APPLICATION OF MULTIVARIATE MAPPING IN CLASSIFICATION OF DISEASES OF BUNAJI CATTLE SLAUGHTERED AT JOS ABATTOIR, PLATEAU STATE, NIGERIA

ABSTRACT

The study aimed at describing objectively, the interdependence among diseases of cattle slaughtered in Jos abattoir and mapping using multivariate techniques. In the study, slaughter health records of cattle slaughtered in Jos abattoir, Plateau State for ten years (2006-2016) was reviewed. The cases at ante-mortem and postmortem were based on examination of animals, organs and carcasses by Veterinary officers. We performed principal component and factor analysis using R 3.0.3 statistical software. Factor 1 was sensitive to lumpy skin disease, wound, mastitis, tuberculosis (TB), Contagious Bovine Pleuropneumonia (CBPP) and jaundice while factor 2 had high scores for abscess, helminthosis and TB. The appearance of TB in both factors implies that TB was a major public health threat among the cattle slaughtered in Jos abattoir from the year 2006 – 2011. From 2012-2016, however, mastitis, splenomegaly, hardware disease and TB were diseases and conditions observed to be more prevalent in Jos abattoir slaughter records. Bovine tuberculosis has been mapped to be the most prevalent disease with significant animal-human interface on the Plateau. Testing using molecular tools and development of algorithm tracker for the detection of bovine tuberculosis should be of great significance to public health in attempt to mitigate the wave of transmission of zoonotic diseases between animals and humans.

KEY WORDS: Diseases, multivariate, mapping, abattoir

INTRODUCTION

“Slaughterhouses are defined as places where animals are slaughtered for food” [1]. “The development of the slaughterhouse industry varies between countries due to cultural differences, the types of animals slaughtered and wealth” [2]. “In developing countries, slaughterhouse facilities vary from large industrial meat processing facilities in cities to small unregulated facilities in rural areas” [2].

“This variation in the meat industry is largely due to lack of private sector investment and inadequate regulation of the trade particularly in rural areas” [3]. “In addition, there is often a deficit of suitable and/or affordable equipment for the processing and transportation of meat” [3]. These factors combined with the lack of understanding of the risks of foodborne diseases lead to poor hygienic conditions in rural slaughterhouses, resulting to consumption of unwholesome meats and meat products [4]. “Although abattoirs are major sources of valuable information for animal disease outbreaks, they also serve as environment for the transmission of meat-borne zoonoses, thereby constituting a major threat to public health and food safety. “Abattoirs, if utilized effectively, play vital roles in disease surveillance through inspection of meat, and this could protect man from most zoonotic diseases which potentially might occur following the consumption of unhygienic, unsafe and unwholesome animal flesh. The purpose of an abattoir is to produce hygienically prepared meat through humane handling of animal using hygienic techniques for slaughtering and dressing” [4]. “Meat hygiene entails production of meat and meat products which are aesthetic, safe, wholesome and fit for consumption. Unhygienic issues related to food animals could emanate from the slaughtering of unfit animals, the slaughtering processes, inefficient standard operating procedures, marketing and improper meat handling practices” [5]. All animals to be slaughtered are examined before and after slaughter by an

Official Veterinarian. Findings of diseases and conditions that could affect public health or animal health are reported to the state government as well as the farm of origin where applicable. The abattoir provides a vast amount of information on zoonotic and notifiable diseases, as well as diseases relevant for animal husbandry or on-farm animal health.

