\ 2 & -1 & -2 & -1 & 2 \\ -1 & 2 & 0 & -2 & 1 \\ 1 & -4 & 6 & -4 & 1 \end{pmatrix} \quad (4)$$

The four rows of C in Eq. (4) are orthogonal polynomial that test for linear, quadratic, cubic and quartic trend line in the mean of the profiles. [13] had shown that the test statistic for the null hypothesis (H₀₁) is given by:

$$\Lambda = \frac{|CEC'|}{|CEC' + CHC'|} = \frac{|CEC'|}{|C(E+H)C'|} = \prod_{i=1}^s \frac{1}{1 + \lambda_i} \quad (5)$$

The test statistic is distributed as $\Lambda_{p-1, \nu_H, \nu_E}$

Where, Λ is Wilks statistic, C is contrast matrix given in Eq. (3), λ_i is ith eigen values of the matrix $(CEC')^{-1}(CHC')$

$$E = \sum_{i=1}^k \sum_{j=1}^n (y_{ij} - \bar{y}_i)(y_{ij} - \bar{y}_i)' \quad (6)$$

$$H = n \sum_{i=1}^k (\bar{y}_i - \bar{y}_..)(\bar{y}_i - \bar{y}_..) \quad (7)$$

Besides the test statistic given in Eq. (5), other equivalent multivariate test statistic that can achieve the purpose can be derived using the Eigen value of the matrix $\lambda_i = (CEC')^{-1}(CHC')$. Three of such test statistic are:

$$Pillai [V^{(s)}] = \sum_{i=1}^s \frac{\lambda_i}{1 + \lambda_i} \quad (8)$$

$$Lawlay - Hotelling [U^{(s)}] = \sum_{i=1}^s \lambda_i \quad (9)$$

$$Rois Largest Root [\theta] = \frac{\lambda_1}{1 + \lambda_1} \quad (10)$$

2.2. Test for Level or Separation (Mean Difference)

For k profiles (groups) the null hypothesis for testing difference in mean level is stated thus:

$$H_{02}: j' \mu_1 = j' \mu_2 = \dots = j' \mu_k,$$

Where, μ_i is ith group mean vector and J is an identity vector.

The test statistic is given by:

$$\Lambda = \frac{|jEj'|}{|jEj' + jHj'|} \quad (11)$$

Where E and H retain its definition in Eq. (6) and Eq. (7), while j is an identity vector. The test statistic in (11) has a

relationship with the other equivalent test as shown in Eq. (8), Eq. (9) and Eq. (10), and the rejection of the null hypothesis (H₀₂) would suggest a significant mean difference.

2.3. Test for Flatness (Trend)

To examine if there is a significant trend in the mean level within the year under review, the null hypothesis is stated thus:

$$H_{03}: \frac{C[\mu_1 + \mu_2 + \dots + \mu_k]}{k} = 0.$$

Where, C retain its meaning in Eq. (3) or Eq. (4), μ_k is the kth group mean vector and k is the number of groups.

The test statistic for the hypothesis (H₀₃) is given by:

$$T^2 = kn(C\bar{y}_..) \left(\frac{CEC'}{\nu_E} \right)^{-1} (C\bar{y}_..) \quad (12)$$

Where, T² is the Hotelling test statistic, K is the number of groups, n is the number of observations, $\bar{y}_..$ is the estimate of the ground mean for the entire groups (μ) and E/ ν_E the estimate of the pooled variance (Σ). C and E retain its definition in equations Eq. (3) or Eq. (4) and Eq. (5) respectively. The test statistic in equation (11) is distributed with T^2_{p-1, ν_E} . Using the C in (1.4) will enable us to detect the pattern of the trend line that most appropriately fits that study data.

2.4. Test on the Profile Means

As in a univariate case where we can formally test the null hypothesis that the mean of our observations are equivalent, same can be performed in a multivariate profile analysis using the Hotelling's T² test. Literatures have identified two basic hypotheses to be tested in this case. The first is the null hypothesis that the ratio of mean over a hypothesized means is equal to one, and the second is, the null hypothesis that these ratios are the same. The second is mostly important when the first is rejected. This test start by assuming the vector of means is equal to a hypothesized one, i.e

$$H_0: \mu = \mu_0.$$

Thus, the first hypothesis is equivalent to testing the null hypothesis

$$H_{01} = \frac{\mu_1}{\mu_1^0} = \frac{\mu_2}{\mu_2^0} = \dots = \frac{\mu_p}{\mu_p^0} = 1.$$

Rejection of this hypothesis implies that at least one of the ratios is not equal to one thereby leading to testing of a second one which is equivalent to testing the null hypothesis

$$H_{02} = \frac{\mu_1}{\mu_1^0} = \frac{\mu_2}{\mu_2^0} = \dots = \frac{\mu_p}{\mu_p^0}.$$

To carry out these two tests, as in [10], the differences between successive ratios are computed. Let this ratio be represented by D_{ij} for each observation, thus, testing the null hypothesis that all the ratios are equal to one another is same as testing the null hypothesis that all mean differences are equal to zero. That is,

$$H_0 = \mu_D = 0.$$

The Hottelling T^2 is then applied to this test. Details on Hotelling T^2 test is given in [12].

