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# Identifying the most important factors affecting the total fertility rate in Sudan using exploratory factor analysis

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## Abstract

Calculating the fertility rate in any population is a crucial priority for healthcare professionals, as it reflects the actual reproductive level in the community. This study aimed to identify the most important economic, social, demographic, and environmental factors affecting the total fertility rate in Sudan. The study relied on the descriptive, multivariate analytical approach and using secondary data from the Multiple Indicator Cluster Survey (MICS) conducted in 2014 for all Sudanese states. The study reached several conclusions, most important of which are: the average number of children a Sudanese woman gives birth to during her fertility years is approximately four; the most significant factors influencing the total fertility rate in Sudan are the family's economic status, the woman's demographic characteristics, and the family's lifestyle. The study concluded with several recommendations, the most important of which are: addressing the community's needs and developing specific strategies for education and health; raising community awareness and guiding them towards better practices by adopting suitable lifestyles that enable them to mitigate the negative impact on fertility rates resulting from poor lifestyle choices.

**Keywords: Fert**ility -Exploratory factor – Births- Women

## 1. Introduction:

Fertility is one of the most important factors affecting population growth. Therefore, calculating the fertility rate in any population is a high priority for healthcare professionals, as it reflects the actual level of reproduction in the community. Understanding vital statistics, which directly contributes to the planning process, necessitates the use of advanced statistical methods in population studies. Consequently, population studies are among the most frequently studied areas of statistical analysis due to the breadth of their influence and the numerous demographic variables requiring statistical analysis. Given the importance of fertility, attention was focused on identifying the most significant demographic, social, economic, and environmental factors affecting the total fertility rate in Sudan during 2014. Exploratory factor analysis was used to analyze and estimate the impact of these factors and determine the most influential ones. Factor analysis is a crucial statistical method for analyzing multiple variables related to a set of characteristics. By using factor analysis, a set of random variables can be reduced to a smaller number of important factors, allowing for a simplified and accurate description of the phenomenon. Factor analysis is distinguished by its ability to reduce numerous variables and prioritize them. A small number of hypothetical variables reflect the overall variance between variables, and this is done in multiple ways, including the principal component method, which requires multiple and lengthy calculations, and after scientific development and the use of computers with programs (SPSS) (SAS).

## 2. study Problem:

Many studies have shown that the average natural fertility rate in women is due to significant variations in fertility and differences in the socioeconomic and demographic levels of those populations. Generally, the relationship between fertility and these factors is complex, therefore requiring further study in developing countries, particularly Sudan, where fertility rates vary according to economic, social, and demographic factors. Most developing societies, including Sudan, suffer from uncontrolled reproduction and high natural population growth due to high fertility rates, which in turn lead to an increased population growth rate. This impacts the overall fertility rate, which is then traced back to its main contributing factors in order to summarize the number of variables that can be used as key indicators for increasing or decreasing fertility rates.

## 3. study Important:

Fertility is one of the main components of population change, alongside migration and mortality. Global interest in fertility issues has increased recently, as it is one of the most important elements that plays a pivotal role in population dynamics. Since fertility often exceeds mortality and migration, it has become an important and influential factor in the direction of population growth. It is also more difficult to understand, model, and analyze than migration and mortality. There is a growing need for more statistical studies to analyze the elements and factors related to fertility and identify the most influential on fertility rates. Therefore, factor analysis was used to study the demographic and social factors affecting the total fertility rate, due to its ability to reduce the factors and identify the most influential on total fertility rates in Sudan.

**4. Study objectives:**

• Identifying the most important demographic factors affecting the total fertility rate in Sudan,
• Identifying the most important social factors affecting the total fertility rate in Sudan,
• Identifying the most important economic factors affecting the total fertility rate in Sudan,
• Identifying the most important environmental factors affecting the total fertility rate in Sudan.

**5. Study hypotheses:**

• There are demographic factors that directly affect the total fertility rate in Sudan, both positively and negatively.
• There are social factors that directly affect the total fertility rate in Sudan, both positively and negatively.
• There are economic factors that directly affect the total fertility rate in Sudan, both positively and negatively.
• There are environmental factors that directly affect the total fertility rate in Sudan, both positively and negatively.

**6. Study methodology:**

This study employs a descriptive and multivariate analytical approach to primary data to identify the factors influencing fertility rates. Factor analysis is used, and the data is analyzed using the Statistical Package for the Social Sciences (SPSS).

**7. Data sources:**

Secondary sources were used to obtain the data for this study. It is the Multiple Indicator Cluster Survey that was collected in 2014 for all states of Sudan.

**8. Previous studies**:

**Fatima Al-Sheikh Al-Nour's 1995 study**, titled "Factors with Economic and Social Impacts on Fertility Variations in the Khartoum North Area (Al-Sha'abiyah)," focused on measuring the effects of age at first marriage, education, wife's employment, monthly income, and contraceptive use on female fertility. The researcher reached the following conclusions: - Education is inversely proportional to fertility, meaning the total number of births decreases as the wife's education level increases. It is directly proportional to age at marriage, meaning the higher the level of education, the older the wife is at marriage. - Age at marriage is inversely proportional to fertility. - The wife's employment negatively affects her fertility, as the average number of births for working women is lower than the average number of births for non-working women, regardless of the type of work. - There is no relationship between contraceptive use and the total number of births in the study sample. - Education positively affects contraceptive use; the higher the education level, the higher the percentage of contraceptive users. - There is no relationship between the wife's employment and her contraceptive use in the study sample. - Income positively affects contraceptive use. Pregnancy.

**The study by Reesa Faqir Al-Hassan (2000)** study, on family planning in Khartoum Governorate. This study aimed to identify the extent of the success of the Sudanese experience in the field of family planning by knowing whether Sudan follows a population policy to solve the problem of population growth and housing distribution between rural and urban areas, in addition to identifying the values, principles, standards, customs and traditions that govern the reproductive behavior of the governorate's population. The study concluded that there is a close link and reciprocal relationship between population growth on the one hand and economic and social factors on the other, as these factors affect the determination of fertility levels and explain the variation in fertility and the practice of family planning. It is also clear from this study that women are more receptive to the ideas of family planning because of the psychological and physical comfort it provides them, which may reflect positively on the family.

**Rabie Mohamed Abdel Rahim's 2000** study on population dynamics (a case study of the Fulani and Hausa in Kassala) aimed to identify the characteristics of population dynamics influenced by socio-economic and demographic factors, as well as the customs and traditions of the Fulani and Hausa, which impact population characteristics. The study's results indicated high fertility rates among the Fulani, attributing this to socio-demographic and environmental factors. Early marriage, prevalent among the Fulani and Hausa, is considered one of the most important social determinants responsible for these high fertility rates. The study also concluded that women's participation in the workforce did not affect their fertility rates when compared to the fertility rate of working women in Kassala State.