"Zoonotic disease characterization is the first approach to a sustainable use of one health protocol across the globe. Disease mapping have been found useful in contrasting size and shape of animals. Infections that are naturally transmitted from vertebrate animals to humans and vice versa are classified as zoonoses" [5]. Many farm animal species are capable of transporting a wide variety of zoonotic diseases in the livestock industry. For instance, zoonotic viruses are typically present in slaughtered cattle, raw hides and skin, blood, meat, and farm settings but are frequently misdiagnosed in the beef industry. Additionally, livestock transported for slaughter into metropolitan areas originates from rural communities with ineffective, disorganised, and frequently nonexistent disease control programmes. Remoteness, poor infrastructure, a lack of qualified veterinary staff, inadequate and inappropriate transport methods, and a lack of funding to support surveillance activities or buy reagents and pharmaceuticals all contribute to the low quality of animal health care services in rural areas. A significant risk of widespread disease in the livestock population and concurrent human exposure to zoonotic disease agents exists in these livestock-rearing areas due to the inadequate veterinary services available there. Another possibility is that many of the animals taken to the slaughterhouse may be carrying illnesses that are chronic or subclinical but are rarely found during standard ante-mortem inspection. "Zoonoses can be transmitted to humans by several routes that include: consumption of infected raw milk and meat; direct contact with infected animals through handling abortions, slaughters, dystocia and parturitions; and indirectly from infected farm environments" [6]. "However, most meat-borne zoonoses are acquired through the consumption of infected and under cooked meat as well as consumption of unpasteurized milk" [6].

As a result, it is critical that cattle owners, dealers, butchers, and policymakers are made aware of the threats posed by meat-borne zoonoses in their communities. In spite of the rich genetic resource of indigenous cattle, there is dearth of information on its characterization and mapping of zoonotic diseases using multivariate analysis. Knowledge of the interrelationship among the zoonotic diseases may be important in disease classification and mapping. However, correlations between zoonotic diseases may be different if the dimensions are treated as bivariate rather than multivariate. This is connected to the interrelatedness or lack of orthogonality (collinearity) of the explanatory variables. To address this limitation, multivariate analysis of data sets such as the use of principal component factor technique becomes imperative. "Principal components are a weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables"[7]. This aids in data reduction, and breaks multicollinearity which may lead to a wrong inference. Hence, the present study aimed at describing objectively trend in disease classification of Nigerian indigenous Bunaji cattle using principal component factor analysis in Jos abattoir.

MATERIALS AND METHODS

Study area

The study was conducted in Plateau State, Nigeria. The state is divided into three agricultural zones: north, central, and south, and it contains seventeen Local Government Areas. The state is in Nigeria's North Central geopolitical zone. The vegetation is Guinea savannah, which is ideal for livestock, poultry, and crop development. Cattle (including exotic breeds), sheep, goats, and pigs are the most common animals produced in the state. The abattoir is located in the Jos South Local Government Area. It is the state's only abattoir and a key source of meat, pork, and other animal products. **Study design:** Presentation of primary data and Secondary analysis of abattoir records on health from cattle slaughtered at Jos abattoir in Plateau State, Nigeria between the periods of January, 2006- December, 2016.

Study population:

Mature male and female Bunaji Cattle slaughtered at the Jos abattoir from January, 2006- December, 2016.

Data collection tools: A line list was used to obtain information from the abattoir records with respect to numbers of cattle slaughtered and diseases recorded on monthly and yearly bases.

The correlation coefficients of diseases were also determined. From the correlation matrix, data for the principal component factor analysis were generated. According to [7], principal component analysis is a method for transforming the variables in a multivariate data set x_1, x_2, ---, xp, into new variables, y_1, y_2,---, yp which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$y_1 = a_{11}\, x_1 + a_{12}\, x_2 + \text{------------------} + a_{1p}x_p$$

$$y_2 = a_2\, x_1 + a_{22}\, x_2 + \text{------------------} + a_{2p}x_p$$

$$y_p = a_{p1}\, x_1 + a_{p2}\, x_2 + \text{------------------} + a_{pp}x_p$$

with the coefficients being chosen so that y_1, y_2, ------, y_p account for decreasing proportions of the total variance of the original variables, x_1, x_2, ------, x_p.or in matrix form:

$$Y_1 = a'x$$

The a_{ji} are scaled such that $a_1'a_1=1$. Y_1 accounts for the maximum variability of the p variables of any linear combinations. The variance of Y_1 is $\lambda_{1.}$ The next, principal component Y_1 is formed such that its variance, λ_2 is the maximum amount of the remaining variance and that it is orthogonal to the first principal component. That is,

$$a_i'a_2= 0$$

Components are extracted until some stopping criteria is encountered or until principal components are formed. The weights used to create the principal components are the eigenvectors of the characteristics equation:

$$(R- \lambda_1 I)\ a = 0$$

Where R is the correlation matrix. The λ_1 are the eigen values, the variances of the components. The eigen values are obtained by solving $(R- \lambda_1 I)a = 0$ for $\lambda_{1.}$

