The financial cost implications of the highly pathogenic notifiable avian influenza H5N1 in Nigeria

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ABSTRACT

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Nigeria and several other nations have recently been affected by outbreaks of the Asian H5N1 strain of highly pathogenic notifiable avian influenza (HPNAI) virus, which affects the poultry sector most heavily. This study analysed previous methods of assessing losses due to avian influenza, and used a revised economic model to calculate costs associated with the current avian influenza outbreaks. The evaluation used epidemiological data, production figures and other input parameters to determine the final costs. An infection involving 10 % of the commercial bird population will cost Nigeria about $245 million and a worse scenario may lead to a loss of around $700 million. The results urge governments to invest more in measures aimed at the effective prevention of HPNAI and to consider the huge economic losses associated with the disease. Finally, an inter-disciplinary approach to managing and controlling HPNAI outbreaks is encouraged.

Keywords: Avian influenza, economics, HPNAI, H5N1, Nigeria, poultry

INTRODUCTION

Fifty-nine countries, including Nigeria, have been affected by highly pathogenic notifiable avian influenza (HPNAI) H5N1 strains since 2004 (OIE 2006; WHO 2006). The livestock sector, especially poultry, plays a very important economic role within the resource poor populations of the developing nations of the world. It provides food (animal protein), income, employment and foreign exchange for countries that trade their animals and animal products (Sonaiya, Branckaert & Gueye 1999; McDermott, Coleman & Randolph 2000; FAO 2002).

The poultry sector represents a major source of income in Nigeria. It contributed approximately 4.45 % of the total animal contribution to the agricultural gross domestic product (GDP) in 2004 (Central Bank of Nigeria 2004). The over 140 million birds are composed of about 60 % backyard poultry stock and about 40 % commercial or semi-commercial birds (Adene & Oguntade 2007). About 75 % of the commercial birds are layer stock and they are responsible for the mass production of eggs and poultry meat in Nigeria. Poultry is vitally important to the rural poor since it is the most widespread form of livestock in Nigeria that the poor rural individuals can afford to keep as a source of income and assets. However, estimating the economics and other financial parameters in the Nigerian poultry industry is extremely

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difficult since data collection is often incomplete or fragmented.

HPNAI has caused high levels of mortality, restriction in international trade, infection of various animal species, endangered food security and carries potential for a human pandemic (FAO 2002; European Commission 2004; Otte, Nugent & McLeod 2004; Holtz-Eakin 2005; Rushton, Viscarra, Bleich & McLeod 2005; Ducatez, Olinger, Owoade, De Landtsheer, Ameerlaan, Niesters, Osterhaus, Fouchier & Muller 2006; OIE 2006). Increasingly, cases of emerging and re-emerging livestock diseases as well as diseases with emergency potential like HPNAI, are becoming more connected with higher densities of livestock, increasing trade resulting in the movement of people and products and breaches in biosecurity at various levels (national, regional and farm), despite improving technologies and advances in information dissemination and management practices.

Although diverse aspects of the avian influenza virus are being investigated worldwide, studies on the socio-economic aspects of avian influenza are limited (Otte *et al*. 2004; Holtz-Eakin 2005). Losses associated with livestock diseases may be easy to identify, but it is extremely difficult to attach a cost implication, and these cost implications are often incomplete (Howe 1985; Otte *et al.* 2004; Holtz-Eakin 2005).

A review of socio-economic evaluation models of previous workers indicated that the cost of any illness is the sum total of direct, indirect, intangible and control costs (Oluokun & David-West 1981; Lasley 1986; Rushton, Thornton & Otte 1999; Szucs 1999; Otte *et al*. 2004; Verbiest & Castillo 2004; Holtz-Eakin 2005; World Bank 2006a). Such a model was used earlier by Oluokun *et al.* (1981) in evaluating costs associated with a Rinderpest outbreak in Nigeria. Hanson & Hanson (1983) also suggested that loss of any kind must be interpreted in terms of population at risk, and that knowledge of morbidity and mortality rates are important in estimating the cost implication.

The costs due to HPNAI outbreaks is less significant than those associated with the post outbreak effects on market, trade, enzootic potential, productivity, dwindling interest in poultry enterprises and the attendant zoonotic and food security risks. In this study, each of these factors was considered in estimating the cost implications of HPNAI on the commercial layer industry, based on the population affected, the population at risk and economics of alternative control measures. These evaluations mathematically estimate the cost implications of HPNAI H5N1 in Nigeria, and the implications for disease control are discussed.

