Use of Geographic Information System (GIS) to Determine Pattern of Spread of Highly Pathogenic Avian Influenza in Nigeria: A Strategy for Public Health Surveillance

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ABSTRACT

Geographic Information System (GIS) is made up of different software tools to acquire, store, extract, transform and visualize spatial data. It provides a platform, record, analyze and monitor data on avian influenza and other trans-boundary Animal Diseases. GIS can increase the efficiency and effectiveness of surveillance systems thereby permitting changes in health status of population, overtime, facilitation, plan, implementation and evaluation of diseases control programmes. Therefore, this study takes a look at the use of GIS to determine pattern of spread of highly pathogenic Avian Influenza in Nigeria. The study evaluates the mechanism as a strategy for Public Health Surveillance. The study discovers that GIS technology can increase the efficiency and effectiveness of surveillance systems through three functions namely data input (data base functions) analysis (interpretation, cluster detection), and outputs (disease risk maps). Hence, it is concluded that the use of GIS to determine the pattern of spread of highly pathogenic Avian Influenza will enhance prompt methods of control and eradication of avian influenza diseases in Nigeria. Consequently, the training of veterinary administrators and other veterinary workers by the Government on the use of GIS to determine the patter of spread of HPAI for proper control of the disease should be treated as a matter of great urgency.

Keywords: *Geographic Information system, Avian influenza, Animal Diseases*

INTRODUCTION

Fowl plague, Avian flu or Avian influenza is a disease of viral aetiology that ranges from a mild or even asymptomatic infection to an acute, fatal disease of chickens, turkeys, guinea fowls and other avian species, especially migratory water fowl. The term "avian influenza" is used to describe influenza "A" virus subtype that primarily affects avian species, the strains in domestic chickens and turkeys are classified according to disease severity with two recognized forms; Highly Pathogenic Avian

ISSN: 2350-2150

Influenza (HPAI also known as fowl plague) and Low Pathogenic Avian Influenza (LPAI). Avian influenza viruses that cause HPAI are highly virulent and mortality rate in infected flocks often approach 100% (WHO, 2005). LPAI viruses are generally of lower virulence, but these viruses can serve as progenitors to HPAI viruses (WHO, 2005). No clinical sign is pathognomonic for avian influenza virus infections and birds of all ages are susceptible. The incubation period varies from between a few hours to three days. Per acute cases show few clinical signs and gross lesions like reduction in egg production which could be slight to severe, increased mortality, diarrhea, dysponea, coughing, rales, sneezing, lacrimation, cyanosis of unfettered parts of the skin and oedema of the head, comb and wattles (WHO, 2005). The systems affected are the respiratory, digestive and reproductive systems. In humans, symptom ranges from typical flu like symptoms of fever, cough, sore throat and muscle aches to eyes infections, pneumonia, severe respiratory diseases and other severe and life threatening complications which may result in death (WHO, 2006).

Avian influenza being a foreign disease in Nigeria, is also of great zoonotic importance, there is need to determine the pattern of spread and socio-economic impact of the disease in order to design effective control, prevention, eradication and surveillance programme. Geographic Information System (GIS) is widely used in epidemiology to process spatial and temporal information about outbreak and spread of disease in order to be able to implement adequate disease control and surveillance programme. Disease control, prevention, eradication and surveillance programme are made simpler, assessable and implementable when the locations and spatial distributions are mapped out, concretized and simplified, a reason for which the GIS as an epizootiological tool becomes so essential and relevant. Therefore it is necessary to make use of GIS technology in the tracking and eradication of avian influenza in Nigeria as it makes economic and strategic planning possible and also provide information on expanse and feature present in our geographic locations.

Recent Avian Influenza Outbreak in Nigeria: On 8th February 2006, Nigeria officially announced cases of the highly pathogenic avian influenza virus H5NI in a poultry in the village of Jaji located in Kaduna State. The outbreak which is the first of its kind in Africa was confirmed by Food and Agriculture Organization (FAO) and the World Organization for Animal Health laboratory for avian influenza in Padova (Italy). The Nigeria Minister of Agriculture announced on 8th February 2006 that all suspected birds Nationwide should be killed and buried in order to contain the outbreak and that Federal Government had set aside the sum of 1.5 billion naira for compensation at the sum of 250 naira per bird killed to all those whose birds were affected and would be killed. FAO advised veterinary services in Nigeria to eliminate the outbreaks through immediate humane culling and to strictly control the movement of people and animals to and from bird flu infected areas *(http:www.humanitarianinfo.org)*. The source is not clear, although the country lies along a flight route for birds migrating from Central Asia which had the first report of H5NI outbreak in late 2003 (WHO, 2006). Since the first confirmed outbreak in Nigeria, the highly pathogenic avian influenza had caused severe socio-economic problems for poultry farmers in Nigeria and through West Africa, which resulted from various outbreaks that occurred to date. The avian influenza virus poses an immediate and potentially severe threat to animal and human health in West Africa.