**Khaled Ahmed Al-Malik's (2000)** study on fertility trends and socioeconomic factors in the tribal contact zone between the Shaiqiya and Badiriya tribes in Marawi Province aimed to examine socioeconomic factors and their impact on fertility in this area. The main objective was to measure the effect of the age at first marriage, education, female employment, family monthly income, and the use or non-use of contraceptives on female fertility. The study concluded that monthly income affects women's fertility in the region, showing an inverse relationship between income and fertility among Shaiqiya women, thus having a negative impact. In contrast, income level positively affected the fertility of Badiriya women. Therefore, the study indicated that income positively influences contraceptive use. Furthermore, the age at marriage is inversely proportional to fertility among Shaiqiya women, while it is directly proportional among Badiriya women. Education also facilitates the use of contraceptives. The higher the educational level, the greater the demand for contraceptives among the two tribes. The educational level is linked to women's work, as there is a direct relationship between education and work for women. The results showed that the work of Shaiqiya women negatively affected their fertility, while the work of Badiriya women did not affect fertility. The study concluded that there is a direct relationship between women's work and their use of contraceptives, and that women's work increases the age of marriage for them.

**Abeer Mubarak Farij Al-Juhani's 2007** study, titled "Factors Affecting the Variation in Fertility Rates of Married or Formerly Married Saudi Women in Jeddah Governorate," aimed to identify the factors influencing the variation in fertility rates among married or formerly married Saudi women in Jeddah Governorate. A social survey methodology was employed to examine reproductive behavior within Saudi families using a stratified purposive sample. The study sought to answer the following questions: Are fertility rates affected by the following factors? Environmental and cultural factors include: the couple's original place of residence, current place of residence, and level of religiosity. Socioeconomic factors include: the couple's educational level, the husband's occupation, the wife's employment status, and family income. Demographic factors include: the wife's current age, age at marriage, duration of marriage, and optimal number of children. Regarding environmental and cultural factors, the study found a strong inverse relationship between the couple's original place of residence, the husband's level of religiosity, and fertility rates. However, no relationship was found between the current place of residence and fertility rates. Regarding socioeconomic factors, the study revealed a strong inverse relationship between the educational level of the spouses and the fertility rate. It also found a strong direct relationship between the husband's occupation and the fertility rate. The study concluded that fertility rates are higher among those with both high and low incomes, while they are lower among those with middle incomes. Furthermore, the study revealed differences in fertility rates based on the wife's employment status, with fertility rates increasing as the number of working wives rises. Concerning demographic factors, the study found a strong direct relationship between the wife's current age, the duration of the marriage, the desired number of children, and the fertility rate. Regarding contraception, the study revealed its widespread use among Saudi women in Jeddah. Modern and effective methods were the most commonly used, while traditional, ineffective methods were the least used. The study concluded that the two most common reasons for contraception use among the study population were to allow for childcare and to space out pregnancies.

**Safaa Mohamed Al-Rifai Shamboul's 2010** study, titled "Indirect Estimation of the Total Fertility Rate from Under-Five Mortality in Sudan," aimed to determine the total fertility rate that aligns with demographic indicators and other under-five mortality within a specific framework. Four methods were employed: First, all previous estimates and reports of total fertility rates were closely examined to establish a correlation between them using harmonic detection. Second, linear relationships were examined between mortality indicators, namely infant mortality, under-five mortality, and life at birth. Under-five mortality was chosen because it exhibits statistically significant characteristics, with a correlation coefficient exceeding 90%. A regression equation was constructed using the least squares method to predict the total fertility rate using data from 48 developing countries. Estimates subjected to rank testing with the total fertility rate were based on the assumption that it would be either greater than or less than six. The final estimate for Sudanese women was 5.7, which represents the fertility rate. The overall figure is consistent with all demographic systems.

**Mohammed Hassan Omar Adam (2014)** study, entitled "Using Factor Analysis to Identify the Most Important Factors Affecting the Total Fertility Rate: A Case Study of Human Development Report Data for 2006," aimed to extract the most important influencing factors through correlation analysis. It sought to identify the factors affecting the total fertility rate in the 2006 Human Development Report data for 177 countries. The study also aimed to assess the effectiveness of this approach in solving the problem. Multiple linear regression and factor analysis were used to describe the relationship between variables using mathematical equations. The study identified the most important explanatory factors contributing to the multi-linearity (life expectancy, school enrollment, percentage of the green population, population under 15 years of age, government spending on health and education, infant mortality, and maternal mortality). Three main factors were identified: first, variables directly affecting the total fertility rate; second, economic and educational data; and third, private spending on health. After applying the multiple linear regression model, the parameters of the model were found to be significant.

**Nancy Mohamed Ibrahim Mohamed Ali's 2014** study, "Indirect Estimates of Total Fertility Rate Using the Child-to-Women Ratio: A Comparison with the Palmore Method," explores the complexities of fertility estimation in developing countries. Estimates obtained from censuses or surveys are often unreliable due to flawed or incomplete data. Therefore, demographers resort to indirect statistical and mathematical methods to process data and arrive at the best possible estimate. Using the Palmore regression method for fertility estimation, implemented for the first time in Sudan, the study calculates total fertility rates (TFR) and age-specific fertility rates (ASFR) based on the population's age and sex distribution, the percentage of women who have been married, and infant mortality rates. It reveals a strong linear relationship between the population's age structure and the total fertility rate, and the regression corrects this relationship when additional fertility measures are included. This study was conducted to calculate all fertility measures agreed upon by demographers, based on long-form data collected during the fifth Sudanese census in 2008. In addition to age distribution, the census provides data on children born in the twelve months preceding the survey, as well as the total number of children born to women throughout their lives. This allows for consistent testing of these measures by comparison with the Palmore estimation method, thus highlighting reporting errors. The fertility measures calculated here are categorized based on two concepts: epochal fertility and cohort fertility. Several indicators were calculated for each of these concepts. The study used data on the total population of Sudan and did not attempt to calculate the same indicators by region or state, as this would have been too large and redundant. The results of this study indicate a decline in fertility, with the total fertility rate (TFR) dropping from 6.7 in 1993 to 5.7 in 2008, a decrease of approximately 30%. The study recommends further research using the Palmore method across different states and regions, as the significant differences observed between states relate to theory and practice. Researchers should also attempt to develop simple methods without compromising the accuracy of correction coefficients. One such method is the Child's Own method, developed by Chin (1981) at the London School of Hygiene and Tropical Medicine. The study also recommends adding questions to the long census form that allow for the application of various indirect methods, such as the Brass p/F method, the Coale-Trusell fertility table model, the Palmore regression model, and the Saba model.