MATERIALS AND METHODS

For the financial cost evaluation of HPNAI in Nigeria, the actual situation and scenarios of mild (10 %) and severe (70 %) generalised outbreaks in the commercial flocks were selected. In Nigeria, the commercial layer is very important, accounting for almost 90 % of all egg production (Adene & Oguntade 2007). Similarly, ~99 % of all infected poultry populations are commercial layers and layer breeders (data retrieved from National Veterinary Research Institute, Nigeria, December 2006). Our estimates deal only with this segment which often operates with little to no biosecurity.

A number of assumptions were made:

1. HPNAI caused 100 % mortality in affected flocks, either through pathologic death or control measures by destruction.
2. One hundred percent cessation in egg production was assumed, based on published reports (Capua & Marangon 2000).
3. HPNAI caused a loss of 6 months in layer/layer breeder systems (downtime and raising new stock to point of lay).
4. Laying birds were in full production and would lay 284 eggs (80 % production) for one laying cycle, and layer breeders would lay 265 eggs (75 % production). Fifty percent of the breeders' offspring would have market value (pullet) and 50 % would be cockerels with zero value. Two hundred chicks per breeder hen are expected and approximately 100 of these chicks will be valued stock (average production standards).
5. All deaths in the poultry population in Nigeria occurring during the study period (January to August 2006) arose from HPNAI or factors associated with it.

Other baseline data were obtained from Resource Inventory Management, Nigeria National Livestock Resource Survey and FAOSTAT-GLIPHA (FAO 2006a, b and c).

It is difficult to place an economic value on human beings affected by HPNAI. The affected human population was not economically assessed. Prevention of the spread of the disease in livestock would prevent its introduction in the human population.

Mathematical models

$$Ci = PS\,\{ʊ + \beta + \delta + \gamma\}$$

Or $Ci = PSʊ + PS\beta + PS\delta + PS\gamma$

Where Ci = cost implications

P = Population of poultry

S = Susceptibility rate of population

ʊ = Direct losses: losses from mortalities (cost due to mortality of poultry and values of chicks lost from breeders)

β = Indirect losses: egg and meat loss (value of direct loss of eggs due to yield reduction, cost of rejection of poultry meat and eggs, and cost associated with glut)

δ = Intangible losses: opportunity cost (cost of rearing replacement stock to production or sale point, cost of feeding to point of production, cost of retaining facilities and staff during downtime and rearing stage, and cost of destroying remaining population of animals)

γ = Miscellaneous costs (cost of intense campaign to win back consumer confidence, cost of control and administrative/governmental policies, and external inputs)

* All calculations were done in Naira (N) (Nigerian currency) and converted to US Dollars ($) at an exchange rate of $1 = N128.50. Details of final data used for the calculations are found in Tables 1 and 2.

Total chicken population in Nigeria = 140 000 000

Commercial chickens = 40 % of 140 000 000
= 56 000 000

Commercial layers and layer breeders = 75 % of 56 000 000
= 42 000 000

Commercial layers = 90 % of 42 000 000
= 37 800 000

Layers in production = 75 % of 37 800 000
= 28 350 000

At 80 % hen-day production:

Number of eggs per day = 22 680 000

Number of eggs per annum [eggs in 12 months (365 days)] = 8 278 200 000

Total number of trays (30 eggs per tray) = 275 940 000 trays per annum

At $2.18 per tray, the total annual value of eggs from all commercial layers will be = $601,549,200

Layer breeders = 10 % of 42 000 000
= 4 200 000

Layer breeders in production = 75 % of 4 200 000
= 3 150 000

At 75 % production:

Total expected chicks per breeder per annum (100 are saleable pullets) = ~200 chicks

Total expected number of valued chicks (pullets) per annum = 100 x 3 150 000

If chicks price range between $0.70 and $1.13 with an average of $0.93:

Total value of chicks expected would be = 100 x 3 150 000 x $0.93
= $294,163,424

Total value of chicks and eggs expected from layer breeders and commercial layers = $294,163,424 + $601,549,200
= **$895,712,624**

Calculating for ʊ (direct costs)

PSʊ1 = Actual determined direct value based on the outbreak situation (January to August)

PSʊ2 = Estimated direct value based on mild scenario of HPNAI outbreak (10 % losses in commercial poultry population).