Avian Influenza Diseases and Pathogen: Avian influenza (AI) is a disease of viral aetiology that ranges from a mild or even asymptomatic infection to an acute fatal disease of chicken, turkey, guinea fowl and other avian species, especially migratory water fowl Avian influenza synonyms include bird flu, fowl plague etc. Fowl plague was determined in 1995 that fowl plague (FP) virus is actually one of the influenza viruses (Beard, 1989). The AI viruses are 80 to 120mm in diameter and 200 to 300mm long and any is filamentous. The virus particle has envelop consisting of spike-shape surface glycoprotein and matrix (M) proteins surrounding a helical segmented nucleocapsid (6 to 8 segments) the spike-shape surface glycoprotein possess heamagglutinating and neuraminidase activity. These two surface antigens haemagglutin (HA) and neuraminidase (NA) are the basis of describing the serologic identity of the influenza viruses using the letters H and N with the appropriate numbers in the viruses designation, like H5NI (Beard,1989).

The family contains five genera, classified by variations in antigenic character of M protein of the virus envelop and nucleoprotein within the virus particles: influenza A, influenza animals (equine, swine avian) belong to type A, and type A influenza virus is the most common type producing serious epidemic in human. Type B and C do not affect domestic animals. There are 15 different haemagglutinin (H1 to H15) and 9 different neuraminidase (N1 to N9) described among the type A influenza viruses. But recently a new type (H16) was isolated from black headed gulls caught in Sweden and the Netherland in 1999 (Fouchier, 2005). The term "avian influenza is used to describe influenza A subtype that primarily affects chicken, turkey guinea fowl, migratory water fowl and other avian species. All known subtype of influenza A can be found in bird, and feral equalic birds are the major reservoir for influenza A virus (Fouchier, 2005). The current strains of H5NI responsible for death of domestic birds in Asia and recently in Nigeria is an HPAI strain, other strain of H5NI occurring else where in the world are less virulent and therefore, are classified as LPAI strains. All HPAI strains identified update have involved H5 and H7 subtypes. Human infections have been associated with both HPAI and LPAI strain (HHS, 2005). The criteria that serve as the basis for classifying an AI virus as HPAI has more recently been modified to include molecular considerations such as the type of amino acids at the cleavage site of its HA.

Geographical Distribution of Highly Pathogenic Avian Influenza: Highly pathogenic avian influenza viruses have periodically occurred in recent year in Australia (H7), England (H7), South Africa (H5), Scotland (H5), Ireland (H5), Mexico (H5), Pakistan (H7), The United States (H5) and Nigeria (H5). Because laboratory facilities are not readily available in some parts of the world to differentiate new castle disease and HPAI, the actual incidence of HPAI in the world's poultry flock is difficult to define. It can occur in any country, regardless of disease control measures, probably because of its prevalence in wild migratory waterfowl, seabird and shorebirds. Avian influenza has produced losses of variable severity, primarily in turkeys in the United States since the mid-1960's. The disease outbreak in turkeys in the United States have been caused by AI viruses with many of the HA designations. It was in the fall of 1983 that a highly virulent H5 virus produced severe clinical disease and high mortality in chickens, turkeys and guinea fowls in Pennsylvania. This severe disease, clinically indistinguishable from classical fowl plague, occurred after a serological identical but apparently mild virus had been circulating in poultry in the area for 6 months outbreak of less virulent AI has frequently been described in domestic ducks in many areas of the world. The AI viruses are often recovered from apparently healthy migratory water fowl, Shorebirds and Seabirds worldwide. The epidemiologic significance of these isolations relative to outbreaks in domestic poultry has led to the generally accepted belief that waterfowl serve as the reservoir of influenza viruses.

Table 1: Countries affected by H5NI Avian Influenza in Poultry or migratory fowl as of December 2005

East Asia	Europe, Siberia Central Asia	Africa
Combodia	Croatia Nigeria	
China	Kazakhstan	Egypt
Hong Kong	Romania	Niger
Indonesia	Russia (Siberia and European Russia	Cameroon
Japan	Turkey	Burkina Faso
Laos	Iraq	
Malaysia	Saudi Arabia	
Mongolia	Cyrus	
South Korea	Greece	
Thailand	Italy	
Vietnam	Bulgaria	
India	Austria	
	Germany	
	Slovenia	
	Azerbaijan	
	Ukraine	
	France	
	Hungry	
	Georgia (former Soviet Republic)	
	Slovakia	
	Bosnia	
	Servia	
	Poland	
	Albania	
	Israel	
	Jordan	
	Czech Republic	
	Denmark	

Source: Infectious Diseases Society of American IDSA (2006). Avian Influenza (Bird Flu): Implications for Human Disease. (http://www.cidrap. UMn.edu/idsa/influenza/avianflu/biofacts/avflu-human.

