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Application of Hierarchical Clustering Technique for the Assessment of Maternal Mortality and Indicators in Nigeria

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ABSTRACT

In many nations, maternal mortality is still the greatest risk factor for women of reproductive age and is still a significant public health concern, particularly in developing nations. The study of maternal motility has become a concern with regard to this reason, and the adopted Sustainable Development Goal (SDG), which aims to significantly reduce the number of deaths to 70 per 100,000 live births by 2030. The objective of this research was to assess the factors responsible for maternal death using multivariate statistical techniques. Data on variables of interest from the 36 states and the federal capital territory have been extracted from the annual abstract of statistics of the NBS and NDHS, among other recent published sources. Cluster analysis (CA) and correlation analysis were applied to the datasets. Hierarchical cluster analysis using the ward method and squared Euclidean distance grouped 37 states into three groups using (Dlink/Dmax) x100<25, with cluster 3 having the highest prevalence, cluster 1 having a moderate prevalence, and cluster 2 having a lesser prevalence, with PPHPS and LTRPS as the important variables. Likewise, the correlation analysis revealed that the variables PPHPS and PWNPS, with a correlation value of 0.829, and PWNPS and PRPS, with a correlation value of 0.711, are the most related factors contributing to the high maternal motility in Nigeria.

1. INTRODUCTION

Globally, over the first five years of the SDG era (2016–2020), there has been little progress in lowering maternal mortality, despite earlier accomplishments during the MDG era [7-25]. About 800 maternal deaths per day, or almost one every two minutes, were predicted to occur worldwide in 2020 due to maternal causes, accounting for 287 000 deaths overall. The

predicted number of maternal deaths in 2000 was 446 000, which is more than a third lower than that figure [25]. Maternal mortality remains a phenomenon that affects African women of reproductive age in many nations and continues to be a severe public health concern, particularly in poorer nations where the estimated death rate is 542 per 100,000 live births [14]. Pregnancy, childbirth, and the postpartum period pose significant risks to women's health and survival, particularly in low- and middle-income nations where 99% of maternal fatalities take place [1]. The target of having a global maternal mortality ratio (MMR) of 70 deaths per 100,000 live births is still unattainable by the halfway point of 2030, with 223 deaths per 100,000 live births recorded in 2020 [17]. Lowering the rate of maternal deaths worldwide to less than 70 per 100,000 live births by the year 2030 is one of the sustainable development objectives, and it is critically needed to improve maternal health [10].

For many nations that still fight to prevent it, this issue persists. Maternal mortality rose to prominence on the international scene due to the more than 500,000 annual deaths of mothers; as a result, it was selected as the primary outcome to gauge improvements in maternal health [16]. Nevertheless, 810 maternal deaths are thought to occur worldwide every day [21]. Maternal mortality has a negative impact on communities, families, and women. The recently enacted SDG 3, which seeks to considerably decrease the amount of mortality to 70 per 100,000 live births by 2030, and the MDG 5, which attempts to lower the burden of maternal death by 75% by 2015, have prompted the implementation of strategies designed to reduce the global impact of maternal mortality [14]. Over the past three decades, a number of nations have decreased their rates of maternal mortality and helped to lower the overall number of maternal fatalities worldwide. Maternal mortality rates, however, have mostly plateaued in sub-Saharan Africa, where more than half of all maternal fatalities occur. Some of the main causes of maternal death in this area are obstructed labor, infection, hemorrhage, and abortions [12], and other factors like hypertension [1]. While some countries in Sub-Saharan Africa have met their MDG 5 target of reducing maternal deaths [4] to 320/100,000 live births [23], others have either experienced no significant change in their levels of maternal mortality or have seen an increase in their rates even with the implementation of evidence-based interventions. Rwanda, for example, used to have the highest rate of maternal deaths in the world of 2300/100,000 live births in 1995 [3-22]. The nations with the greatest number of MMRs at the end of the MDG era were Burundi, the Central African Republic, and Chad [23].

