DISCRIMINANT ANALYSIS BETWEEN EXCLUSIVE AND COMPLIMENTARY BREASTFEEDING METHODS OF INFANTS BETWEEN THE AGES OF 23 AND 59 MONTHS IN PLATEAU NORTH SENATORIAL DISTRICTS

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Abstract: This study adopts the Linear Quadratic Discriminant Analysis method in the classification of ordinal dataset problems involving two group cases. The essence was to determine if there are significant differences based on some selected variables between infants that had exclusive breastfeeding and those that had complementary breastfeeding in their first six months of life. The variables chosen to determine this are weight, height, morbidity, and level of activeness of the child. The Discriminant analysis which is a parametric technique to govern which weightings of the selected independent variables are best to discriminate between the two groups shows that 52% of the population studied practice exclusive breastfeeding while 48% practice complementary breastfeeding during the first six months of life of the child. The Wilks' Lambda shows that the most discriminating variable between the two groups is the weight of the child. The height and level of activeness of the child also discriminate between the two groups. It was also observed that the length of time the child was also breastfed has a significant impact ondifferentiating between the two groups. The classification results show the derived Fishers' discriminant function classifies only 59.1% of the cases correctly, this implies that the model is weak in actually discriminating between the two groups, this invariably implies that either the two groups are too closely related based on the selected variables or that a more powerful data mining tool be used to establish the difference between the two groups.

Keywords: Discriminant, exclusive, complimentary, breastfeeding, classification

INTRODUCTION

Proper and adequate nutrition during infancy and early childhood is essential to ensure the growth, health, and development of children to their full potential. Inadequate nutrition leads to malnutrition, and this has been responsible, directly or indirectly, for 60% of the 10.9 million deaths annually among children under five. Quite a number of these deaths, which are often associated with inadequate feeding of the infant, occur during the first year of life. No more than 35% of children worldwide were exclusively breastfed during the first four months of life; complementary feeding frequently begins too early or too late, and feeds are often nutritionally inadequate and unsafe. Malnourished children who survive are more frequently sick and suffer the life-long consequences of impaired development (Maduforo, 2014).

It has been recognised worldwide that proper and adequate breastfeeding is essential for the survival of infants at the early stage of life as breast milk is considered the best source of nutrition for an infant. The World Health Organization (WHO) recommends that infants be exclusively breastfed for the first six months, followed by breastfeeding along with complementary foods for up to two years of age or beyond (Motee and Jeewon, 2014). Exclusive breastfeeding can be defined as a practice whereby the infants receive only breast milk without mixing it with water, other liquids, tea, herbal preparations, or food in the first six months of life, except for vitamins, mineral supplements, or medicines while complementary breastfeeding is the transition from exclusive breastfeeding to family food alongside breast milk which WHO recommends that this should take place from 6-23 months of the infant's life.

Despite the recommendation by WHO to exclusively breastfeed an infant for the first six months of life, this has been difficult to adhere to by so many mothers. Some of the major factors that are responsible for this in adherenceinclude breast problems such as sore nipples or mother's perceptions of producing inadequate milk and societal barriers such as employment, length of maternity leave, inadequate breastfeeding knowledge, lack of familial and societal support, and lack of guidance and encouragement from health care providers (Motee and Jeewon, 2014). Another reason that has been alluded to is that there is no form of difference between children that were exclusively breastfed and those that had complementary feeding in their first 6 months of life. A cohort study of 100 infants in Iran, Khadivzadeh and Parsai (2004) showed that exclusive breastfeeding is superior only to at least the first six months of age of the infants.

This study intends to find out using empirical evidence whether there are perceive differences between infants that were given exclusive breastfeeding and those that had complementary feeding during the first 6 months of life after the supposed period of breastfeeding which is two years. Factors to be considered are such as height, weight, morbidity, and activity level of the child.

The aim of the study is therefore to work is to discriminate between children that were exclusively breastfed and those that had complementary feeding, this would determine if the two groups are distinct or not based on the variables selected for the study.

