



The Effect of Highly Pathogenic Avian Influenza (HPAI) H5N1 Outbreaks on Mixed Species Poultry Farms in Nigeria

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ABSTRACT

The first outbreak of highly pathogenic avian influenza (HPAI) H5N1 virus in Nigeria was in 2006 and it involved different poultry species, mostly chickens in different ages, reared and bred on the same premises with some numbers of ducks, geese, turkeys and ostriches. To determine the effect of HPAI on mixed species poultry farming in the face of the ongoing 2015-2016 resurgent HPAI in Nigeria, data of confirmed 2006-2008 HPAI H5N1 outbreak in poultry were expressed as percentage proportions and used to produce spatial map using ArcGIS10.3 (ESRI®, USA) against some ecological features of the country. The outbreaks were more clustered in poultry farm dense areas especially in the northern states while very few clustering were observed around Important Bird Area and wetlands. A total of 177,996 (25.9%) on farm bird mortality was recorded from the selected outbreaks. From the backyard flock, the total mortality was 25, 915 birds (14.6%) and from the commercial flock, total mortality was 152, 081 birds (85.4%). The commercial flocks recorded higher mortality rate ($P < 0.0001$). In the single species flock, total mortality recorded was 173, 425 (25.5%) while in the mixed species flock, total mortality was 4, 571 (52.9%). Mortality rate was much higher in the mixed species flock ($P < 0.0001$) and ranged from 4.92 – 73.15% with the chicken-duck-turkey mixed flock farms having the highest rate (73.15%). Results show a higher risk of HPAI disease occurrence in multiple, mixed species poultry than in single species poultry production.

Key words: HPAI, Mixed species, Nigeria, Poultry

INTRODUCTION

Poultry production is a major economic activity in Nigeria and poultry population is reported to be the largest in Africa (Durosinslorun, et al., 2010; Nawathe and Abegunde, 1980 and Mohan et al., 1981). Poultry production is said to contribute significantly to the family income, particularly in the sub-urban and less privileged rural communities (CBN, 2004) and it is a major protein source for rural villages (Joannis et al., 2006). Since the evolution of H5N1 in Hong Kong in 1996 and its spread in Asia, Europe, and Africa with interspecies transmission, many human deaths have been recorded (Swayne, 2000; WHO, 2006) and several millions of poultry have been affected. Interspecies transmission usually occurs especially between closely related host species in the same taxonomic family (Mohan et al., 1981; Swayne, 2008). In Nigeria, evidence has emerged on the circulation of HPAI in apparently healthy waterfowls (Meseko et al., 2010),

signifying the importance of these species in the maintenance and transmission of the virus. Waterfowls, ducks and geese are known natural reservoir of influenza viruses, although ducks have higher virus isolation rates (Shortridge, 1992). Waterfowls have been reported to be less susceptible to HPAI infection than chickens (Keawcharoen et al., 2008; Stallknecht and Shane, 1992), thereby being able to shed the virus as healthy carriers in backyard farms and in live bird markets (Meseko et al., 2010). Waterfowls are also seen to be a linkage between wild birds and domestic poultry population in farms and live bird market (LBM) (Meseko et al., 2010). The first outbreak of highly pathogenic avian influenza (HPAI) H5N1 virus in Nigeria in 2006 involved about 47,000 birds of different species, mostly chickens in different age category, reared and bred on the same premises (Joannis et al., 2008). A small number of geese, turkeys

and ostriches, raised in the open, were also affected (Adene et al., 2006; Joannis et al., 2008). Due to the first H5N1 avian influenza infection in Nigeria, more than a million poultry were affected with one confirmed human death (Joannis, et al., 2008). At the end of the 2006-2008 outbreak, it is reported that 1654 cases were officially documented in 97 local government areas in 32 states and the federal capital territory (FCT) (Ekong et al., 2011), out of which 299 cases (Akanbi, 2014, Ekong et al., 2011, Joannis, et al., 2008) were positive in 25 states and the FCT (Akanbi, 2014 and Joannis et al., 2008). The country experienced severe losses in poultry accounting for approximately one million birds by June 2006, which stood at a cost of US\$ 4.82 million (Metras et al., 2013 and Otte, 2008). By 2008, about 1,264,191 birds had been depopulated, and the compensation paid to farmers was about N631 million (US\$5.43million) (Maina, 2008). In the face of the ongoing 2015 resurgent HPAI in Nigeria (Monne et al., 2015), this study is aimed at determining the possible factors influencing the mortality of different bird species and their association; also, to analyze the effect of the Nigeria HPAI H5N1 on mixed species poultry farms during 2006-2008. This will contribute to effective control measures for the ongoing 2015-2016 resurgent HPAI in Nigerian poultry.