The Geographic Information System (GIS) and How it works: According to Scocco Foglia, Cercarelli, Gatti and Catoric (2006), GIS are made of different software tools to acquire, store, extract, transform and visualize spatial data. GIS applications concern mainly geographical or topographical cartography and thematic or planning cartography, but any information potentially linked to the territory can be entered in a GIS. GIS integrate the application of computer-aided design (CAD) and relational data bases (DSMS). The use of Geographical Information System (GIS) is now well established in veterinary science particularly for assisting in the managing of exotic disease outbreaks. However, most usage remains reliant on adhoc desktop and GIS, there has been less success in incorporating activities into national and regional surveillance systems for epidemic disease (Durr, 2006). Rocque (2006) stated that geographic information system represent new tools for the study of epidemiology and its application for parasitology has become more and more advanced in particular, the study of the spatial and temporal pattern of disease. The GIS works by relating information from different sources in a spatial context to reach a conclusion about the relationship between geographic location and information sourced. Information is inputted in map form, data or digitized forms into GIS with the aid of coordinates of longitude and latitude. Epizootiologists have traditionally used maps when analyzing associations between location, environment and disease (Kosenko Kotsjumbas, Lukyanchuk and Anol, 2006). GIS is particularly well suited for epizootiology because of its spatial analysis and display capabilities.

Mapping the Primary Outbreak and Spread of Highly Pathogenic Avian Influenza in Nigeria: The Federal Government proactively established a risk assessment commission on Highly Pathogenic Avian Influenza (HPAI) in 2005. The commission is made up of two committees namely: a Veterinary Surveillance and Preparedness Committee in the Ministry of Agriculture and a Medical Surveillance and Preparedness Committee in the Ministry of Health, prior to the Nigerian Avian Influenza (AI) epidemics. Following the detection of the first AI outbreak on January 16, 2006 and the subsequent spread of the disease across poultry flocks in Northern and Southern Nigeria, the presidency created an AI emergency center at the Federal Capital Territory, Abuja as an inter ministerial portfolio to coordinate all reports on diagnosis, trend and control measures taken against the disease.

More than 100 Nigerian Poultry farms have since been confirmed positive; the farms are located at graded distance from central coordinating unit in Abuja. All samples from suspected cases requiring laboratory diagnosis were tested at National Veterinary Research Institute (NVRI) in Vom, Plateau State, Nigeria. It has therefore become possible to provide consistent reports of the disease emerging trend across the country. Due to AI high zoonotic potential, a unified surveillance system became a necessity; the system had to be able to integrate the spatial and non-spatial data colleted by the veterinary and medical surveillance committees. One of the first

ISSN: 2350-2150

outputs of the new unified surveillance system has been a geographic model describing the spatial distribution of 169 poultry farms suspected of being infected; 107 farms (63.3%) of these 159 were confirmed positive by NVRI between January 16 and August 31, 2006. Farms were distributed in various States in Nigeria. Their locations were mapped using the ESRI ArcGIS Desktop in a personal geo-database containing the data collected by the medical surveillance committee on the same premises. This output was used to illustrate the potential usefulness of a unified surveillance system in Nigeria (Olugasa, Ekong, Oyetunde, Akanbi and Adewale, 2006).

GIS Application to the Surveillance and Control of Trans-boundary animal diseases at international level: In response to lack of early warning in dealing with livestock diseases, FAO has developed and launched in 1994 the Emergency Prevention System for Trans-boundary Animals and Plant Past Diseases (EMPRES) programme emphasizing the prevention of emergencies due to trans-boundary epidemic disease of livestock that are of significant economic, trade and or food security importance for a considerable number of countries which can easily spread to other countries and reach epidemic proportions; and where control of management including exclusion requires co-operation between several countries.

EMPRES Early Warning activities, mainly based on disease surveillance reporting and epidemiological analysis which are supported by EMPRESS information system which enables integration, analysis and sharing of animal health data combined with relevant layers of information such as socio-economic production and climate data. As a matter of fact data integration analysis and mapping represent a key towards the better understanding of distribution and behaviour, source and evolution of a disease for definition of appropriate cost effective disease control strategies.