This study would bring to the fore using the discriminant analysis the significant differences between the two groups based on the selected factors if there is any and thereby providing a basis of emphasis on such factors during the first 6 months of the feeding of the infant. The study would strengthen the body of knowledge on the distinction between infants that had exclusive breastfeeding for the first six months of life and those that were complementarily fed.

REVIEW OF RELATED LITERATURE

Breastfeeding and complementary feeding are very essential for optimal growth, survival, and development of infants during the early stage of life and these also have long-term consequences in later life. Adequate nutrition during infancy and early childhood are fundamental to the development of a child's full potential. The period from birth to two years is very important and critical in the life of the infant. It is a period of growth both health-wise and even behavioural. The consequences of poor nutrition during this period of life could include significant illnesses, delayed mental and physical development, and even death if adequate care is not well taken. Withouta doubt, breastfeeding is seen and recognized as the best feeding option for children at this early stage of life because of its nutritive, protective, psychological, and economic value (Maduboro, 2014)

The complementary feeding period generally from 6-24 months is particularly vulnerable in the lives of children. It is the peak period for growth faltering, deficiency of certain micronutrients, and high prevalence of some childhood illnesses like diarrhoea and respiratory infection. Malnutrition from inadequate breastfeeding and poor complementary feeding practices is a particular risk in this age group of children in resource-poor countries of sub-Saharan Africa and contributes significantly to high child mortalities in this region. Exclusive breastfeeding up to six months of age and breastfeeding up to 12 months was ranked number one, with complementary feeding starting at six months' number three. These two interventions alone were estimated to prevent almost one-fifth of under-five mortality in developing countries (Ogunba, 2006).

Another review also confirmed these benefits of exclusive breastfeeding, revealing that suboptimal breastfeeding during 0-6 months can lead to harmful outcomes. Predominant breastfeeding (breastfeeding plus water) increases the risk of child mortality by 1.48 times as compared to exclusive breastfeeding. Partial breastfeeding (breastmilk plus other kinds of milk or foods) increases child mortality by 2.8 times, as compared to exclusive breastfeeding. The relative risk for the prevalence of diarrhoea is 1.26 and 3.04 for predominant and partial breastfeeding, as compared to exclusive breastfeeding. The relative risk for pneumonia is 1.79 and 2.49 for predominant and partial breastfeeding, as compared to exclusive breastfeeding (Bhutta, 2008, Arun, Faridi, and Dadhich, 2010).

The importance of breastfeeding and complementary feeding was reemphasized by the World Health Assembly (WHA) resolution 545.25 on "Global Strategy for Infant and Young Child Feeding" it emphasized the necessity of exclusive breastfeeding for six months while promoting the timely introduction of adequate, safe, and appropriate complementary feeding together with continued breastfeeding for 2 years and beyond. Breastmilk meets all of an infant's nutritional requirements for the first six months of life and is superior to any substitute. Early infant malnutrition disease and deaths result from the failure of mothers to exclusively breastfeed their babies from birth despite the perceived overwhelming advantages to the infant. The Nigeria Demographic and Health Survey in 2003 reported that the rate of exclusive breastfeeding for six months is still very low in Nigeria, between 15% and 17% (Maduboro, 2014). This still clearly shows that in Nigeria exclusive breastfeeding is still yet to be accepted as an essential weapon for the survival of the infant, this probably could be due to the belief that whether the infant is exclusively breastfed or complementarily fed in the first six months of life, it has no impact on the infant's life. Although Cai, Wardlaw& Brown (2012) reported that the rate of exclusive breastfeeding in sub-Saharan Africa has increased tremendously from about 12% to 28%, this still shows that it is yet to be accepted as a norm for infant feeding in this region which Nigeria is inclusive.