During the evaluation, factors were rotated with Varimax rotation of Kaiser. The aim of the Varimax rotation is to maximize the sum of variances of a_{ij}^2 quadratic weight. Anti-image correlations, Kaiser – Meyer Olkin measures of sampling adequacy and Barlett's Test of Sphericity were computed to test the validity of the factor analysis of the data sets. The appropriateness of the factor analysis was further tested using communalities (proportion of variance) and ratio of cases to variables.

Data analysis: Data was entered and analyzed using R 3.0.3 version to determine the principal component and factor scores.

RESULT AND DISCUSSION

The principal component matrix of zoonotic diseases in cattle slaughtered at Jos abattoir from 2006 – 2011 are presented in Table 1. Seven components were extracted after the varimax rotation from the 14 disease variables used in this study. Lumpy skin disease and wound related infection have high loadings for PC1, Emaciation for PC2, Fracture and TB for PC3, Negative effect of Mastitis for PC4, CBPP and hardware diseases for PC5, Negative effect of streptothricosis for PC6 and uterine prolapse for PC7. The cumulative variance accounted for disease classification was 85.20% with an eigen variance of 9.473. The communalities, which represent the proportion of the variance in the original variables that is accounted for by the factor solution, ranged from 0.736 in fracture – 0.928 in hardware disease. These further lend credence to the appropriateness of the factor analysis in disease mapping for public health intervention and appropriate policy intervention. The barlett test of sphericity was 0.136 which lend credence to the reliability of the model classifier. This was supported by Kaiser-Meyer-Olkin measure of sampling adequacy studied from the diagonal of partial correlation, revealing the proportion of the variance in the zoonotic disease caused by the underlying factor. The overall significance of correlation matrix used in building the principal component analysis was tested with Barlett's Test of sphericity for zoonotic diseases which provided enough support for the validity of the factor scores of the data set. We further reduced the dimensionality of using factor score (Figure 1), and the algorithm was able to accurately classify the interrelationship among the disease pattern as two factors. Factor 1 was sensitive to lumpy skin disease, wound, mastitis, TB, CBPP and jaundice while factor 2 had high scores for abscess, helminthosis and TB. The appearance of lumpy skin disease in the generalized component is a major public health threat among the cattle slaughtered in Jos abattoir during the period of 2006 – 2011. Lumpy skin disease may be mechanically transmission by insects [10]. Therefore, it appears that insect control could provide a workable defence against field LSD outbreak in cattle herds.

Table 1: Principal component analysis matrix of diseases in cattle slaughtered at Jos abattoir from 2006-2011

Disease	PC1	PC2	PC3	PC4	PC5	PC6	PC7	Communality
Emaciation	-.051	**.726**	.181	-.051	.384	-.322	-.151	**.839**
Fracture	-.395	.261	**.648**	.225	-.085	-.185	-.015	**.736**
Lumpy skin	**.756**	-.200	.058	-.058	.058	.282	-.251	**.764**
Streptothricosis	.005	-.525	-.050	-.058	.113	**-.774**	-.154	**.918**
Uterine prolapse	.395	.306	-.325	.363	-.150	-.065	**.618**	**.895**
Wound	**.770**	.180	.181	-.261	.175	-.059	.201	**.800**
Abscess	-.225	-.466	.423	-.281	.432	-.049	.488	**.953**
Helminthosis	-.494	-.432	.259	.155	.388	.492	.078	**.920**
Mastitis	.425	.081	.331	**-.723**	-.053	.161	-.223	**.898**
TB	-.434	.240	**-.630**	-.367	-.007	.237	.005	**.834**
CBPP	-.499	.373	-.278	-.053	**.602**	.010	-.185	**.864**
Splenomegaly	-.071	.329	.560	.438	-.264	.192	-.143	**.746**
Jaundice	.525	.273	.039	.214	**.644**	.090	.101	**.831**
Hardware disease	.397	-.373	-.251	.609	.294	.024	-.332	**.928**