1.1 Nigerian maternal mortality rate

Maternal mortality has persisted as an issue in several Sub-Saharan African nations, including Nigeria [14]. The nation hasn't made much headway in reducing the number of maternal fatalities [4]. Despite initiatives like encouraging institutional deliveries, providing training, and assigning more qualified healthcare professionals, maternal death rates in Nigeria continue to rise. Additionally, according to [10], it is one of the top six nations in the world that accounts for more than 50% of all maternal deaths worldwide. Nigeria, with an estimated MMR of 840/100,000 live births, has the second-highest number of maternal fatalities (50,000) recorded in 2008 [23].

Similar to several nations in Sub-Saharan Africa, obstetric hemorrhage, eclampsia, sepsis, and consequences resulting from botched abortions are the primary causes of maternal death in Nigeria [13]. Likewise, research indicates that variables including age, education, poverty, nutritional food crime, and social autonomy—all among which have been linked to maternal mortality—are connected to this result in Nigeria. The objective of this research is to determine the important parameters responsible for the prevalence of maternal mortality among the states of Nigeria using cluster analysis.

2. MATERIAL AND METHODS

2.1 Sources of Data and Description

The research primarily employed secondary data from the Nigeria Demographic and Health Survey, the ecology of Nigeria, the National Bureau of Statistics Annual Abstract of Statistics, along with other recently published. In Nigeria, the annual report is a reliable source of statistical data about institutions and agencies. It compiles socioeconomic details and other pertinent Nigerian statistics. It compiles socioeconomic information and other pertinent Nigerian statistics. A national sample study, the Nigeria Demographic and Health study offers current data on fundamental health and demographic variables as well as additional background information about the participants. The National Population Commission deployed the NDHS and put it into operation.

Table 1: Description of data

SN	Variables	Description	Type
1	NOWPS	Nutrition of pregnant women	Integer
2	PRPS	Poverty rate per state	Integer
3	MMRPS	Maternal motility rate per state	Integer
4	LRPS	Literacy rate per state	Integer
5	DOPPS	Density of population per state	Integer

2.2 Agglomerative Hierarchical Clustering

Agglomerative hierarchical clustering is the technique most frequently used to create embedded classification systems [15]. Distinguishing between an implementation, which pertains to the specifics of the algorithm utilized, and a strategy involving a compactness requirement and the intended structure of a 2-way tree reflecting the partial order on subsets of the power set is often helpful. The objects to be classified include numerical measurements on a set of variables or qualities, just like with many other multivariate approaches. As a result, the rows of an array or matrix are the subject of the analysis [15]. In cases where we don't already have a matrix of numerical numbers, we might need to expertly create one. The rows of the matrix, or its objects, can be thought of as vectors in a multidimensional space, where the number of variables, or columns, determines how dimensional the space is.

It is not the only geometric framework in which clustering algorithms may be developed. It is not inconsistent to view the problem in geometric terms (and in matrix terms—for instance, describing the adjacency relations in a graph) with appropriate alternate forms of storing a rectangular array of data. Data analysis, interactive user interfaces, storage and retrieval, and pattern identification are some of the reasons why clustering is generally motivated, including hierarchical clustering and its applications [6].

2.3 Correlation

A statistical technique for assessing the strength of the association between two quantitative variables is correlation analysis [18]. According to [10], a high correlation indicates a strong association between two or more variables, whereas a weak correlation indicates little to no relationship. Stated differently, it refers to the method of examining the degree of the association using the statistical data that is at hand. In this research, the correlation will be used to determine the most common factor that causes or effects the high rate of maternal motility in Nigeria.

3. RESULTS AND DISCUSSION

...3.1 Descriptive Statistics

Descriptive statistics of the respective values for all the collected data of 36 states including capital territory, Abuja are presented in Table 2.

Table 2: Basic statistics of the collected data over 36 states and FCT (Abuja).