MATERIALS AND METHODS

Data from the HPAI H5N1 outbreaks in Nigeria from 2006-2007 were used for this study and were sourced from the database of the National Veterinary Research Institute (NVRI), Vom, Nigeria, the national diagnostic laboratory for the HPAI H5N1 in Nigeria. The data included H5N1 confirmed cases mainly from the backyard, small scale commercial and free range poultry, excluding positive sera and samples from LBMs which lacks flock history. The data included date of outbreak, farm location, flock size, morbidity and mortality records supplied directly by the clients who submitted poultry mortalities to the laboratory. These carcasses were confirmed positive for HPAI H5N1 using virus isolation (VI) in 9-11 days embryonating eggs and/or reverse transcriptase polymerase chain reaction (PCR). Of the 299 HPAI H5N1 confirmed cases available in the database (Akanbi, 2014; Joannis et al., 2008 and NVRI, 2008), 170 (56.9%) cases with full history (flock size and number dead inclusive) were selected for this study. All the spatial data were added to Geographical Information System (GIS) using Environmental Systems Research Institute (ESRI) ArcGIS 10.3 (ESRI®, California, USA) and Quantum GIS (QGIS) 2.8.2 Desktop (OSGeo, Oregon, USA) to generate maps against some ecological features of the country (important bird areas (IBA), urban areas, water

bodies and wetlands), national poultry population and farm locations. The spatial data was visualized using QGIS. The outbreaks were categorized into two groups: Group 1: outbreak with single species flock, comprising of 156 cases of the total 170 cases (91.76%) and group 2: outbreak with mixed species flock, comprising of 14 cases of the total 170 cases (8.23%). Single species flocks included: chicken only; duck only; turkey only and guinea fowl only flocks. Mixed species flocks included: chicken and duck only; chicken and turkey only; chicken, duck and turkey only; chicken, duck and guinea fowl only flocks. Data sorting and descriptive analysis were conducted in Excel (Microsoft® Office Excel 2003) and statistical tests were undertaken in MedCalc® software version 11.1 (MedCalc, 2011). The proportions of dead birds were calculated for each flock type. The Chi-square (χ^2) test for comparisons of two proportions (with Yates' correction for continuity) was used to test for differences in proportions between the backyard and commercial flocks and between the single species and mixed species flocks. The ratio of the odds of mortality among the different categories was also compared. In all the analyses, confidence interval for this difference was held at 95% and values of $P \leq 0.05$ were considered significant.

Ethical Approval

This study was evaluated and followed the ethical guideline of the Ethics Committee of the National Veterinary Research Institute, Vom, Nigeria.

RESULTS

The 170 HPAI H5N1 cases with a full history used for this study were distributed across 20 States (Jigawa, Kaduna, Bauchi, Kano, Edo, Nasarawa, Adamawa, Katsina, Taraba, Plateau, Niger, Bornu, Enugu, Lagos, Anambra, Rivers, Kwara, Oyo, Ogun and Benue) and the FCT, Abuja. The spatial relationship of the coordinates of the outbreaks against the background of ecological features (important bird areas, urban areas, water bodies and wetlands), national poultry population and farm locations are depicted in figure 1. The outbreaks were more clustered in poultry farm dense areas especially in the northern states of Plateau, Kano and Kaduna. Very few clustering were observed around IBA and wetlands. Although there are more farms in Lagos and Ogun state in the south, less cases of HPAI were observed with less clustering. Bauchi state, with highest poultry density in the country (Adene and Oguntade, 2006), especially subsistence had several cases around dispersed farm settlements. Out of the 170 outbreak cases selected for this analysis, 131 outbreak cases (77.1%) represents backyard flock while 39 (22.9%) represents commercial poultry flocks (Table 1).