Uchenna (2012) opined that in Nigeria, breastfeeding is a maternal option that involves a complex interaction of cultural, religious, socio-economic, psychological factors, and many more. The extended family system is practiced with much consideration to the culture and antecedents of the predecessors. These social practices have had a lot of influence on the practice of breastfeeding and especially exclusive breastfeeding (Uchendu, 2009). One of such practices is that children are taken away quickly from their mothers immediately after birth believing that the first milk or colostrum from the mother's breast is toxic. When the clear milk finally comes, then the mother begins to breastfeed the child. She also often gives the child water or other fluids to drink. Often as early as four months of age, many women start to give other foods to their baby also.

This study is out to show with clear empirical evidence using discriminant analysis if there is adistinction between children who have been exclusively breastfed for the first six months of their life with only breast milk and those that had complementary feeding during the same period.A similar empirical study carried out by Raheel and Tharka (2018) used multivariate logistic regression analysis to show factors that are associated with why women stop feeding their infants before the recommended 6 months of exclusive breastfeeding and to assess the mothers' knowledge regarding the importance and benefits of breastfeeding. A cross-sectional study was conducted in two cities of Riyadh and Dammam using a structured questionnaire.

MATERIALS AND METHODS

Discriminant Analysis

Discriminant analysis is a statistical technique that is useful in the investigation of various aspects of a multi-variate research problem. The multiphasic character of discriminant analysis is (a) the establishment of significant group-differences, (b) the study and 'explanation' of these differences, and finally (c) the utilization of multivariate information from the samples studied in classifying a future individual known to belong to one of the groups represented. Essentially these same three problems are related to discriminatory analysis. Originally developed in 1936 by R.A. Fisher, Discriminant Analysis is a classic method of classification that has stood the test of time. Discriminant analysis often produces models whose accuracy approaches (and occasionally exceeds) more complex modern methods. Discriminant analysis can be used only for classification (i.e., with a categorical target variable), not for regression. The target variable may have two or more categorical data. The objective of discriminant analysis is to classify objects, by a set of independent variables, into one of two or more mutually exclusive and exhaustive categories (Johnson and Wichern, 2007).

Given a set of p independent variables, the technique attempt to derive a linear combination of these variables which best separates or discriminates the groups. The functions are generated from a sample of cases for which group membership is known; the functions can then be applied to new cases with measurements for the predictor variables, but unknown group membership.

The procedure automatically chooses a first function that will separate the groups as much as possible, it then chooses the second function that is both uncorrelated with the first function and provides as much further separation as possible. The procedure continues adding functions in this way until reaching the maximum number of functions as determined by the number of predictors and groups in the dependent variable. In two group discriminant functions, there is only one discriminant function. The discriminant score obtained from the discriminant function is used to classify the dependent variable into one of the two or more groups (Balogun, Akingbade, and Oguntunde, 2015)

For classificatory discriminant analysis, Fisher's Discriminant function is generally used. Fisher's idea was to transform the multivariate $\boldsymbol{x}$ to univariate observations $\boldsymbol{y}$ such that the y's derived from the populations were separated as much as possible. Fisher's approach assumes that the populations are normal and also assumes the population covariance matrices are equal because a pooled estimate of a common covariance matrix is used.

A fixed linear combination of the $\boldsymbol{x}$'s takes the values $y_{11}, y_{12}, \ldots, y_{1n_1}$ for the observations from the first population and the values $y_{21}, y_{22}, \ldots, y_{2n_2}$ for the observations from the second population and so on. The separation of these sets of univariate y's is assessed in terms of the differences between the y expressed in standard deviation units. That is,

$$\text{separation} = \frac{|\bar{y}_1 - \bar{y}_2|}{s_y},$$

$$\text{where } W = \frac{\sum_{j=1}^{n_1}(y_{1j}-\bar{y}_1)^2 + \sum_{j=1}^{n_2}(y_{2j}-\bar{y}_2)^2}{n_1+n_2-2}$$

is the pooled estimate of the variance. The objective is to select the linear combination of the $\boldsymbol{x}$ to achieve maximum separation of the sample means $\bar{y}_i$. This result in the linear combination $y = \hat{\boldsymbol{l}}'\boldsymbol{x} = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}\boldsymbol{x}$ which maximizes the ratio