Variables	N	Minimum	Maximum	Mean	Std. Deviation
DOPPS	37	2277961.0	44734903.0	6317377.19	6905261.32
MMRPS	37	1.20	15.00	6.71	3.45
LRPS	37	36.55	84.10	62.06	13.25
NOWPS	37	.50	24.10	8.35	6.79
PRPS	37	.80	8.90	2.71	1.52
PPHPS	37	.00	50.30	14.70	17.34

3.2 Data similarities and State Grouping using Cluster Analysis (CA)

By using a dendrogram with (Dlink/Dmax) × 100 < 25, CA was able to group the 37 sampling states into three statistically significant clusters (cluster 1, cluster 2, and cluster 3). These clusters contained 15, 13, and 9 states, respectively, as represented in Figure 1. Maternal mortality parameters were found to be greater in cluster 3's sampling state classification than in clusters 2 and 1, according to the cluster features listed in Table 3. Conversely, cluster 2's bulk of parameters are far smaller. Consequently, clusters 1 and 2 indicate moderate and low maternal mortality states, cluster 3 and high maternal mortality states, respectively. It is evident that the CA approach is useful in providing a reliable national classification of the factors associated with maternal mortality. By decreasing the number of sample states in the monitoring network, this will assist in developing a future mortality sampling strategy optimally while at the same time keeping the relevance of the results unaffected

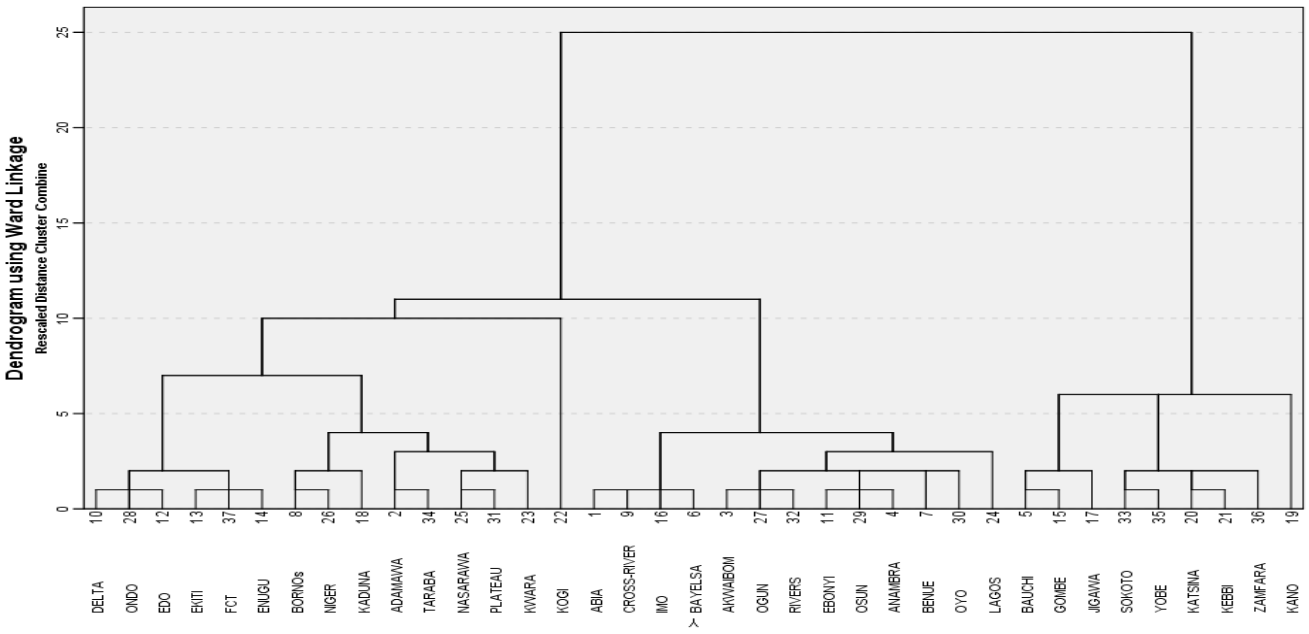

Figure 1: Dendrogram showing sampling states clusters for the collected data.