**9. Theoretical Framework:**

Factor analysis combines the variables affecting a particular phenomenon into a smaller number of factors, which facilitates a deeper study of the phenomenon and thus understanding it. It clarifies the effect of each factor on it. One of the best definitions of factor analysis is the statement of one researcher that “factor analysis is expressing the greater by the lesser.” In addition, factor analysis has many other benefits and uses, including the following: (Farag, 1991).

**Factor analysis is used to explore the factors influencing a phenomenon.**

**-** Factor analysis is used to explore the internal relationships between a number of variables and how they are related and affect each other.

- Factor analysis is used to predict variables in the fields of education, economics, sociology, psychology, management, and other humanities fields (Abu Hashim, 2003).
- Factor analysis can be used as a preliminary step in studying a particular phenomenon to first reduce the number of influencing variables, and then to use another statistical method with this smaller number of variables (e.g., regression or t-test).
- Factor analysis can be used to reduce the number of dependent variables used in analysis of variance (MANOVA).
- Factor analysis is used in the construction of a test or scale.
- Factor analysis is used to verify the construct validity of a test or scale.

**Factorial concepts**: There are some important terms or expressions in factor analysis, which are (Faraj, Previous reference).

**Eigenvalue:**

The Eigenvalue root measures the magnitude of the variance in all variables calculated on a single factor. The latent root is not a ratio to explain the variance but to measure the magnitude of the variance and is used for comparison purposes. According to Kerr's criterion, a factor in which the value of the latent root is greater than one is accepted, but if the values are less than one, the factor is rejected.

**Communalities:**

It is the sum of the squares of the factor loads on the different variables, which were extracted from the factor matrix. Each variable contributes different sizes to each of the factors, and the sum of the squares of these contributions or saturations in the factors is the value of the contributions (Farag, Previous reference).

**Factor extraction:**

Factor extraction involves selecting the set of variables that explain the greatest possible amount of the total variance; this constitutes the first factor. Then, the set of variables that explain the greatest possible amount of the remaining variance after extracting the first factor is selected; this constitutes the second factor, and so on.

**Rotation:**

After identifying the factors and their saturations, the process of rotating the factors to another location helps in interpreting them. The main objective of rotating the factors is to arrive at a suitable combination of factors that can be interpreted. Thus, rotating the factors helps in interpreting the factors logically (Joudah, 2008).

**Loadings:**

Factor saturation is the degree of correlation of each variable with a particular factor. The concept of factor saturation is very important, as many calculations are processed from factor saturation tables. If the saturation of a particular factor is greater than 0.3, then the variable that is related to it helps to describe it well. As for factor saturations that are less than 0.3, they can be ignored and not taken into account.

**Factor analysis model: (Richard, 1998):**

Assuming that the observed random vector (x) has (P) elements, and that its mean vector is (μ) and its covariance matrix is (ε), the factorial model assumes that (x) depends linearly on a small number of unobserved random variables (Fm), …, F1(F2), called common factors) and also on a number of (P) sources of variation (Pε), …, 2ε, 1ε(Pε), called errors or specific factors) (Mustafa Zayed, 2007).

$$X_1 - \mu_1 = e_{11}F_1 + e_{12}F_2 + ... + e_{1m}F_m + \varepsilon_1$$

$$X_2 - \mu_2 = e_{21}F_1 + e_{22}F_2 + ... + e_{2m}F_m + \varepsilon_2$$

$$X_p - \mu_p = e_{p1}F_1 + e_{p2}F_2 + ... + e_{pm}F_m + \varepsilon_p \longrightarrow 1$$

Using matrices, we find that

$$X - \mu = LF + \varepsilon \rightarrow 2$$

**Since:**

μ − X: Value of observed original variables less the arithmetic mean, consisting of dimensions (Px1)

L: Loading matrix of correlation coefficients between observed variables and unobserved factors
in dimensions (Pxm)
F: Value of common factors in dimensions (mx1)
ε: Value of residuals in dimensions (Px1)

**The structure of covariance for the factor analysis model (**Al-Ansari,1999)

The idea behind applying this model is to create a data matrix and then analyze the components of this matrix. Therefore, it is necessary to identify the structure of this matrix, which must meet the following conditions:

$$1 - cov(X) = LL + \varphi \rightarrow 3$$

That is:

$$var(X) = e_{i1} + e_{i2} + \cdots + e_{im} + \varphi \rightarrow 4$$

$$cov(X, X_i) = e_i e_k + \cdots + e_{i1} e_{k1} \rightarrow 5$$

$$cov(Xi, Fi\ ) = e_i \acute{e}_I \rightarrow 6$$

The variance of the random variable xi can be divided into two parts: one part due to the common factors, called the variance of xi due to the common factors (the), and one part due to the specific factor (the variance of the specific factor). If we denote the variance of (x) due to the common factors by the symbol (hi), then

$$\sigma_{ii} = e_{i1} + e_{i2} + \cdots + e_{im} + \varphi \rightarrow 7$$

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$$\sigma_{ii} = vxi + asv \rightarrow 8$$

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**The basic assumptions of factor analysis:(** Grilli,2007).

The first assumption: This assumption is based on the existence of correlations between a set of variables, and that these correlations result from the presence of common factors among them. Factor analysis aims to explain these correlations by using factors that are less than the number of variables used, and that these factors take the standard values of the variables to obtain variables that are normally distributed with a mean of zero and a variance of one. This facilitates calculations and eliminates any discrepancies in the unit of measurement for the variables. Under this assumption, the total variance of the variables is divided into three types: - Common variance: Also called common variance or commonity quantities, it is the part of the variance that is related to the other variables through common factors and is calculated from the coefficients of the common factors.

- Specific variance: This is the part of the total variance that is not related to any variable but rather to the variable itself.

- Error variance: This is the part of the total variance resulting from factors that are not explained in the model. The second hypothesis: The second hypothesis in factor analysis assumes a correlation between the two variables (i) and (j). This correlation can be calculated based on the nature and effect of the loadings (saturations) of the common factors. This hypothesis can be represented for orthogonal factors by the following equation:

$$R=ai1aj1+ai2aj2+\ldots\ldots.+aiqajq \rightarrow (9)$$

That is, the correlation coefficient between any two variables is equal to the product of the loads of the variables and the factors common to each other.

