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# National surveillance and control costs for highly pathogenic avian influenza H5N1 in poultry: A benefit-cost assessment for a developing economy, Nigeria

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ABSTRACT

We conducted benefit-cost analysis of outbreak and surveillance costs for *HPAI* H5N1in poultry in Nigeria. Poultry's death directly cost US$ 939,734.0 due to outbreaks. The integrated disease surveillance and response originally created for comprehensive surveillance and laboratory investigation of human diseases was adapted for *HPAI* H5N1 in poultry. Input data were obtained from the field, government documents and repositories and peer-reviewed publications. Actual/forecasted bird numbers lost were integrated into a financial model and estimates of losses were calculated. Costs of surveillance as alternative intervention were determined based on previous outbreak control costs and outputs were generated in SurvCost® with sensitivity analyses for different scenarios.

Uncontrolled outbreaks will lead to loss of over US$ 2.2 billion annually in Nigeria with 47.8% of the losses coming from eggs. The annual cost of all animal related health activities was < US$ 99.0 million, only one-third of this amount was linked with H5N1 surveillance and response activities. Recurrent cost was 96.2% of the total surveillance and response costs, and 31.0% of the *HPAI* surveillance cost was spent on personnel with 3.8% as capital cost. Cost-wisely, routine monitoring and surveillance for *HPAI* are 68 times more cost effective than to do nothing. Assuming that successful control and eradication of *HPAI* H5N1 is partially attributable to H5N1 surveillance and response, a quarter or half of the success will result in 17 or 34 times more benefits. Although animal surveillance and response activities for avian influenza appeared expensive, their implementation are economically cost beneficial for developing countries.

## 1. Introduction

Avian influenza, particularly of the highly pathogenic H5N1 subtypes but also other influenzas have continued to infect poultry production throughout Africa. While Egypt has been confirmed to have endemic *HPAI* H5N1 situation in poultry (FAO, 2011), re-infections remain the major challenge in certain African countries including Nigeria, Cote d'Ivoire, Ghana, Libya, Burkina Faso, Togo and Benin (OIE, 2015). Between December 2014 and May 2016, Nigeria alone lost over 2.7 million birds at a direct cost of at least US$ 939,734 and other consequences (OIE, 2016).

As part of the effort to control the continued outbreaks of the H5N1 virus, the internationally acceptable standards stipulated by the FAO/OIE include the following among others: movement restriction, import control, rapid laboratory diagnoses, stamping out of outbreaks, vaccination, compensation, market closure, reporting, compartmentalisation and sustained active and passive surveillance (OIE/FAO, 2007; FAO, 2008; Kanamori and Jimba, 2008). To date, comprehensive

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phylogenetic and ecological analyses have been conducted (Williams and Peterson, 2009; Cattoli et al., 2009; Couacy-Hymann et al., 2012). The cost associated with losses and excess spending to curtail outbreaks of H5N1 influenza virus have been quantified in the household, backyard and commercial poultry (Rushton et al., 2005; Fasina et al., 2012). In addition, the implementation of surveillance has been suggested (Ferrer et al., 2014; Brown et al., 2015), but a comprehensive cost assessment of such policy has not been documented. It is however pertinent to assess these costs to assist policy makers who are faced daily with difficult political and economic decisions of striking careful balance among the many competing interests. These include; health, social, economic, industrial and political for nations' limited resources and to determine the impacts of proposed and ongoing programmes on avian influenza control (FAO, 2004).

Integrated disease surveillance and response(IDSR) is the strategic tool primarily developed for the utilization of surveillance and laboratory data for the rapid detection, reporting and investigation of preventable and priority diseases in humans (WHO, 2000). Whereas the programme was originally developed to conduct functional, timely and effective surveillance for human communicable and non-communicable diseases in order to enhance crucial decision-making process for national public health, it is opined that the model can be modified for the comprehensive assessment of animal health problems.

In Nigeria, previous reports have recommended the use of a multidisciplinary and multi-sectoral approach to conduct national surveillance. Such team should consist of a combination of the federal, state and private sectors with the aim of optimization of rapid and accurate detection of cases of *HPA*I H5N1 outbreaks in poultry, and reporting these outbreaks through the same line of command from the local level to the national office (UNSIC, 2006; The World Bank, 2008; Jonas and Warford, 2014; Brown et al., 2015). Following reports of outbreaks, appropriate authorities should be informed to effect and enforce necessary control measures while the same is notified to the OIE.