Table 3: Cluster characteristics using ward's method

Indicators	Cluster 3 (N=9)		Cluster 2 (N=13)		Cluster 1 (N=15)	
	Mean	SD	Mean	SD	Mean	SD
DOPPS	5973150.4	3048466.3	5579323.7	2617200.	7163559.6	10491985.2
MMRPS	8.5200	4.49583	3.9462	1.97384	7.6667	2.13113
LRPS	46.7344	5.69313	75.0192	5.87376	60.0200	9.59144
PWNPS	18.9333	3.35000	4.2538	1.78401	5.5600	3.67866
PRPS	3.8111	2.04722	2.4769	1.05210	2.2467	1.23223
PPHPS	41.1444	8.32002	3.0000	5.39011	8.9667	9.83635

3.3 Correlation

The correlation analysis in this case aimed at obtaining the factors that are related and seem to have a greater contribution to the prevalence of maternal mortality. Therefore, as we can observe from Table 4, the factors that are more likely to be associated with each other are the percentage of poorest households per state (PPHPS) and the percentage of women without nutrition per state (PWNPS), which are the main factors to be considered in eradicating and reducing the high rate of maternal mortality in Nigeria

Table 4: Correlation is significant at the 0.01 level (2-tailed).

	DOPPS	MMRPS	LRPS	PWNPS	PRPS	PPHPS
CC DOPP	1.000	0.180	0.096	0.082	0.711	0.024
Sig. (2-tailed)	.	0.286	0.572	0.630	0.000	0.886
N	37	37	37	37	37	37
CC MMRPS	0.180	1.000	-0.306	0.085	-0.033	0.177
Sig. (2-tailed)	.286	.	0.065	0.616	0.848	0.294
N	37	37	37	37	37	37
CC LRPS	0.096	-0.306	1.000	-0.716	-0.222	-0.741
Sig. (2-tailed)	0.572	0.065	.	0.000	0.186	0.000
N	37	37	37	37	37	37
CC PWNPS	0.082	0.085	-0.716	1.000	0.457	0.829
Sig. (2-tailed)	0.630	0.616	0.000	.	0.004	0.000
N	37	37	37	37	37	37
CC PRPS	0.711	-0.033	-0.222	0.457	1.000	0.418
Sig. (2-tailed)	0.000	0.848	0.186	0.004	.	0.010
N	37	37	37	37	37	37
CC PPHPS	0.024	0.177	-0.741	0.829	0.418	1.000
Sig. (2-tailed)	0.886	0.294	0.000	0.000	0.010	.
N	37	37	37	37	37	37

3.4 Discussion

In the quest to lower maternal mortality in Nigeria, our research indicates that two critical issues must be given top priority: ways to significantly enhance pregnant women's empowerment and nutrition, and ways to supply professional attendants at a reasonable cost who can handle emergencies and complications. These results show a strong correlation between the percentage of the poorest households and a decrease in maternal mortality, which is consistent with other research [19]. Previous research [8] have also demonstrated that maternal mortality is highly impacted by the proportion of pregnant women who lack education and appropriate nutrition. Since the Ministry of Health does not have jurisdiction over women's education, any successful campaign for lowering maternal mortality in Nigeria will need to work closely with groups outside the ministry of health in order to be meaningfully successful. This is a crucial factor to take into account because previous attempts to lower maternal mortality have frequently concentrated mostly on medical measures. The improvement of programs like "Action against Hunger" was shown to be one of the major factors in the study's decrease in maternal mortality. Throughout history, the proportion of births attended by medical professionals has been largely unchanged, even in the face of the government's opposition to funding a standard family program. Therefore, in order to jointly address the issue by raising awareness on television and social media, the government works closely with states—particularly those where the problem is persistent—such as Kano, Zamfara, Kebbi, Katsina, Yobe, Sokoto, Jigawa Gombe, and Bauchi. Meanwhile, other states must consistently block the problem's negative effects on their states.