**Steps for using factor analysis:**

Performing factor analysis requires four basic steps: (Thabet,1991)

1. Calculating the correlation matrix of all variables included in the analysis: The starting point is calculating the correlation matrix between the variables included in the analysis. This step gives an initial indication of how factor analysis works, and it shows that factor analysis derives its factors from the correlations between different variables.
2. Factor extraction: The purpose of this stage is to extract the factors. Factors are the foundations upon which the constructs that classify the set of variables under analysis are based. Factor analysis begins with a measure of the total variance observed in all the variables included in the analysis. It then selects the set of variables that explain the largest amount of variance, called the first factor. Factor analysis then extracts the second factor, which is the set of variables that explain the largest amount of the remaining variance after extracting the first factor. This is called the second factor, and this process continues to extract a third, fourth, and fifth factor, and so on, until a number of factors, potentially equal to the number of variables, has been extracted. The default procedure is to initially assign each variable a commonity value of 1.0. Commonity values are designed to show the proportion of variance that the factors contribute to explaining

a variable. These values range between zero and one, where zero indicates that the common factors do not explain any of the variance in a given variable, while one indicates that all the variance can be explained by the common factors. After extracting the first factor, a latent root is printed to the right of the factor number. The latent root is a function of the proportion of variance contributed by the factor. Each factor (not each variable as in the case of commonality values) and the first latent root, which is always the largest latent root (and its value is always greater than 1.0), and then the percentage of the variance contributed by the factor is given (latent root divided by the number of variables), followed by a cumulative percentage for each subsequent factor, and the values of the latent root are less than the previous factor, and the sum of the cumulative percentage (explained variance) is 100% after extracting the last factor (Abu Alam, 2003).

3. Factor selection: Estimating the number of factors to be identified in a factor study is one of the problems facing researchers, as there is no accepted mathematical rule. However, there are a number of criteria that can be used for this purpose, and the most important criteria for identifying factors are the following:
   **Tuker's test:(** Zayed,2007).

As its name suggests, it is based primarily on the use of the Phi coefficient and relies on the principle that if there is no clear discrepancy in the size of the residuals from one matrix to another that follows it (after extracting another factor), then the essential general factors in the correlation matrix have already been extracted and what remains is nothing but a residual of no importance.

**Humphrey test: (**Abu Hashim, Previous reference)

Gradually, after each factor is extracted, Humphrey's criterion is based on a completely different basis. On the one hand, it depends on the size of the original sample in which the correlations between its variables were calculated. Secondly, it depends on the size of the original sample in which the correlations between its variables were calculated. And secondly, it depends on the idea that only two saturations (not three) are sufficient to estimate the existence of a general factor. And on that basis, we are satisfied with this rule by using factor indicators that are saturations of two variables, in addition to calculating the standard error of a zero-correlation factor to compare them as an indicator to stop or continue in extracting new factors (Farag, previous reference).

**Comb test: (** Zayed, Previous reference)

The logic of this approach depends on addressing the pattern of residuals in the matrix more than on their size or significance, as it assumes that in the case of highly significant factors that have not yet been extracted and not just a false variance in the matrix, we should not expect more negative values in a matrix after the opposite than what is expected by chance in a matrix resulting from positive correlations.

**Kaiser test:** (Thabet, Previous reference)

The Kaiser criterion is a mathematical criterion in nature, invented by Guttmann in 1954. The logic of this criterion depends on the magnitude of the variance expressed by the factor. For a factor to be a class, its variance or latent root must be greater than or at least equal to the magnitude of the original variance of the variable. Since we cannot theoretically extract all the variance of the variable into one factor, obtaining a factor whose latent root is not less than one must mean that the source of its variance is more than one variable. Thus, it is a factor expressing a common variance between multiple variables. Accordingly, this criterion requires reviewing the latent root of the resulting factors, and factors whose latent root is greater than one are accepted and considered general factors. This method seems particularly valid and appropriate for the principal component method of "Hotling". The significant factors in this method are those whose latent root is equal to or greater than one, i.e., the variance accommodated by each factor (the sum of the squares of the saturations on each factor), provided that one has been placed in the diagonal cells. Fortunately, this method gives results that are very close to the number of factors usually extracted, in addition to the ease of calculating this criterion, which is commonly used. It is worth mentioning that the results of this criterion are consistent with other criteria, and the basis for its use is that "it is unreasonable to accept factors that do not accommodate a greater variance than is available in the original variables themselves." That is, a factor that accepts a latent root of less than one indicates a small amount of variance in the original variables themselves, so it is better to exclude it because it is not significant.

**10: Data analysis and discussion of results:**

Descriptive analysis:

**Table (1): Shows the age distribution of women of reproductive age**

| Age group | Frequency | Percent |
|---|---|---|
| 15 - 19 | 4271 | 8.8 |
| 20 - 24 | 3557 | 7.4 |
| 25 - 29 | 3728 | 7.7 |
| 30 - 34 | 2813 | 5.8 |
| 35 - 39 | 2739 | 5.7 |
| 40 - 44 | 1774 | 3.7 |
| 45 - 49 | 1444 | 3.0 |
| Total | 20326 | 42.1 |

**Source: Prepared by the researcher based on 2014 MICS data**

From the table above and the figure below, it is clear that the majority of the women of reproductive age surveyed fall into the age group (15-19) years, with a percentage of 8.8%, while the lowest percentage was for the sample of women of reproductive age who fall into the age group (45-49) years, with a percentage of 3.0%.

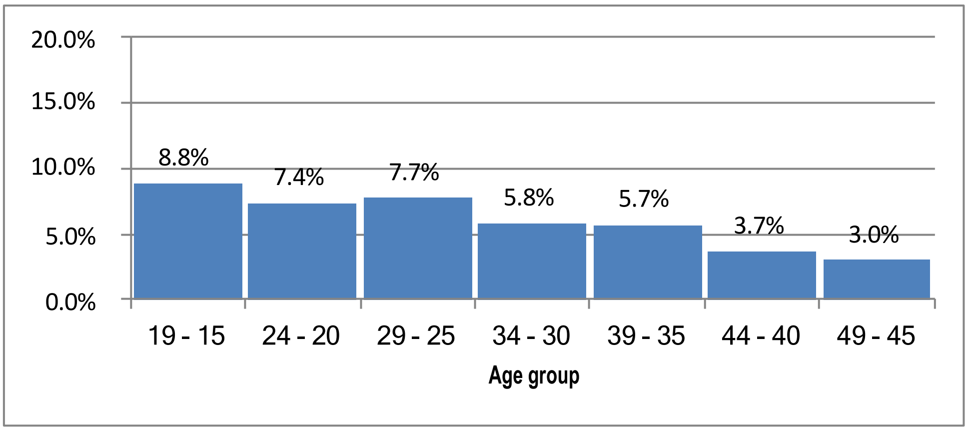



**Figure (1) shows the age distribution of women of reproductive age.**

**Table. (2) shows whether the woman has enrolled in any educational institution.**

| | Frequency | Percent |
|---|---|---|
| Yes | 14387 | 70.8 |
| No | 5240 | 25.8 |
| Missing | 699 | 3.4 |
| Total | 20326 | 100.0 |

**Source: Prepared by the researcher based on 2014 MICS data**

From the table above and the figure below, it is clear that the majority of the female respondents had enrolled in educational institutions, representing 70.8%, while those who had not enrolled represented 25.8%.