EMPRES-1 is a web-baded secured Global Animal Health Information System which is linked to a GIS that provides a platform record, analyze and monitor data on avian influenza and other Trans-boundary Animal Diseases (TADS) such as rift valley fever and foot and mouth diseases. The system aims at delivering timely and accurate situation updates as well as relevant risk analysis distributed in electronics format (AIDE News HPAI, EMPRES Watch Massager, Disease Tracking List, Rift, Valley Fever Bulletin) to member countries and partner institutions (WHO, 2005).

GIS Driven Real Time Surveillances System: A GIS-driven web-based real time surveillance system was developed to support the extensive surveillance programme carried out on West Nile virus infections identified in Canada in 2001. The GIS-driven real time surveillance system has developed and integrated four key components in real time disease surveillance.

(1) Real-time surveillance for reporting cases and testing results in a distributed environment.

ISSN: 2350-2150

(2) Real-time web GIS to improve data quality, to visualize spatial trend and patterns.
(3) Open GIS for sharing surveillance information, and for overlaying external risk factor data on real-time maps.
(4) Security and confidentiality management of data and maps.

This system has identified nine GIS components for surveillance. They include:
(1) Comprehensive geo-referencing
(2) Spatial validation of location relationship
(3) Interactive real-time for any date periods
(4) Automatically created static maps
(5) OGC WWS tools
(6) GIS and mapping functions in data entry and editing paper
(7) Dynamic link between real-time interactive maps and data editing pages
(8) Six different Web GIS
(9) Public WMS services

In this system, GIS has enhanced and enriched traditional surveillance system as it allowed users to visualize events, to put events in a spatial context to compare disease and social-economic, environmental factors and to link spatial and non-spatial information in an integrated system. The system also supported spatial analysis and decision making by improving spatial data quality (Shuai, Buck, Chevalier and Socket, 2006).

Limitations to the Application of GIS-Based Disease Surveillance Database in Nigeria: Surveillance for disease events or conditions in animal populations has an implicit spatio-temporal component. Data generated within surveillance systems permit changes in health status of population over time and space to be identified, facilitating the planning implementation and evaluation of disease control programmes. GIS technology can increase the efficiency and effectiveness of surveillance systems through three functions namely data input (data base functions) analysis (interpretation, cluster detection), and outputs (disease risk maps). The application of GIS-based surveillance is illustrated by a project recently implemented in Romania to detect avian influenza incursions between October 2005 and March 2006.

However, low stock of livestock base data is one of the challenges or limitations to the adoption or application of modern geographic information technologies in the control of epizootics in Africa, including Nigeria. Other limitations include inability to acquire relevant software or hardware and the need for training or retraining of veterinary geo-informatics personnel. Some of the specific limitations of the promotion of the effective use of geo-informatics for disease surveillance, monitoring and control which are typical of other developing African countries include poor rudimentary and inconsistent disease reporting procedures (based mainly on administrative boundaries rather than geo-referenced points), non-computerized

ISSN: 2350-2150

(manual) disease recording techniques, raw, unanalyzed data, poor information networking and lack of awareness on training of veterinary administrator in modern information systems development. Deliberate multilateral reorientation, training and funding assistance is needed to overcome these limitations to the promotion and veterinary use of GIS and other geo-informatics in a third world country like Nigeria (Onyeka, Ogundipe, and Bablobi, 2006).

CONCLUSION AND RECOMMENDATIONS

Avian influenza outbreak had caused economic loss in various parts of the world in which Nigeria also experiences its recent outbreak. The public health and socio-economic impact of the outbreak of the disease calls for efficient, assessable and simple methods of the disease investigation, by employing the use of GIS, so as to design an appropriate and prompt method of control and eradication of avian influenza disease in Nigeria. There is the need for urgent attention to be given to HPAI disease control and eradication programme in Nigeria. The status of animal disease, Zoonotics diseases and disease of great socio-economic effects in which Avian Influenced is a very good example should be considered in planning of veterinary education syllabus at both the professional and sub-professional levels. This should be done to include setting up of laboratories where technical activities involved in confirmatory diagnosis of disease in affected area could be monitored on Geographic Information software that contains each district, local government area and state. The shape files may also identify other laboratories and epizootiologists involved in the control and eradication of such diseases (e.g. Avian Influenza) in the country. With the GIS, proper mapping out of the regions and technical activities made available at necessary quarters, decision making can be done faster and measures taken promptly. Emphasis should be placed on the training of veterinary administrators and other veterinary workers by the government on the use of GIS to determine the pattern of spread of HPAI for proper control of the disease. These recommendations will have little effect without the support of the planners and policy makers at the national, state and local government as well as the community levels.

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ISSN: 2350-2150