4. CONCLUSION.

This study was able to categorize Nigeria's states based on how similar or close they were to each other, as well as identify the factors that contribute most to the high rate of high maternal motility in the nation. As a result, government attention and concentration should be directed more toward the observed state. According to this study, one of the primary factors influencing the maternal mortality ratio is the availability of the poorest housewives, who will tend to and supply all the essentials during labor. The lack of nourishment for women, particularly those who give birth, is a significant contributing cause. Only if the government allocates more funds to initiatives like "Action against Hunger" and elevates women's education to a national political priority can the government's goals for reducing maternal mortality be met. There is a network of competent, safe mothers in Nigeria. Nevertheless, political focus is still low on this network, which has not yet fully utilized its potential influence. Considering that MDG Goal 5 was not effectively met, innovative and practical approaches to lowering maternal death rates should be implemented, involving all relevant parties, particularly men who typically make the majority of the decisions in societies that are controlled by males and have strong cultural influences. Wives should be able to attend prenatal clinics, give birth in a hospital, and receive wholesome food from their husbands. Women should go to prenatal clinics, give birth in hospitals, and seek medical attention as soon as possible. Parents must make educational investments for their girls. Instead of bothering patients, medical staff should be more concerned. The government ought to help by offering food programs, empowerment initiatives, and qualified medical personnel; enhancing healthcare infrastructure; and raising public awareness of the value of prenatal care. Health professionals must receive the necessary training and equipment to enable them to practice at their best. Through the media, public officials and community leaders should enlighten, educate, and raise public awareness of maternal health issues. It

is imperative that the health sector receive more support. Pregnant women should not be required to pay user fees; this will also greatly improve matters. It should be a priority to equip basic health facilities with the necessary equipment for obstetric treatment. Above all, especially for women, education needs to be properly funded and prioritized. Proponents of reducing maternal mortality must closely monitor advancements in the field of education, particularly with regard to the growth of the medical and nursing workforces. Given the accelerating approach of 2016, Nigeria appears to be far from meeting the goals established for reducing maternal mortality.

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Ethical Consideration

No any Ethical clearance required before the commencement of these research.

References

[1] Abubakar, I. B. (2019). *Maternal mortality from a human rights perspective: A case study of North-Eastern Nigeria* (Doctoral dissertation, University of Pretoria).

[2] Abubakar, U., Abubakar, A., Sulaiman, A., Ringim, H. I., Salisu, I. A., Osi, A. A., James, I., Sani, A. M., & Haruna, I. S. (2023). Application of Artificial Neural Network For Predicting Hypertension Status And Indicators In Hadejia Metropolitan. *Fudma Journal of Sciences*, *7*(1), 284–289. https://doi.org/10.33003/fjs-2023-0701-2052

[3] Adamu, Y. M., Salihu, H. M., Sathiakumar, N., & Alexander, G. R. (2003). Maternal mortality in Northern Nigeria: a population-based study. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *109*(2), 153-159.

[4] Alkema, L., Chou, D., Hogan, D., Zhang, S., Moller, A. B., Gemmill, A., & Say, L. (2016). Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *The lancet*, *387*(10017), 462-474.

[5] Akinlo, A., Idemudia, E. S., Ogunjuyigbe, P. O., & Solanke, B. L. (2016). Women's empowerment status and exposure to maternal mortality risks in Nigeria. *Gender and Behaviour*, *14*(1), 7085-7099.

[6] Contreras, P., & Murtagh, F. (2015). Hierarchical clustering. *Handbook of cluster analysis*, 103-123.

[7] Cresswell, J., & World Health Organization. (2023). *Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division*. World Health Organization.

[8] Daru, J., Zamora, J., Fernández-Félix, B. M., Vogel, J., Oladapo, O. T., Morisaki, N., & Khan, K. S. (2018). Risk of maternal mortality in women with severe anaemia during pregnancy and postpartum: a multilevel analysis. *The Lancet Global Health*, *6*(5), e548-e554.