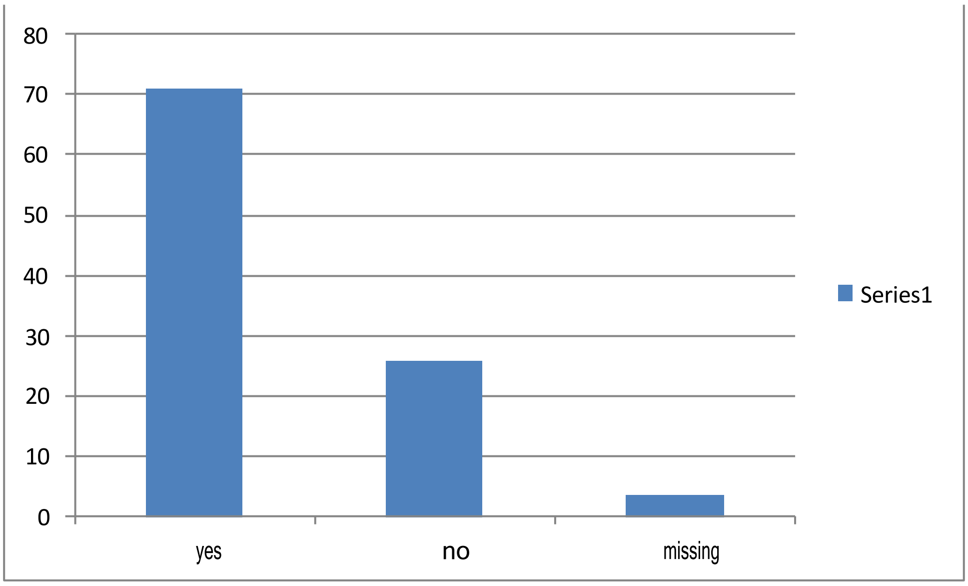



**Figure (2) shows whether the woman has enrolled in any educational institution**

**Table (3) shows the highest level of education among women of reproductive age.**

| | Frequency | Percent |
|---|---|---|
| Retreat | 1516 | 10.5 |
| Preschool | 15 | .1 |
| Primary | 30 | .2 |
| Elementary | 1074 | 7.5 |
| Fundamental | 5352 | 37.2 |
| Vocational Training | 8 | .1 |
| General Secondary | 411 | 2.9 |
| Intermediate | 41 | .3 |
| Higher Secondary | 3988 | 27.7 |
| Secondary | 17 | .1 |
| Intermediate Diploma | 113 | .8 |
| University | 1776 | 12.3 |
| Postgraduate | 35 | .2 |
| Unknown | 4 | .0 |
| Missing | 7 | .0 |
| Total | 14387 | 100.0 |

**Source: Prepared by the researcher based on 2014 MICS data**

From the table above and the figure below, it is clear that the highest educational level for women of reproductive age is primary education, at 37.2%, while the lowest percentage was for secondary, vocational training, and pre-secondary education, at 0.1%.

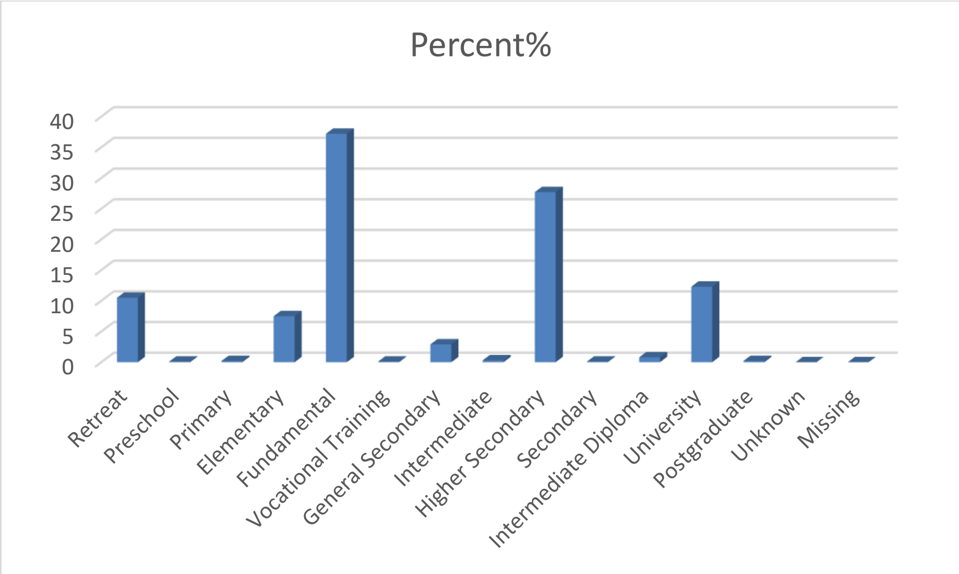



**Figure (3): shows the highest level of education for women of reproductive age.**

**Calculating fertility rates:**

$ASRFx = \frac{B_X}{W_X} * 1000 \rightarrow (10)$

$ASRF$ = Specific fertility rate for the age group

$B_X$ = Live births during the year for women in age group

$W_X$= Number of women in age group

The Multiple Indicator Cluster Survey (MICS) questionnaire included a question about the date of birth for each live birth of any targeted woman in the 15-49 age group. To calculate the number of live births over 12 months, a date variable was created starting from October 2013, since the survey was conducted in October 2014. Therefore, all live births born between October 2013 and the time of the survey for each woman in a specific age group are represented.

**Table (4): Shows specific fertility rates by age**

| Age groups | Number of women | Births | ASFRs |
|---|---|---|---|
| 19 - 15 | 4271 | 234 | 54.788 |
| 24 - 20 | 3557 | 587 | 165.027 |
| 29 - 25 | 3728 | 796 | 213.519 |
| 34 - 30 | 2813 | 578 | 205.475 |
| 39 - 35 | 2739 | 411 | 150.055 |
| 44 - 40 | 1774 | 127 | 71.590 |
| 49 - 45 | 1444 | 28 | 19.391 |
| Total | 20326 | 42 | 879.844 |

**Source: Prepared by the researcher based on 2014 MICS data**

## Total Fertility Rate:

The total fertility rate refers to the average number of live births a woman can have and is calculated as follows:

**TFR = 879.844 * 5/1000 = 4.4**

**In Sudan, the average number of live children a woman gives birth to during her reproductive lifetime is 4 children.**

**Exploratory Factor Analysis of Variables Affecting Total Fertility Rate:**

In this section, factor analysis is performed using principal component analysis and Varimax rotation. in Appendix shows the correlation matrix for the variables affecting fertility. The purpose of the correlation matrix is to provide insight into the structure of the factor through the correlational relationships between a set of variables. If a group of variables is highly correlated, this indicates that these variables constitute a specific component of the factor analysis. The correlation matrix shows a strong correlation between maternal age, paternal age, breastfeeding, and age at first marriage. Age at first marriage is associated with only one variable, university education, which indicates the limited contribution of this variable to fertility. In the Kordofan states, the correlation is associated with the variables of wealth, sanitation, and cooking fuel.