$$\frac{(Squared\ distance\ between\ sample\ mean\ of\ y)}{(Sample\ variance\ of\ y)} = \frac{(\bar{y}_1 - \bar{y}_2)^2}{S_y^2}$$

$$= \frac{(\hat{\boldsymbol{l}}'\bar{x}_1 - \hat{\boldsymbol{l}}'\bar{x}_2)^2}{\hat{\boldsymbol{l}}'\boldsymbol{S}_{pooled}\hat{\boldsymbol{l}}'}$$

The maximum of the above ratio is $\boldsymbol{D}^2 = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}(\bar{x}_1 - \bar{x}_2)$, the Mahalanobis distance.

If we assume the populations are multivariate normal with a common covariance matrix, then a test of $\boldsymbol{H}_o$: $\mu_1 = \mu_2$ versus $\boldsymbol{H}_1$: $\mu_1 \neq \mu_2$ is accomplished by referring $\frac{n_1+n_2-p-1}{(n_1+n_2-2)p}\left(\frac{n_1 n_2}{n_1+n_2}\right)\boldsymbol{D}^2$ to an F-distribution with $v_1 = p$ and $v_2 = n_1+n_2-p-1$ degrees of freedom. If $\boldsymbol{H_o}$ is rejected we conclude the separation between the two populations is significant (Johnson and Wichern, 2007).

The discriminant function is a weighted average of the values of the independent variables. The weights are selected so that the resulting weighted average separates the observations into groups. High values of the average come from one group, low values of the average come from another group. The problem reduces to one of finding the weights which, when applied to the data, best discriminate among groups according to some criterion. The solution reduces to finding the eigenvectors, V, of S_W^{-1}, S_A. Where S_W and S_A are the sum of squares for within groups and error respectively. The canonical coefficients are the elements of these eigenvectors.

A goodness-of-fit parameter, Wilks' lambda Λ, is given as follows (Todorov, and Filzmosor, 2007) :

$$\Lambda = \frac{|S_W|}{|S_A|} = \prod_{j=1}^{m} \frac{1}{1+\lambda_j}$$

where λ_j is the jth eigenvalue corresponding to the eigenvector described above and m is the minimum of $K-1$ and p, K is the number of groups and p is the number of variables measured on each observation.

The canonical correlation between the jth discriminant function and the independent variables is given by:

$$r_{cj} = \sqrt{\frac{\lambda_j}{1+\lambda_j}}$$

The overall covariance matrix, T, is given by:

$$T = \left(\frac{1}{N-1}\right)S_T$$

The within-group covariance matrix, W, is given by:

$$W = \left(\frac{1}{N-K}\right)S_W$$

The among-group (or between-group) covariance matrix, A, is given by:

$$A = \left(\frac{1}{K-1}\right) S_A$$

The linear discriminant functions are given by:

$$y = \hat{\boldsymbol{l}}'\boldsymbol{x} = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}\boldsymbol{x}$$

The standardized canonical coefficients are given by:

$$v_{ij}\sqrt{w_{ij}}$$

where v_{ij} are the elements of V and w_{ij} are the elements of W.

The correlations between the independent variables and the canonical variates are given by:

$$Corr_{jk} = \frac{1}{\sqrt{w_{jj}}}\sum_{i=1}^{p} v_{ik}\, w_{ji}$$

For this work, the discriminant analysis was used to classify the two methods of breastfeeding into groups of those infants who were exclusively breastfed for the first six months of life of the infant and those who were complementarily fed. This classification was done based on the factors such as height, weight, morbidity, and activity level of these children and other related factors. The analysis was carried out with the aid of Statgraphics and SPSS version 25 statistical packages.

Study Design

The cross-sectional design was used in this study, where children within ages 23 to 59 months were identified at a single time. The design aimed at determining the effect the different method of breastfeeding has had on these children who are between same age brackets.