A comprehensive and sustained national surveillance programme possesses the benefit of reducing zoonotic threat posed by H5N1 to humans while protecting the poultry industry (UNSIC, 2006; The World Bank, 2008; Jonas and Warford, 2014; Brown et al., 2015). In this instance, we utilized the detailed information from these previous reports, trained and adapted the IDSR model for animal disease (avian influenza H5N1) surveillance using the Nigerian poultry population and outbreak scenarios, estimated the cost of losses using financial modelling and determined the benefit-cost ratio of implementation of surveillance compared with doing nothing as a key aspect of control measure.

## 2. Materials and methods

### 2.1. Data collection and management

Primary economic, policy-related and market data were sourced from the field (farms, live bird markets (LBMs), government officials, policy makers and official reports). Secondary data were obtained from the repository of the OIE, FAO, government websites, reports and peer-reviewed publications. All data were entered in Microsoft Excel® and duplicate or incomplete data were first confirmed with the national authorities and corrected or removed where confirmation cannot be obtained. All data were entered by two persons and reconfirmed by a third individual for accuracy and consistency. Over 2,765,201 poultry have died or were culled in at least 465 outbreaks which occurred between 24 December 2014 and May 2017 (OIE, 2016).

### 2.2. Estimation of poultry population and determination/confirmation of outbreak

Nigerian poultry population data for the years 2006 to 2013 were obtained from the FAO (Food and Agriculture Organization of the United Nations) (2016) website. Annual increases or decreases in the poultry populations were calculated and mean difference was obtained for the eight-year period (Supplementary Material 1a). The obtained mean difference for the 8 previous years was used to estimate the annual increase to determine the Nigerian poultry populations for 2014 to 2016.

To avoid misclassification, we identified outbreak based on the following definition: Following report(s) of abnormal clinical signs and suspected heightened deaths in poultry, in farms or LBMs, teams of outbreak control and surveillance officers were dispatched to the outbreak sites. The teams were responsible for sample collections, implementation of temporary movement control policies, stamping out activities, and immediate dispatches of the samples to the National Veterinary Research Institute, Nigeria. Diagnoses were based on real-time reverse transcriptase polymerase chain reaction (RRT-PCR) and or egg inoculation for virus isolation (Monne et al., 2015). Typically, diagnostic results were obtained within 24 h from the receipt of samples. An outbreak is confirmed only if the RRT-PCR result is positive. All negative results were confirmed by a second round of test before they can be confirmed as negative and duplicate results are forwarded to the National agricultural authority for notification to the OIE. All reports from the field that were not confirmed by laboratory assessment were excluded and based on daily count data of outbreaks, an epidemic curve was developed (Fig. 1 a and b).

### 2.3. Financial modelling

To calculate losses due to avian influenza H5N1, the actual number of birds lost in the recent outbreaks (December 2014 to May 2016; n = 2,765,201 birds (4.10% of the 2016 population for layers/breeders) and the actual poultry population estimate for 2016 were integrated into a partial budget model (Supplementary Material 1b). These birds were categorized into bird types (layer, breeder, broiler and cockerels) for purposes of determining the poultry structure, valuation and payment of compensation. The partial budgeting (partial cost analysis) has been used previously to estimate farm animal losses at farm, regional, national or trans-national levels and empirical assumptions have been made (Rushton et al., 2005; Otte et al., 2008; Fasina et al., 2008). Estimates of direct and indirect losses, outbreak response surveillance costs, diagnostic costs, biosecurity upgrade costs, movement control costs, market closure costs, border control costs, stamping out costs, cleaning and disinfection costs, compensation costs, vaccination costs, industry restructuring costs and transport costs were conducted and integrated (Tambi et al., 1999; Tisdell et al., 1999; Rushton et al., 1999; Hinrichs et al., 2006; McLeod, 2007; Otte et al., 2008). Because poultry is a short cycle animal with a lifespan of approximately 1 year in the farm, the net present values were used and losses of future values were not calculated. However, it was noted that certain costs including but not limited to biosecurity upgrade and industry restructuring as well as training costs, may represent long term investments but does not significantly impact the overall costs since annual costs were used for these variables.

### 2.4. Surveillance costs and benefit-cost analyses

SurvCost® software was obtained from the website of Centers for Disease Control and Prevention (http://www.cdc.gov/globalhealth/healthprotection/idsr/tools/survcost.html). Comprehensive list of all items for planned surveillance activity in Nigeria was obtained from three official sources: 1) the Integrated National Avian and Pandemic Response Plan, 2007–2009 (UNSIC, 2006); 2) the Avian Influenza Control and Human Pandemic Preparedness and Response Project (The World Bank, 2008) and 3) Global Program for Avian Influenza and Human Pandemic Preparedness and Response (The World Bank, 2006). Details of the data were confirmed from experts and workers in the field where necessary. Based on the working knowledge of past surveillance