Table (5): Shows the Kaiser-Mayer-Olkin test for the adequacy of sample size for analyzing factors affecting the total fertility rate:

| KMO | DF | Sig |
|---|---|---|
| **0.206** | **666** | **0.000** |

**Source: Prepared by the researcher based on 2014 MICS data**

We notice from the previous table that the KMO value is 0.206, since the p-value is less than 0.05, we reject the null hypothesis which states that the sample is insufficient for factor analysis. This means that the sample is more than sufficient, as the sample size used here was 11,701 women who had at least one child.

**Table (6): Shows the Communalities**

| Communalities | | |
|---|---|---|
| | Initial | Extraction |
| Age of woman | 1.000 | .830 |
| Age at first union | 1.000 | .495 |
| Age of husband | 1.000 | .781 |
| Northern region | 1.000 | .686 |
| Eastern region | 1.000 | .908 |
| Khartoum region | 1.000 | .554 |
| Central south eastern region | 1.000 | .816 |
| Kordufan | 1.000 | .899 |
| Darfur region | 1.000 | .844 |
| MEAN(Walth,2) | 1.000 | .798 |
| Child still being breastfed | 1.000 | .405 |
| Illiterate | 1.000 | .851 |
| Khalwa and pre-school | 1.000 | .784 |
| Basic | 1.000 | .950 |
| Secondary | 1.000 | .841 |
| Intermediate diploma | 1.000 | .906 |
| University + | 1.000 | .833 |
| Current use of family planning | 1.000 | .635 |
| Ever use of family planning | 1.000 | .694 |
| Ever circumcised | 1.000 | .419 |
| Source of drinking water | 1.000 | .340 |
| Sanitation | **1.000** | **.554** |
| Material of floor | **1.000** | **.793** |
| Material of roof | **1.000** | **.778** |
| Fuel cooking | **1.000** | **.730** |
| Area | **1.000** | **.624** |
| Extraction Method: Principal Component Analysis. | | |

**Source: Prepared by the researcher based on 2014 MICS data**

The correlation coefficients indicate the degree of correlation between a variable and the extracted factors. The coefficient value ranges from 0 to 1, and the closer the coefficient is to 1, the more significant the variable and the stronger its correlation with the factors. It is noted that basic education had the highest correlation value, indicating that it is one of the most important factors affecting fertility in Sudan, with a value of 0.95. This was followed by the Eastern Region, intermediate diploma, Kordofan Region, women's age, Central and Southern Regions, Darfur Region, illiteracy, secondary education, and university education and above, all of which had high correlation coefficients above 0.80. Next came the wealth index as a measure of economic status, followed by Quranic school education and literacy. Generally, education is observed to be one of the most important variables with a strong correlation with the factors. This was followed by the type of flooring material and the husband's age. The Northern Region, previous use of family planning methods, type of roofing material, and type of cooking fuel had correlation coefficients between 0.60 and 0.78. Age at first marriage, national capital, and type of sanitation have a social security rating between 0.50 and 0.60.

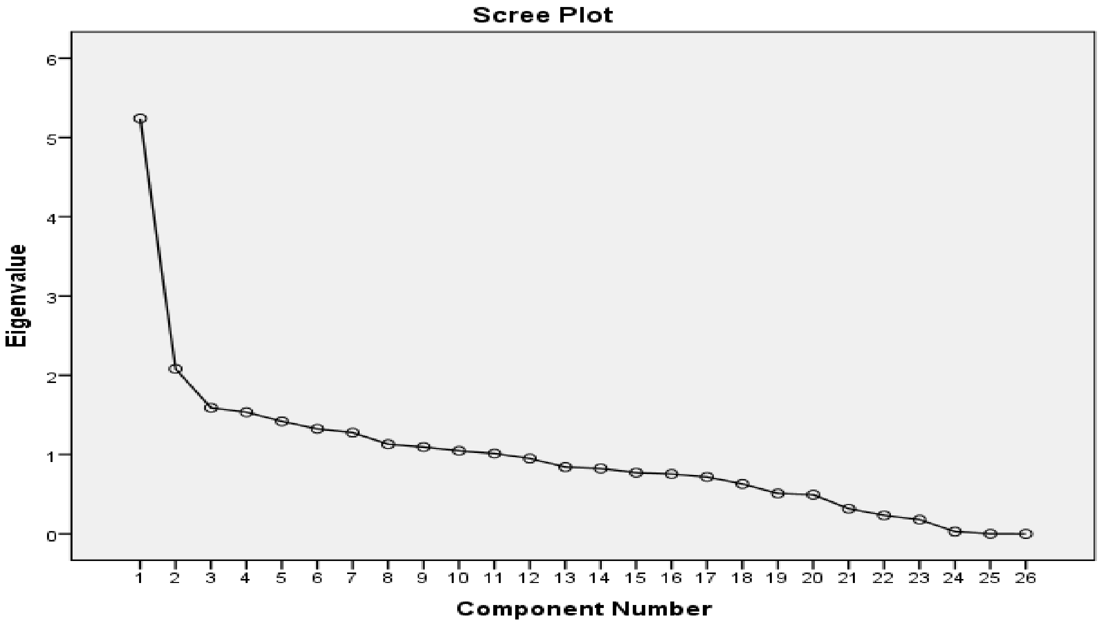
**Table (7): Shows the total explained variance**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative% | Total | % of Varian e | Cumulative % |
| 1 | 5.239 | 20.152 | 20.152 | 5.239 | 20.152 | 20.152 | 3.129 | 12.036 | **12.036** |
| 2 | 2.080 | 8.002 | 28.153 | 2.080 | 8.002 | 28.153 | 2.075 | 7.981 | **20.017** |
| 3 | 1.590 | 6.114 | 34.267 | 1.590 | 6.114 | 34.267 | 1.940 | 7.463 | **27.480** |
| 4 | 1.534 | 5.900 | 40.167 | 1.534 | 5.900 | 40.167 | 1.835 | 7.058 | **34.539** |
| 5 | 1.419 | 5.457 | 45.624 | 1.419 | 5.457 | 45.624 | 1.802 | 6.931 | **41.469** |
| 6 | 1.323 | 5.090 | 50.715 | 1.323 | 5.090 | 50.715 | 1.744 | 6.709 | **48.179** |
| 7 | 1.276 | 4.909 | 55.623 | 1.276 | 4.909 | 55.623 | 1.444 | 5.554 | **53.732** |
| 8 | 1.130 | 4.346 | 59.970 | 1.130 | 4.346 | 59.970 | 1.297 | 4.989 | **58.721** |
| 9 | 1.095 | 4.210 | 64.179 | 1.095 | 4.210 | 64.179 | 1.282 | 4.931 | **63.652** |
| 10 | 1.047 | 4.026 | 68.206 | 1.047 | 4.026 | 68.206 | 1.132 | 4.356 | **68.008** |
| 11 | 1.013 | 3.895 | 72.101 | 1.013 | 3.895 | 72.101 | 1.064 | 4.093 | **72.101** |
| 12 | .950 | 3.652 | 75.753 | | | | | | |
| 13 | .842 | 3.239 | 78.992 | | | | | | |
| 14 | .825 | 3.172 | 82.164 | | | | | | |
| 15 | .772 | 2.969 | 85.133 | | | | | | |
| 16 | .755 | 2.904 | 88.037 | | | | | | |
| 17 | .718 | 2.760 | 90.798 | | | | | | |
| 18 | .629 | 2.420 | 93.218 | | | | | | |
| 19 | .509 | 1.959 | 95.177 | | | | | | |
| 20 | .495 | 1.902 | 97.079 | | | | | | |
| 21 | .317 | 1.221 | 98.300 | | | | | | |
| 22 | .233 | .897 | 99.197 | | | | | | |
| 23 | .179 | .690 | 99.887 | | | | | | |
| 24 | .029 | .111 | 99.998 | | | | | | |
| 25 | .001 | .002 | 100.000 | | | | | | |
| 26 | 2.559 E-15 | | 100.000 | | | | | | |