3. Result and Discussion

This section presents the results of analysis and discussion under various sub-headings for age specific fertility rate (ASFR) collected for Urban and Rural areas over three time periods (2003, 2008, 2013), total fertility rate (TFR) and Mean number of children ever born

(MNCEB) collected for the six geopolitical zones of Nigeria over three time periods (2003, 2008, 2013).

Table 2 and Table 3 present significant values for various hypothesis tested. Except for the ASFR_URBAN, other datasets had results that led to rejection of the null hypothesis H_{01} . In essence, only ASFR for the urban residence had ratio of means over hypothesize mean value equal to one. Thus, the null hypothesis H_{01} was not rejected in the case of ASFR_URBAN. Consequent upon the rejection of H_{01} in the datasets (excluding ASFR_URBAN), H_{02} was tested. Results in third column of Table 2 showed that H_{02} was rejected in the case of TFR for South-East, South-South and North-East and MNCEB for North-Central, North-East and South-South. Thus, for these datasets, rejection of the both H_{01} and H_{02} could be an indication that the TFR and MNCEB values for these zones are significantly different from both each other and some hypothesized values. Reasons for this may not be far from those identified in the introduction.

Table 1. Age Specific Fertility Rate in Nigeria for women age 15-49

Age	Urban			Rural		
	2003	2008	2013	2003	2008	2013
15-19	88	70	62	146	148	162
20-24	186	177	188	252	254	267
25-29	258	245	237	282	277	265
30-34	222	223	218	257	252	247
35-39	156	130	148	174	177	169
40-44	51	60	59	81	101	91
45-49	12	36	20	22	48	35
Mean	139.0	134.43	133.14	173.43	179.57	176.57
Standard Deviation	91.31	82.95	86.19	97.61	86.38	89.99

Table 2. Significant values for test on the profile mean vectors across various groups

Datasets\Hypothesis	H_{01}	H_{02}
ASFR_URBAN	0.0931	0.6005
ASFR_RURAL	9.0007	0.50970
TFR_NORTH_CENTRAL	0.00000647	0.28360
TFR_NORTH_EAST	0.0016	0.02970
TFR_NORTH_WEST	0.003	0.10370
TFR_SOUTH_EAST	0.0128	0.01070
TFR_SOUTH_SOUTH	0.0056	0.04360
TFR_SOUTH_WEST	0.0039	0.32670
MNCEB_NORTH_CENTRAL	0.0003	0.01770
MNCEB_NORTH_EAST	0.0003	0.07010
MNCEB_NORTH_WEST	0.00000655	0.48070
MNCEB_SOUTH_EAST	0.0101	0.22960
MNCEB_SOUTH_SOUTH	0.00000582	0.00522
MNCEB_SOUTH_WEST	0.0011	0.18870

Table 3. Significant values of test for Parallelism, Flatness and equal Levels

Dataset\Tests	Parallelism	Equal Levels	Flatness
ASFR	Wilks=0.4202 Pillai=0.4202 H-Lawley=0.4202 Roy=0.4202	0.4500	0.7999
TFR	Wilks=0.1349 Pillai=0.1794 H-Lawley=1029 Roy=0.0123	0.0000116	0.0071
MNCEB	Wilks=0.7809 Pillai=0.7804 H-Lawley=0.7824 Roy=0.3317	0.0000592	0.0871

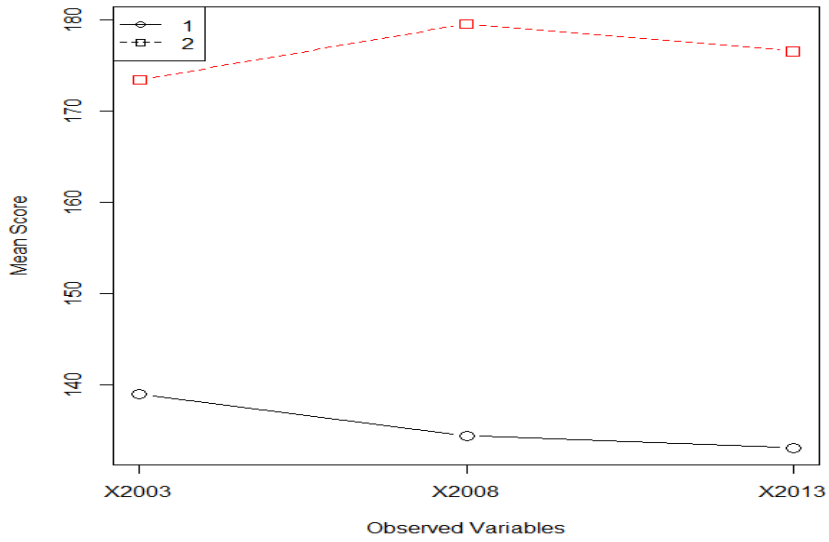


Figure 1. Profile plot of ASFR for Urban(1) and Rural(2) dwellers observed over three periods