The study area was Plateau North Senatorial district of Plateau State in Nigeria, the study area comprises six local government areas; Jos North, Jos South, Barkin Ladi. Jos East, Bassa, and Riyom.

Sampling Technique and Sample Size

Purposive sampling was used to select the children between the ages of 23 to 59 months in the selected local government areas. The objective is to choose a group of participants who possess the characteristics of the population of interest so that the study results can be generalized. And to do this effectively, kindergarten schools were identified in the selected areas, there children within the desired age bracket for the study were identified and administered a structured questionnaire which was in two sections, one part filled in the school and then taken home to the mother for the other part to be filled. A total of 2000questionnaires were with the aid of field assistants administered proportionally to the six local government areas. Out of the total administered 1358 were adequately filled and returned.

RESULTS

Of the total number of the 1358 questionnaires that were returned, 708 of them which represent 52% practiced exclusive breastfeeding while 48% practiced complementary breastfeeding, this still shows that a large number of people in this area of the world still do not practice exclusive breastfeeding probably due to one reason or the other which could be attributed to belief, employment status of the mother, knowledge of breastfeeding to mention a few. Of those that breastfed their baby using the exclusive method of feeding, 50% fed the babies with breast milk for a year or less, which means after six months of exclusive breastfeeding of the infants, they fed the baby for just another six months or less. Of the 48% that practiced complementary breastfeeding, 61% of them fed their babies for more than a year, this is possibly to compensate for the fact that they did not practice exclusive breastfeeding. Of the number that practiced exclusive breastfeeding, 19% say their children hardly fall sick, 78% say they fall sick once in a while and 3% say they fall sick frequently. For those that practiced complementary breastfeeding, 75% say they fall sick once in a while and 22% say they hardly fall sick. This figure shows that there is hardly any significant difference in the morbidity between the two groups. So we can say infant morbidity and method of breastfeeding have little or no association. This result is almost the same with the level of activity of the child, 90% of those that practiced exclusively says the children are active while it is 87% for those that practiced complementary breastfeeding.

The discriminant analysis assessed the study using the canonical discriminant function coefficients, Wilks' Lambda, and an associated chi-square and the percentage of the methods of breastfeeding that were correctly classified into the group. In testing the classification performances of the discriminant function, we use the overall hit ratio which is the same thing as the percentage of the original group cases correctly classified. Also the greater the magnitude of the coefficients in the standardized discriminant function, the greater the impact of the variable as an identifying variable. However, to test the significance of the discriminant function as a whole the Wilks' Lambda was used. The smaller the Wilk's lambda the more important is the variable in the discriminating function. The ANOVA table for the discriminant function score is another overall test of the discriminant analysis model. It is an F test, where a 'sig.' p-value < .05 means the model differentiates between the groups significantly better than chance.

Table 1: Test of equality of group means

Variables	Wilks' Lambda	F	P-value
How many under-five children do you presently have?	1.000	0.129	0.719
Height of the child	0.995	6.519	0.011
Weight of the child	0.972	38.927	0.000
What is the birth order of your child?	0.998	3.109	0.078
For how long did you feed your child with breast milk?	0.983	23.714	0.000
Sex of the child	0.999	1.602	0.206
How would you classify this child?	0.997	3.522	0.061
How often does your child fall sick in a year?	0.999	0.875	0.350

Table 1 shows the test of equality of means, this test is usuallyassessed using the Wilks Lambda, the statistic takes on values between 0 and 1, if it is 0 it means the variable completely discriminates, but if it is 1, it does not discriminate at all. Here it is discovered that the most discriminating variable between the two groups is the weight of the child, which implies that this variable is very important in discriminating between the two groups. Others that are significant alongside weight because they have a p-value<0.05 are the length of time the baby was fed with breast milk (0.983), the height of the child ((0.995), and close to it is the level of activeness of the child (0.997) and the birth order (0.998), but the discrimination of this variables are not significant. The worst variable in the discrimination model isthe number of under-five children the mother has presently (1.000) and the morbidity of the child (0.999).