**Source: Prepared by the researcher based on 2014 MICS data**

The first column in the table of total variance explains the eigenvalues of each component or factor extracted using the principal component method. The higher the eigenvalue of a factor, the greater its significance and the more it explains the total variance. Factors or components with eigenvalues greater than one are considered. Therefore, we see that 11 factors or components were extracted as fertility factors in Sudan. The last three columns provide the eigenvalues, the percentage explaining the factor, and the cumulative percentage. We observe that the first factor alone explained 12% of the total variance, followed by the second factor with an explanation rate of 7.98%, and so on. Thus, the 11 extracted factors collectively explain 72.1% of the total variance, which is a high explanation rate.

**Figure (4): shows the eigenvalues of the factors.**




It is observed from the figure above that the first eleven factors all had eigenvalues greater than one, and the second factor and above had eigenvalues less than one, which confirms the importance of the factors that were found, compared to the rest of the other factors.

Factor rotation:

The axes of the components are rotated while maintaining the perpendicularity between them, as this type is characterized by independence. One of the most commonly used methods for rotating the axes is Varimax, or what is sometimes known as the method of greater variance, which maintains the independence between the factors in a way that makes the variance of the saturation degrees of each factor as great as possible.

**Table (9): Shows the factor saturations after rotation**

| | Component | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age of woman | | .894 | | | | | | | | | |
| Age at first union | | | | | | .638 | | | | | |
| Age of husband | | .876 | | | | | | | | | |
| Kordufan region | | | | .314 | .482 | .365 | | | | | |
| Eastern region | | | | | | | | .935 | | | |
| Khartoum region | | | .717 | | | | | | | | |
| Central south eastern region | .777 | | | | | | | | | | |
| Kordufan | | | | | | | | | .908 | | |
| Darfur region | -.607- | | | | | | | -.468- | -.452- | | |
| MEAN(Walth,2) | .441 | | .373 | | .415 | .360 | | | | | |
| Child still being breastfed | | -.608- | | | | | | | | | |
| Iiilterate | | | | -.796- | | | | | | | |
| Khalwa and pre-school | | | | | | | -.840- | | | | |
| Basic | | | | .857 | -.307- | | | | | | |
| Secondary | | | | | .872 | | | | | | |
| Intermediate diploma | | | | | | | | | | | .944 |
| University + | | | | | | .839 | | | | | |
| Current use of family Planning | | | | | | | | | | -.685- | |
| Ever use of family planning | | | | | | | | | | .784 | |
| Ever circumcised | | | | | | | .599 | | | | |
| Source of drinking water | | | | | | | | | .378 | | |
| Sanitation | .317 | | .378 | | .362 | | | | | | |
| Material of floor | .800 | | .307 | | | | | | | | |
| Material of roof | .791 | | .312 | | | | | | | | |
| fuel cooking | .587 | | | | .304 | | | | | | |
| Area | | | .743 | | | | | | | | |

**Source: Prepared by the researcher based on 2014 MICS data**

After rotating the axes, 11 factors or components were extracted to explain the variables affecting fertility in Sudan. The first factor included the following variables: the Central-Southern Region, the

Darfur Region, the MEAN(Walth,2), Sanitation, the type of roofing and flooring materials, and the cooking fuel used in the home. The highest saturation level was for the type of flooring material, followed by the type of roofing material, then the Central-Southern Region, and finally the wealth index, with a saturation level of 0.441. Therefore, the first factor can be called the economic factor of the household in which the woman lives. Although there are two geographical variables, the Central-Southern Region and Darfur, they relate to specific economic conditions. In the states of the Central-Southern Region, economic activity is primarily based on agriculture, while in the Darfur Region, it is based on livestock. Its equation is written as follows:

$$f_1 = 0.777x_7 + 0.607x_9 + 0.80x_{23} + 0.791x_{24} + 0.537x_{25}$$

The second factor included: the mother's age with the highest saturation level of 0.894, followed immediately by the husband's age with a saturation level of 0.87, and breastfeeding. This factor is called the woman's demographic characteristics (1), and it is written as follows:

$$f_2 = 0.894x_1 + 0.876x_3 - 0.608x_{11}$$

The third factor consists of variables, Khartoum State, type of sanitation, and type of area (urban/rural), which expresses the lifestyle, and its equation is as follows:

$$f_3 = 0.717x_6 + 0.372x_{22} + 0.743x_{26}$$

The fourth factor is formed by the variables: educational level (illiteracy, basic education, or low education). The equation is written as follows:

$$f_4 = 0.796x_{12} + 0.857x_{14}$$

The fifth factor is from the Kordofan region, secondary education, and its equation is as follows:

$$f_5 = 0.482x_4 + 0.872x_{15}$$

The sixth factor, encompassing age at first marriage, current employment, and university education or higher, can be termed a mediating factor. The equation is written as follows:

$$f_6 = 0.638x_2 + 0.839x_{17}$$

The seventh factor, consisting of seclusion and pre-school education and female circumcision, can be called a social factor.

$$f_7 = 0.84x_{13} + 0.599x_{20}$$

The eighth factor included one variable, the Eastern Region, with a very high saturation level reaching 0.935. The median diploma is a factor of intermediate education, and the equation is as follows:

$$f_8 = 0.935x_5$$

The ninth factor included the Kordofan region and drinking water sources, and since the Kordofan states have some drinking water shortage problems due to certain environmental conditions, it can be called the environmental factor, and its equation is.

$$f_9 = 0.908x_8 + 0.378x_{21}$$

The tenth factor includes two variables: past and present use of family planning methods, and can be called family planning, and its equation is:

$$f_{10} = 0.685x_{18} + 0.784x_{19}$$

The eleventh factor included one variable, which is the level of intermediate diploma education, and it can be called mediating factor 2, and it is as follows:

$$f_{11} = 0.944x_1$$

## 11: Results and Recommendations

### 11-1: Results

•The average number of children a Sudanese woman has during her reproductive period is about 4 children.