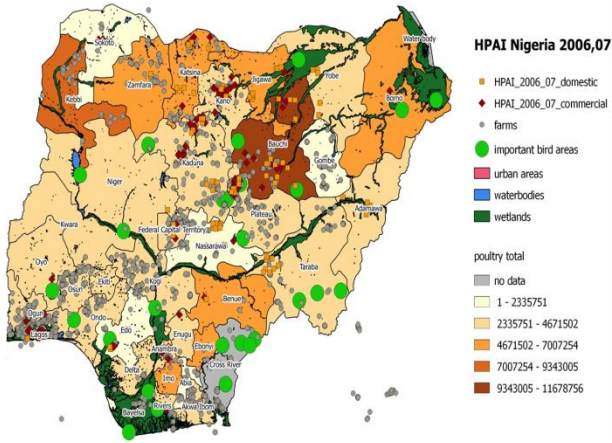


Figure 1. Spatial relationship of HPAI outbreaks against the background of ecological features, national poultry population and farm locations in Nigeria during 2006-2007

A total of 177,996 (100%) on farm poultry bird mortality was recorded from the 170 outbreak cases selected. From the backyard flock, total mortality was 25, 915 poultry birds (14.6%) and from the commercial flock, total mortality was 152, 081 poultry birds (85.4%), (Table 1). A statistically significant proportional difference of 2.2% ($P < 0.0001$) was found between the percentage mortality in the commercial flocks compared to backyard flock (Table 2).

The commercial flocks recorded a slightly higher percentage mortality ($P < 0.0001$). In the single species flock, the total poultry mortality recorded was 173, 425 (97.4%) while in the mixed species flock, total mortality was 4, 571 (2.6%). A statistically significant proportional difference of 27.4% ($P < 0.0001$) was found for this group. Percentage mortality was much higher in the mixed species flock ($P < 0.0001$), while the percentage mortality in the single species flock type farms ranged from 10.4 – 92.08% with turkey-only - farm having the highest rate (92.08%). This is followed by duck-only-farm (58.62%) the lowest was in guinea fowl –only-farm (10.40%), (Table 1). Mortality rate was much higher in the turkey only flocks ($P < 0.0001$) and duck only flocks ($P < 0.0001$), compared to chicken only flocks (Table 2). Higher percentage mortality was recorded among local chickens only flocks ($P < 0.0001$), compared to exotic chicken only flocks. The percentage mortality in the mixed species flock type farms ranged from 4.92 – 73.15% with the chicken-duck-turkey mixed flock farms had the highest rate (73.15%), the lowest was in chicken-geese mixed farm (4.92 %), (Table 1). The mixed species flocks that included chickens had a higher mortality rate ($P < 0.0001$), compared to mixed species flocks that did not include chickens. Mixed species flocks that included ducks had a higher percentage mortality ($P < 0.0001$), compared to mixed species flocks that did not include ducks. Mixed species flocks that included chicken and ducks had a

higher percentage mortality ($P < 0.0001$), compared to mixed species flocks that did not include chickens and ducks. Mixed species flocks that included turkeys had a higher percentage mortality ($P < 0.0001$), compared to mixed species flocks that did not include turkeys. Mixed species flocks that included turkeys and ducks had a higher percentage mortality ($P < 0.0001$), compared to mixed species flocks that did not include turkeys and ducks.

Table 1. Flock size and mortalities rates of different bird species and flock types during the 2006-2008 HPAI in Nigeria. Analysis from MedCalc® software.