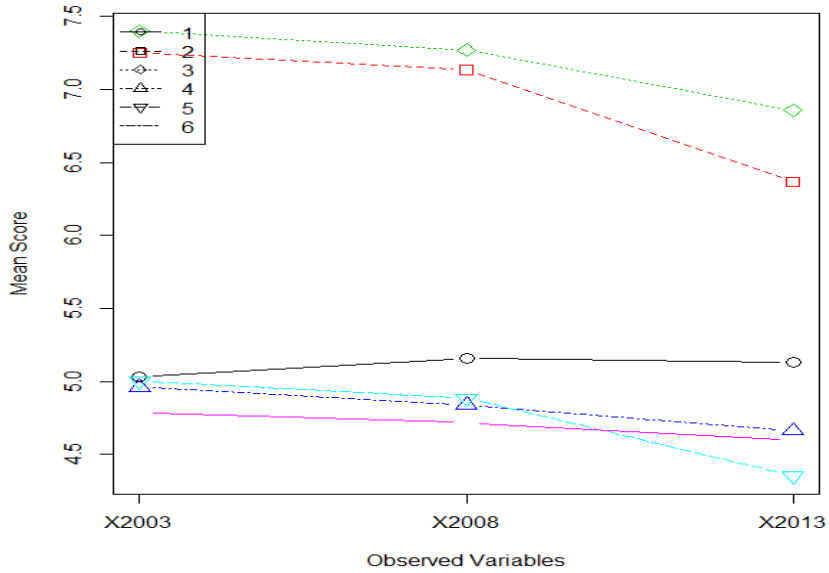


Figure 2. Profile plot of TFR for the six geopolitical zones observed over three periods (1=North-Central, 2=North-East, 3=North-West, 4=South-West, 5=South-South, 6=South-West)

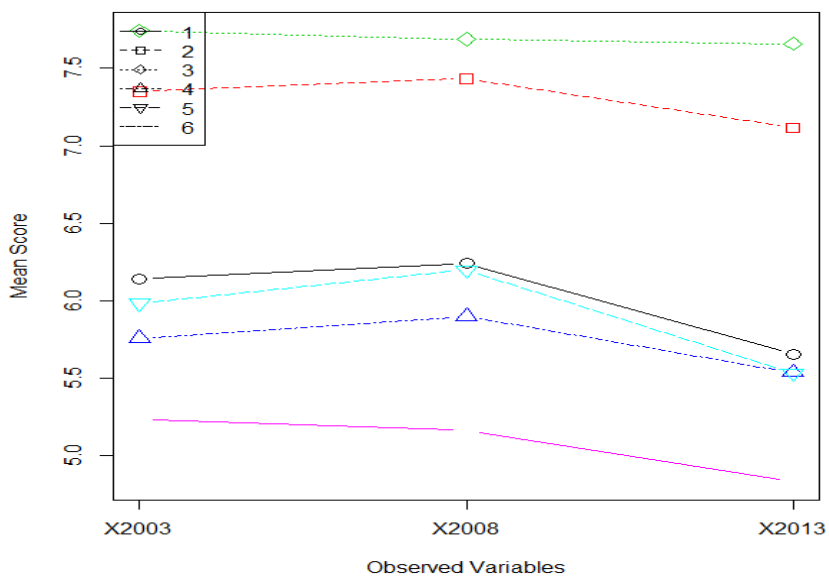


Figure 3. Profile plot of MNCEB for the six geopolitical zones observed over three periods (1=North-Central, 2=North-East, 3=North-West, 4=South-West, 5=South-South, 6=South-West)

In Table 3, testing for parallelism of ASFR gave evidence for non-rejection of the null hypothesis of parallelism, thus, there is no significant interaction between group memberships and the time points. ASFR may not be associated to residency (Rural or Urban) with respect to the various years considered. Same was the case for TFR in which situation we infer that TFR also is not associated with residency (geopolitical zone) over the years considered. For the MNCEB, test statistics gave different values in which case none presented enough evidence that could warrant rejection of the null hypothesis of parallelism. Profile plots presented in Figure 1, Figure 2, and Figure 3 further buttress the result of test for parallelism. For each plot, the lines are clearly seen parallel to each other over the three time points for the various residencies, as such, ASFR, TFR and MNCEB collected and analyzed has shown independence with respect to years and residency.

Testing for equality of levels showed that for ASFR, the null hypothesis of equal levels is not rejected implying that the group (residency) levels are not significantly different from another. But for TFR and MNCEB, the null hypothesis of equal levels was rejected, an indication that there is significant difference in TFR and MNCEB over the various geopolitical zones. It suffices to say that, there is a significant difference in the means of TFR and MNCEB for the various geopolitical zones of Nigeria. Differences and variations in vital statistics across regions as shown by the results obtained in this study informs a need to further identify why the differences.

In testing for flatness given that the profiles are parallel, the null hypothesis of flatness is not rejected for ASFR. For TFR, the null hypothesis of flatness was rejected while MNCEB fail to produce enough strong evidence as to reject the null hypothesis of flatness. Thus, within each residency (Rural and Urban), there is no difference between mean response of ASFR. In each of the geopolitical zones, average TFR is shown to exhibit differences while MNCEB does not.

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