[9] Franzese, M., & Iuliano, A. (2018). Correlation analysis. In *Encyclopedia of bioinformatics and computational biology: ABC of bioinformatics* (Vol. 1, pp. 706-721). Elsevier.

[10] Heitkamp A, Meulenbroek A, van Roosmalen J, Gebhardt S, Vollmer L, de Vries JI, Theron G, van den Akker T. Maternal mortality: near-miss events in middle-income countries, a systematic review. Bull World Health Organ. 2021 Oct 1;99(10):693-707F. doi: 10.2471/BLT.21.285945. Epub 2021 Aug 30. PMID: 34621087; PMCID: PMC8477432.

[11] Hogan, M. C., Foreman, K. J., Naghavi, M., Ahn, S. Y., Wang, M., Makela, S. M.,& Murray, C. J. (2010). Maternal mortality for 181 countries, 1980–2008: a systematic analysis of progress towards Millennium Development Goal 5. *The lancet*, *375*(9726), 1609-1623.

[12] Khan, K. S., Wojdyla, D., Say, L., Gülmezoglu, A. M., & Van Look, P. F. (2006). WHO analysis of causes of maternal death: a systematic review. *The lancet*, *367*(9516), 1066-1074.

[13] Mairiga, A. G., & Saleh, W. (2009). Maternal mortality at the state specialist hospital Bauchi, Northern Nigeria. *East African medical journal*, *86*(1).

[14] Meh, C., Thind, A., Ryan, B. *et al.* Levels and determinants of maternal mortality in northern and southern Nigeria. *BMC Pregnancy Childbirth* 19, 417 (2019). https://doi.org/10.1186/s12884-019-2471-8

[15] Murtagh, F., & Contreras, P. (2012). Algorithms for hierarchical clustering: an overview. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *2*(1), 86-97.

[16] Ronsmans, C., & Graham, W. J. (2006). Maternal mortality: who, when, where, and why. *The lancet*, *368*(9542), 1189-1200.

[17] Souza, J. P., Day, L. T., Rezende-Gomes, A. C., Zhang, J., Mori, R., Baguiya, A., & Oladapo, O. T. (2023). A global analysis of the determinants of maternal health and transitions in maternal mortality. *The Lancet Global Health*.

[18] Temizhan, E., Mirtagioglu, H., & Mendes, M. (2022). Which correlation coefficient should be used for investigating relations between quantitative variables. *Acad. Sci. Res. J. Eng. Technol. Sci*, *85*, 265-277.

[19] Titilayo, A., Palamuleni, M. E., & Omisakin, O. (2015). Knowledge of causes of maternal deaths and maternal health seeking behaviour in Nigeria. *African population studies*, *29*(2).

[20] Usman, N. O., Abdullahi, H. M., Nmadu, A. G., Omole, V. N., & Ango, J. T. (2019). Estimation of maternal mortality by sisterhood method in two rural communities in Kaduna State, Nigeria. *Journal of Medicine in the Tropics*, *21*(2), 62-66.

[21] WHO. WHO maternal mortality: WHO. World Health Organization; 2016. Available from: https://www.who.int/en/news-room/fact-sheets/detail/ maternal-mortality. Cited 28 June 2017

[22] World Health Organization. (2007). Maternal mortality in 2005: estimates developed by WHO, UNICEF, UNFPA, and the World Bank.

[23] World Health Organization. (2014). Trends in maternal mortality: 1990 to 2013: estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division: executive summary. *Trends in maternal mortality: 1990 to 2013: estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division: executive summary*.

[24] WHO, U. (2010). UNFPA, the World Bank. Trends in maternal mortality: 1990 to 2008 Estimates developed by WHO, UNICEF. *UNFPA and the World Bank. Geneva: World Health Organization*.

[25] World Health Organization. (2023). Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division: executive summary.