PC1=2.83; 20.20, PC2=1.97; 14.04, PC3=1.81; 12.90, PC4=1.63; 11.66, PC5=1.20; 8.55, PC6=1.00; 7.16
Eigen variance=9.473 and cumulative variance=85.20%
Kaiser-Meyer-Olkin Measure of Sampling Adequacy=0.271
Chi-square=105.874
Bartlett's Test of Sphericity(p)=0.136

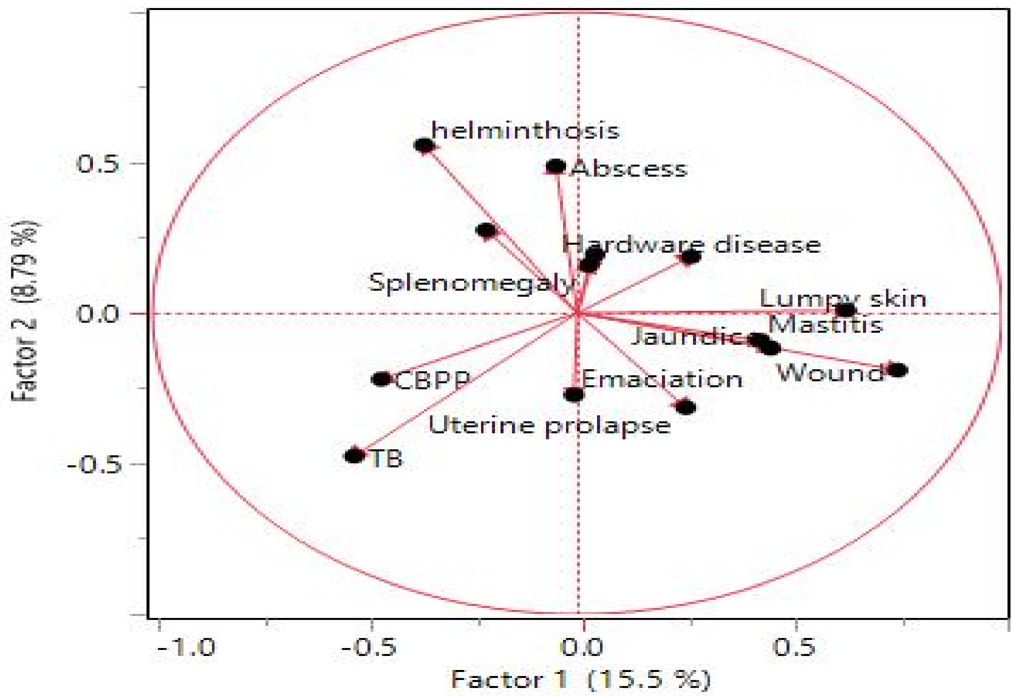

Figure 1: Factor plot of diseases in cattle slaughtered at Jos abattoir from 2006-2011

Table 2 shows the principal component matrix of disease in cattle slaughtered at Jos abattoir from 2012 – 2016. Six components were extracted from the original 14 disease variables (most of which are zoonotic) used in this study. Fracture, Streptothricosis and Splenomegaly have high loadings for PC1. Mastitis, TB, Splenomegaly for PC2, CBPP for PC3, abscess for PC4 and jaundice for PC6. The cumulative variance accounted for disease classification was 75.93% with an eigen variance of 9.126. The communalities, which represent the proportion of the variance in the original variables that is accounted for by the factor solution, ranged from 0.575 in fracture – 0.892 in jaundice. Factor 1 was sensitive to lumpy skin, wound, mastitis, TB, CBPP and jaundice while factor 2 had high scores for abscess, helminthosis and TB. The appearance of TB in both factors implies that TB was a major public health threat among the cattle slaughtered in Jos abattoir during the period of 2012 – 2016. In Figure 2, mastitis, splenomegaly, hardware disease and TB are the major zoonotic diseases that are of public health importance in Jos abattoir during the period of 2012 – 2016.