Table 2: Log Determinant

Method of Breastfeeding	Rank	Log Determinant
Exclusive (Baby Friendly)	10	1.780
Complementary (Breast milk and other food)	10	1.498

Table 2 shows the values of the log determinants, log determinant for exclusive breastfeeding (EBF) is 1.780 while that of complementary breastfeeding (CBF) is 1.498. these values because they are small and very close to each other indicate that the group covariances are similar and also homogenous, this satisfies one of the assumptions of normality in using the discriminant analysis.

The eigenvalue was found to be 0.058 and the canonical correlation is 0.224, these values are quite low which is indicative that most of the variance in the dependent variable is not explained by the function and that also explains why the canonical correlation is low. But the low correlation also shows the absence of multi-collinearity which also makes discriminant analysis suitable for the analysis of the data.

Table 3: Test of function

Function	Wilks' Lambda	Chi-square	p-value
1	0.945	76.727	0.000

Table 3 shows the test of functions, 0.945 shows that the variables do not discriminate greatly between the two groups, because the smaller this value is the more discriminating power there is. The chi-square statistic which is 76.727 is also significant which implies that the means of the functions listed are equal and the function does better than the chance at separating between the two groups.In other words, the separation between the two groups by these variables is not by chance.

Table 4: Standardized Canonical Discriminant Function Coefficients

Variables	Function 1
How many under-five children do you presently have?	0.026
Height of the child	0.010
Weight of the child	-0.683
What is the birth order of your child?	0.141
For how long did you feed your child with breast milk?	0.532
Sex of the child	-0.139
How would you classify this child?	0.271
How often does your child fall sick in a year?	-0.178

This study is discriminating between just two groups which implies that we would only have one discriminating function. Table 4 shows the coefficients of the standardized canonical discriminant function. It can be observed from the table that weight and the length of time the baby was breastfed have the largest absolute value, the larger the absolute value of the coefficient of a variable, the more discriminating ability it has.

Table 5: Classification Results

		Method of Breastfeeding	Predicted Group Membership		Total
			EBF	CBF	
Original	Count	EBF	428	280	708
		CBF	276	374	650
	Percentage	EBF	*60.5*	*39.5*	100.0
		CBF	*42.5*	*57.5*	100.0

Table 5 shows the percentage of observations that were correctly classified using the derived discriminant function. The percentage of the correctly classified observation based on the predicted group membership is 59.1% and the apparent error rate is 40.1%.