Categories	Flock number	Total flock size	No dead	No alive	Mortality rates
Flock Type					
Single Flock	156	679291	173425	505866	25.53
Mixed Flock	14	8637	4571	4066	52.92
Husbandry					
Backyard	131	107732	25915	81817	24.06
Commercial	39	580196	152081	428115	26.21
Single Flock					
Chicken (All)	147	678931	173243	505688	25.52
Duck	4	116	68	48	58.62
Guinea fowl	1	125	13	112	10.4
Ostrich	1	18	8	10	44.44
Turkey	3	101	93	8	92.08
Chicken Type					
Chicken	132	673267	170846	502421	25.38
Local Chicken	14	2838	1029	1809	36.26
Mixed Flock Type					
Chicken, Duck	1	41	17	24	41.46
Chicken, Duck, Turkey	2	5587	4087	1500	73.15
Chicken, Geese	1	508	25	483	4.92
Chicken, Geese, Turkey	1	364	29	335	7.97
Chicken, Guinea fowl	1	250	135	115	54
Chicken, Guinea fowl, Duck	1	17	6	11	35.29
Chicken, Guinea fowl, Duck, Turkey	1	393	25	368	6.36
Chicken, Pigeon, Turkey	1	370	142	228	38.38
Chicken, Turkey	2	690	61	629	8.84
Geese, Duck	2	371	28	343	7.55
Ostrich, Geese, Peasant	1	46	16	30	34.78
Mixed Flock Group					
Mixed with Chicken	9	8220	4527	3693	55.07
Mixed without Chicken	2	417	44	373	10.55
Mixed with Duck	5	6409	4163	2246	64.96
Mixed without Duck	6	2228	408	1820	18.31
Mixed with Chicken and Duck	4	6038	4135	1903	68.48
Mixed without Chicken and Duck	7	2599	436	2163	16.78
Mixed with Turkey	5	7404	4344	3060	58.67
Mixed without Turkey	6	1233	227	1006	18.41
Mixed with Turkey and Duck	2	5980	4112	1868	68.76
Mixed without Turkey and Duck	9	2657	459	2198	17.28

Table 2. Odds ratio analysis from MedCalc® software of the association between different bird flock types (single or mixed) during the 2006-2007 HPAI H5N1 outbreaks in Nigeria.

Categories	Odds ratio	95% Confidence interval	p-value
Mixed Flock	3.28	3.14-3.42	<0.0001
Single Flock	1		
Husbandry			
Commercial	1.12	1.11-1.14	<0.0001
Backyard	1		
Single Chicken Flock			
Local Chicken	1.67	1.55-1.81	<0.0001
Chicken	1		
Single Flock			
Duck	4.32	2.97-6.27	<0.0001
Turkey	33.93	16.48-69.87	<0.0001
Ostrich	2.34	0.92-5.92	0.0738
Guinea Fowl	0.34	0.19-0.60	0.0002
Chicken (All)	1		
Mixed Flock Group			
Mixed with Chicken	10.39	7.58-14.25	<0.0001
Mixed without Chicken	1		
Mixed with Duck	8.27	7.34-9.31	<0.0001
Mixed without Duck	1		
Mixed with Chicken and Duck	10.78	9.60-12.11	<0.0001
Mixed without Chicken and Duck	1		
Mixed with Turkey	6.29	5.41-7.32	<0.0001
Mixed without Turkey	1		
Mixed with Turkey and Duck	10.54	9.40-11.82	<0.0001
Mixed without Turkey and Duck	1		

DISCUSSION

The majority of the cases included in this study were distributed across 20 States of Nigeria which included Jigawa, Kaduna, Bauchi, Kano, Nasarawa, Adamawa, Katsina, Taraba, Plateau, Niger, Bornu, Kwara, Edo, Enugu, Anambra, Rivers, Lagos, Oyo, Ogun and Benue and the FCT, Abuja. Predominantly backyard poultry flocks most of which were from the northern part (north central, north east and northwest) of the country were mostly involved.

It is reported that the northern part of Nigeria sustains a large backyard poultry population and the highest concentration of domestic ducks, reared under free-range conditions (Cecchi et al., 2008), it cannot be ascertained whether this result is a reflection of the finding of Cecchi et al. (2008) or perhaps, the reported HPAI cases were more from this part of the country. Although our findings highlighted the significant role, the north of Nigeria and backyard poultry play in the