•The main demographic factors affecting the total fertility rate in Sudan are the mother's age, the father's age, breastfeeding, and the use of family planning methods.

•The main social factors affecting the total fertility rate in Sudan are the mother's level of education and female circumcision.

• The main economic factors affecting the total fertility rate in Sudan are wealth index, type of roofing and flooring materials, type of cooking fuel used in the household, and source of drinking water.

•The main environmental factors affecting the total fertility rate in Sudan are the type of sanitation and the type of area (urban/rural).

### 11-2: Recommendations

• It is essential to develop future plans related to childcare and maternal health, as our societies have high fertility rates, and this will positively impact fertility rates.

• Attention should be paid to the needs of the community, and strategies should be developed specifically for education and health. • Encouraging organizations and activities that support the idea of providing women with comprehensive education, given its significant benefits for women and its role in maintaining stable or relatively low fertility rates.

• Raising community awareness and guiding them towards better practices by promoting suitable lifestyles that address the negative impact on fertility rates resulting from unhealthy lifestyles.

• Re-evaluating family planning methods and aligning them with the overall population plan and fertility rate objectives.

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# Appendix

ملحق (2)

| | Age of woman | Age at first union | Age of husband | Kordufan region | Eastern region | Khartoum region | Central south eastern region | Kordufan | Darfur region | Wealth | Child still being breastfed | Illiterate | Khalwa and pre-school | Basic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age of woman | 1.000 | .261 | .746 | .106 | -.012 | .045 | .015 | -.049 | -.061 | .191 | -.367 | .079 | .003 | -.070 |
| Age at first union | .261 | 1.000 | .117 | .170 | -.044 | .088 | .033 | -.050 | -.117 | .281 | -.028 | -.181 | -.095 | -.058 |
| Age of husband | .746 | .117 | 1.000 | .056 | -.031 | .031 | .033 | -.039 | -.028 | .127 | -.312 | .098 | .011 | -.059 |
| Kordufan region | .106 | .170 | .056 | 1.000 | -.148 | -.085 | -.193 | -.153 | -.210 | .428 | -.052 | -.177 | -.093 | .073 |
| Eastem region | -.012 | -.044 | -.031 | -.148 | 1.000 | -.108 | -.244 | -.193 | -.265 | -.075 | -.044 | .000 | .171 | -.047 |
| Khartoum region | .045 | .088 | .031 | -.085 | -.108 | 1.000 | -.140 | -.111 | -.152 | .283 | -.023 | -.139 | -.036 | .020 |
| Central south eastem region | .015 | .033 | .033 | -.193 | -.244 | -.140 | 1.000 | -.251 | -.345 | .107 | .011 | -.079 | .019 | .048 |
| Kordufan | -.049 | -.050 | -.039 | -.153 | -.193 | -.111 | -.251 | 1.000 | -.272 | -.191 | .033 | .106 | -.109 | .025 |
| Darfur region | -.061 | -.117 | -.028 | -.210 | -.265 | -.152 | -.345 | -.272 | 1.000 | -.327 | .045 | .183 | .016 | -.090 |
| MEAN(Walth,2) | .191 | .281 | .127 | .428 | -.075 | .283 | .107 | -.191 | -.327 | 1.000 | -.110 | -.424 | -.136 | .102 |
| Child still being breastfed | -.367 | -.028 | -.312 | -.052 | -.044 | -.023 | .011 | .033 | .045 | -.110 | 1.000 | -.006 | -.012 | .011 |
| Illiterate | .079 | -.181 | .098 | -.177 | .000 | -.139 | -.079 | .106 | .183 | -.424 | -.006 | 1.000 | -.239 | -.547 |
| Khalwa and pre-school | .003 | -.095 | .011 | -.093 | .171 | -.036 | .019 | -.109 | .016 | -.136 | -.012 | -.239 | 1.000 | -.235 |
| Basic | -.070 | -.058 | -.059 | .073 | -.047 | .020 | .048 | .025 | -.090 | .102 | .011 | -.547 | -.235 | 1.000 |
| Secondary | -.027 | .194 | -.042 | .151 | -.042 | .095 | .005 | -.047 | -.085 | .333 | -.001 | -.300 | -.129 | -.296 |
| Intermedaite diploma | .006 | .097 | -.012 | .038 | -.023 | .085 | .006 | -.030 | -.032 | .112 | -.001 | -.056 | -.024 | -.055 |
| University + | .016 | .296 | -.026 | .098 | -.046 | .125 | .032 | -.056 | -.078 | .312 | .008 | -.179 | -.077 | -.176 |
| Current use of family planning | -.024 | .098 | -.039 | .128 | -.047 | .133 | .028 | -.020 | -.130 | .278 | .048 | -.185 | -.086 | .053 |
| Ever use of family planning | .066 | .077 | .033 | .159 | -.034 | .026 | .040 | -.027 | -.111 | .228 | -.059 | -.132 | -.060 | .059 |
| Ever circumcised | .058 | .053 | .022 | .108 | -.007 | .033 | -.054 | .086 | -.106 | .145 | -.038 | -.084 | -.211 | .115 |
| Source of drinking water | .082 | .128 | .052 | .110 | -.017 | .103 | .066 | .057 | -.226 | .301 | -.058 | -.210 | -.031 | .088 |
| Sanitation | .132 | .215 | .095 | .315 | -.077 | .261 | .042 | -.138 | -.216 | .677 | -.071 | -.316 | -.068 | .062 |
| Material of floor | .101 | .196 | .068 | .196 | -.102 | .231 | .326 | -.112 | -.392 | .556 | -.056 | -.322 | -.068 | .095 |
| Material of roof | .101 | .197 | .065 | .188 | -.081 | .231 | .310 | -.116 | -.386 | .549 | -.056 | -.320 | -.067 | .095 |
| fuelcooking | .122 | .247 | .077 | .323 | .029 | .274 | .250 | -.222 | -.445 | .748 | -.079 | -.397 | -.134 | .140 |
| Area | .095 | .143 | .061 | -.034 | .031 | .275 | -.067 | -.022 | -.064 | .459 | -.062 | -.226 | -.043 | .041 |