The appearance of TB in Jos abattoir from 2006 -2016 as a major public health threat interfacing between animal to human should be a great concern to public health specialist, government and private sectors. "Animal and human tuberculosis (TB), are caused by pathogenic bacteria of the Mycobacterium tuberculosis complex, *M. bovis* and *M. tuberculosis*" [8] are "widespread and affecting the animal industries and human health in Africa" [9].

Table 2: Principal component analysis matric of zoonotic disease in cattle slaughtered at Jos abattoir from 2012-2016

Disease	PC1	PC2	PC3	PC4	PC5	PC6	Communality
Emaciation	-.233	.151	.480	.259	.477	-.050	**.605**
Fracture	**-.603**	.209	-.342	.181	.112	-.073	**.575**
Lumpy skin	.401	-.509	-.095	-.202	-.335	-.297	**.671**
Streptothricosis	**.724**	.124	-.073	.355	.052	.000	**.674**
Uterine prolapse	.127	-.434	-.436	.470	.127	.486	**.868**
Wound	.504	-.163	.375	.291	-.279	.435	**.773**
Abscess	.501	-.099	-.158	**-.626**	.375	-.068	**.823**
Helminthosis	.399	.418	.115	-.236	-.561	.217	**.765**
Mastitis	.480	**.621**	-.383	.244	.186	-.143	**.877**
TB	-.314	**.611**	.482	-.281	-.066	.202	**.828**

CBPP	.022	-.345	**.629**	.050	.309	.169	**.642**
Splenomegaly	**.638**	**.629**	.007	.085	.207	.047	**.854**
Jaundice	.082	.003	.379	.547	-.284	**-.602**	**.892**
Hardware disease	**-.693**	.294	-.262	.159	-.304	.176	**.784**

PC1=3.01; 21.48, PC2=2.10; 15.01, PC3=1.72; 12.26, PC4=1.49; 10.66, PC5=1.26; 8.97, PC6=1.06; 7.56

Percent variance=9.126 and cumulative variance=75.93%

Kaiser-Meyer-Olkin Measure of Sampling Adequacy=0.259

Chi-square=88.53

Bartlett's Test of Sphericity(p)=0.554

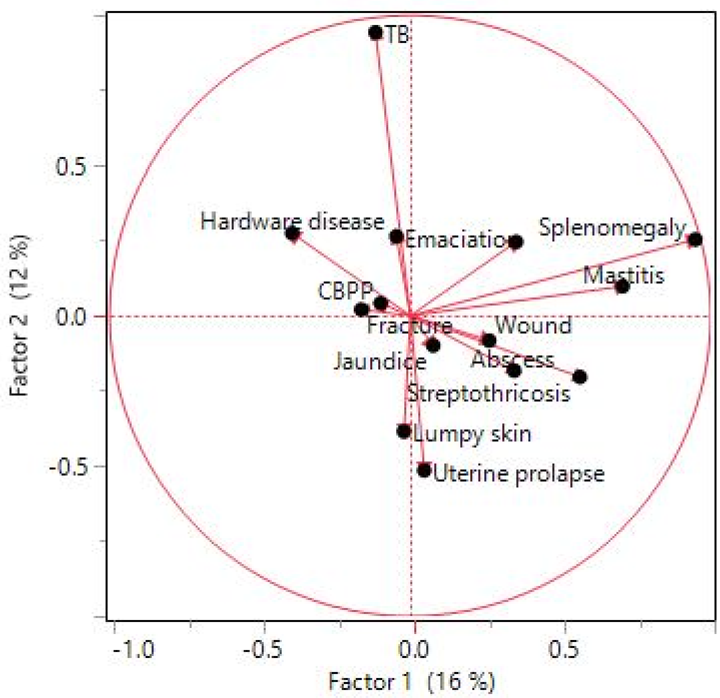

Figure 2: Factor plot of zoonotic disease in cattle slaughtered at Jos abattoir from 2012-2016

CONCLUSION

Lumpy skin, streptothricosis and tuberculosis has been mapped to be the most prevalent zoonotic disease in cattle slaughtered at Jos abattoir, Plateau State. Development of algorithm tracker for bovine tuberculosis should be a significant public health priority in minimizing the wave of transmission of disease from animal to human.

Ethical Approval: Since the study is a secondary analysis of existing data, approval from an ethical committee was not needed.

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