transmission of highly pathogenic avian influenza infections in Nigeria, cases were also recorded from the southern part of the country; and also in commercial poultry. Our spatial analysis also suggests that poultry farm-dense areas had an influence on the occurrence and frequency of HPAI outbreaks especially in the northern states of Plateau, Kano and Kaduna. This is logical, as higher biosecurity would be needed in such areas in order to reduce HPAI transmission from one poultry farm to the other. Also, ecological features such as important bird areas, wet lands, water bodies and urban areas seem to have clustering of HPAI cases in this study. This may suggest under reporting of HPAI cases from these areas, less poultry farming activities or that these features may not have played significant role in the transmission of HPAI in Nigeria. The backyard poultry system (Adene and Oguntade, 2006) contributes significantly to the family income, especially in sub-urban and less privileged rural communities (CBN, 2004) and plays a major role in protein supply (Joannis et al., 2006). Of the two poultry production systems practiced in Nigeria (Adene and Oguntade, 2006), the backyard poultry recorded a higher HPAI cases than the commercial poultry. In Nigeria, backyard poultry has been identified as one of the two major source populations for the HPAI H5N1 virus in northern Nigeria for its frequent contact with wild birds (Fusaro et al., 2010). This is evident in our result which showed that of the 170 HPAI H5N1 cases, most of which are from the north of Nigeria used for this study, the backyard flock represents 77.1% (131) while commercial poultry flock represents 22.9% (39) and the chicken cases and farms were most infected. This is similar to the development in south-east Asia, whereby, the backyard poultry have been found to be an important source and persistence of HPAI H5N1 (Tiensin et al., 2005). Other factors found to be responsible for the dissemination of avian influenza virus in poultry, included rearing of multiple species in backyard poultry (Bavinck et al., 2009). Our results showed that mortality rate was twice as high in mixed species flocks as in single species flock, a statistically significant proportional difference of 27.4% ($P < 0.0001$) and with highest odds ratio ($P < 0.0001$) was found for this group. Percentage mortality was much higher in the mixed species flock ($P < 0.0001$). Highest HPAI mortality rate of 73.15% was found for chicken, duck and turkey mixed species flocks, higher than any other species combinations involved in this study, suggesting a higher risk of HPAI disease occurrence in this combination of mixed poultry farming. It is reported that interspecies transmission usually occurs especially between closely related host species in the same taxonomic family (Mohan et al., 1981 and Swayne, 2000). In Nigeria, evidence has emerged on the circulation of HPAI in apparently healthy waterfowls (Meseko et al., 2010), signifying the importance of these species in the maintenance and transmission of the virus. Waterfowls, ducks and geese are known natural reservoir of influenza viruses, although ducks have higher virus isolation rates (Shortridge, 1992). Waterfowls have been reported to be less susceptible to HPAI than chickens (Stallknecht and Shane, 1988) thereby being able to shed the virus

as healthy carriers in backyard farms and in live bird markets (Meseko et al., 2010). Waterfowls are also seen to be a linkage between wild birds and domestic poultry population (Meseko et al., 2010) in farms and Live Bird Market (LBM).

It has been reported that the mortality due to Avian influenza may be low in the ducks and geese (Compitelli et al., 2004), this is contrary to our findings in single flock ducks where mortality was 58.62%, only second to that of turkey which has the highest mortality rate (92.08%) amongst single flocks. Also, contrary to field observations that highest mortalities have been recorded mostly in chickens and turkeys (Aly et al., 2008), our study found the highest mortalities in duck and turkey single flocks in Nigeria. Earlier report of cases in four northern states in Nigeria by Saidu et al. (2008) found higher mortality rates for both geese and ducks than the mortality rates for turkeys, chickens, pigeons and guinea fowls. In this national study, it is observed that turkey had the highest mortality rate among single flock type while mortality rate was not as high in chicken as it is in duck. Mortality rates in the single species flock type farms ranged from 10.4 – 92.08%, with guinea fowl being the lowest (10.4%).

This study showed that HPAI occurrence was reported more in backyard poultry, and mixed species poultry farming especially combination of duck, turkey and chicken with increases in mortality rate and odds of infection by HPAI outbreak in Nigeria. Also, it reveals that, among single flock, mortality rate was highest in turkeys. The findings emphasizes the role played by poultry farming practices in the dissemination of avian influenza in Nigeria, shedding insights towards better HPAI control measures which can be beneficial to controlling the ongoing 2015 HPAI H5N1 outbreak in Nigeria.

CONCLUSION

The findings from this study showed that there is a higher risk of HPAI H5N1 infection in mixed species poultry farming in Nigeria. Therefore to militate against the effect of the ongoing 2015-2016 resurgent HPAI H5N1 in poultry in Nigeria, farmers in particular, small holders should be discouraged from mixed poultry farming as one of the species could be more susceptible to HPAI and thereby be the source of introduction.

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Competing interests

The authors declare that there are no significant personnel, professional or financial competing interest that might have influenced the presentation of the results of the study described in this manuscript.

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