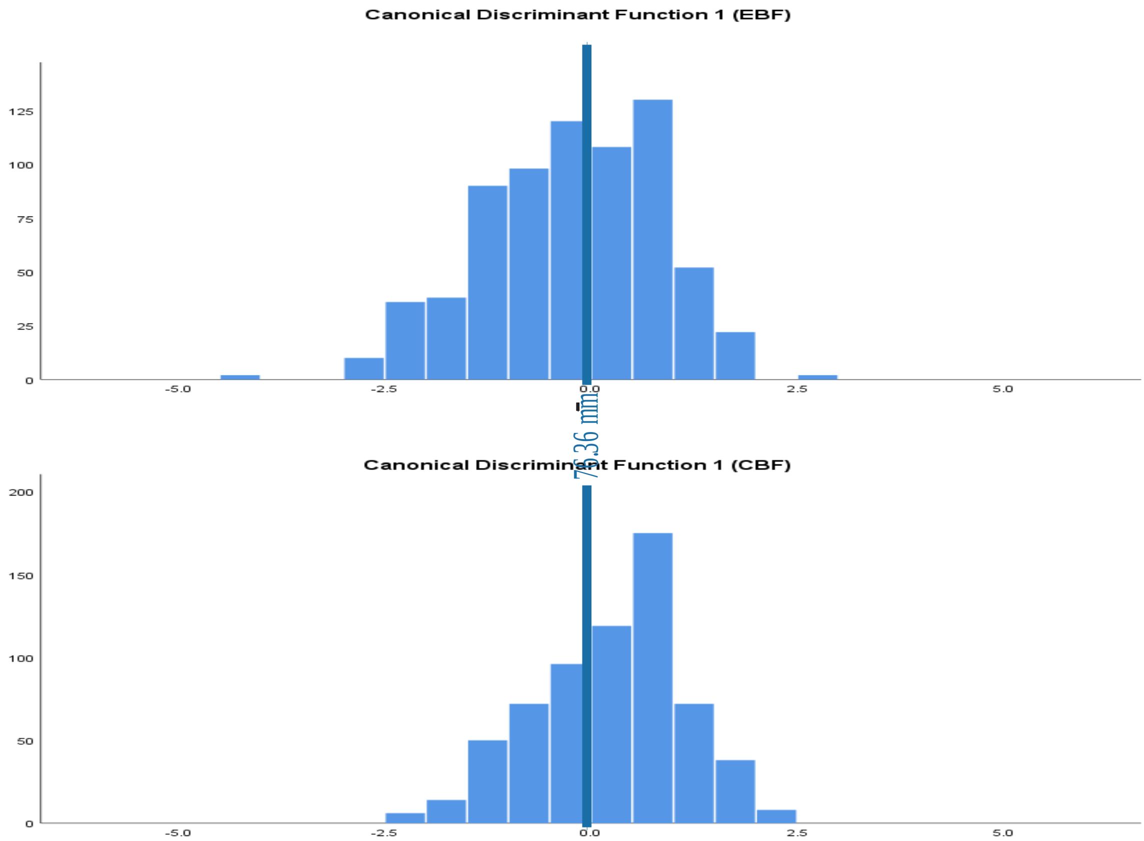

Figure 1

The figure shows the canonical distribution function for both the exclusive breastfeeding (EBF) and the complementary method of breastfeeding, if the two groups are so distinct the bars in the two distributions would not overlap too much, but in this case, they overlap greatly from the centroid, which implies they are not too distinct.

Discussions

From the results obtained, it can be observed that the weight, height of the child, and length of time the baby was fed with breast milk is what distinguish the two groups, although not so strong because of the strength of the Wilks Lambda. The variables that were dropped from the model are morbidity, level of activeness of the child, birth order of the child, and the number of under 5 children the woman has. Weight and height made the pronounced result that separate the two groups, infants that were given exclusive breastfeeding in the first 6 months of life had better weight and height than those with complementary breastfeeding, this is also confirmed by Kuchenbecker, Jordan, Kennedy, Muehlhoff,etal. (2014), in a cross-sectional study carried out in Malawi, exclusive breastfeeding gave a significant improvement in stunting and wasting. The result of this study could not show any significant difference in child morbidity and level of activeness of the child.

The model used, the discriminant analysis did not perform optimally looking at the percentage of correctly classified cases. The correctly classified cases in this model are 59.1 percent and the apparent error rate is 40.9, this error rate is quite large, Onoja, Babasola, and Ojiambo (2018) suggested an error rate of ten percent, while Gagne (2014) opined that an efficient model should be able to classify seventy percent of the cases correctly. From the foregoing, the discriminant analysis used here is not efficient although the criteria of its use were met, it can be observed from *Figure 1* that there was so much overlapping between the two distributions, this also shows that the variables chosen for this study do not distinguish well enough between the two groups and or that the two groups are so tightly knitted together to distinguish between them.

Conclusion

The model has shown no noticeable difference between the two groups, those exclusively breastfed and those with complementary breastfeeding, except in their weight and their height. Although the data met the assumptions for discriminant analysis, the model has not performed optimally, the model was not able to distinguish clearly between the two groups. It is suggested that a more powerful data mining tool should be employed since the apparent error rate is large. Or the model was not able to distinguish between the two groups because there was a large amount of overlap between them, which also indicates that the groups are not too distinct. Probably future research should consider other variables.

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