PSʊ3 = Estimated direct value based on severe scenario of HPNAI outbreak (70 % losses in commercial poultry population).

PSʊ = Market value of birds + value of chicks lost

PSʊ1 = $5,732,460 + $1,074,023 = $6,806,483

PSʊ2 = $37,926,000 + $29,416,342 = $67,342,342

PSʊ3 = $265,482,000 + $205,914,397 = $471,396,397

Calculating for β (indirect costs)

PSβ = Cost (glut)

Costs associated with glut: reduction in price observed x (total annual national production [trays per annum] – trays lost to mortality in HPNAI)

PSβ1 cost (glut) 1 = ($2.28 – $2.02) x (275 940 000 – 5 650 704)
= $42,068,373

PSβ2 cost (glut) 2 = ($2.28 – $1.56) x (275 940 000 – 27 594 000)
= $154,612,296

PSβ3 cost (glut) 3 = ($2.28 – $1.16) x (275 940 000 – 193 158 000)
= $83,748,327

Calculating for δ (intangible costs)

Since intangible costs are costs of rearing replacement stock, facilities retention, staff retention, downtime cost and destruction/disposal of remaining of affected flocks,

therefore PSδ = Replacement cost + downtime cost + destruction/disposal cost

Replacement cost = (99.985 % cost for raising pullets to POL* + 0.015 % cost for layer breeders pullets to POL) x total number lost

* *POL: Point of lay bird*

Downtime cost for facilities = Facility cost per bird per annum x downtime period per annum x number of birds

N100 per bird per annum† x 3/12 months‡ x number of birds

† *$778.21 per 1 000 birds per annum for retaining poultry pen (field investigations and data from poultry producers, 2006)*

‡ *Average downtime period is 2–4 months (~3 months)*

Destruction/disposal costs are borne by Government as well as part of the cost of control.

PSδ1 = {(0.99985 x $4.28 + 0.015 x $13.23) x 785 570) + ($0.78 x 3/12 x 785 570)}
= $3,516,156

$$PS\delta 2 = \{(0.99985 \times \$4.28 + 0.015 \times \$13.23) \times 4\,200\,000) + (\$0.78 \times 3/12 \times 4\,200\,000)\}$$
$$= \$18{,}798{,}906$$

$$PS\delta 3 = \{(0.99985 \times \$4.28 + 0.015 \times \$13.23) \times 29\,400\,000) + (\$0.78 \times 3/12 \times 29\,400\,000)\}$$
$$= \$131{,}592{,}341$$

Calculating for γ (miscellaneous costs)

Nigerian Government budget allocation for 2005 used as a guide for 2006.

Compensation reported till date = $182,640 (www.nigeria.gov.ng/avian%20flu%20center)

TABLE 1 Types and number of birds affected between 10 January and 31 August 2006

Species affected	Number	Percentage
Chicken: layer/pullet§	770 826	98.12
Chicken: broiler/cockerel	2 755	0.004
Chicken: layer breeder	11 501	0.015
Guinea fowl/quail	19	0.000024
Duck/goose	148	0.000188
Ostrich*	218	0.000278
Turkey	101	0.000129
Wild bird (multi species)	2	0.0000025
Total	**785 570**	**~100**

§ Include local , backyard and free range laying hens
* Ostriches numbers were estimated based on field investigation

TABLE 2 Parameters used in assessing the economic impacts

S/no.	Description	Symbol	Basic data	Actual scenario	Mild scenario	Severe scenario
1	Population size at risk (layers and breeders)	P	42 000 000	0.0056 % (758 570)	10 % (4 200 000)	70 % (29 400 000)
2	Susceptible population	S	100 %	100 %	100 %	100 %
3	Mortality/disposal		100 %	100 %	100 %	100 %
4	Commercial layer population affected		37 800 000	774 069	3 780 000	26 460 000
5	Layer breeder population affected		4 200 000	11 501	420 000	2 940 000
6	Total market value of adult birds (commercial layer at ~$7 and layer breeders at ~$27.30)	Layer Breeder	$264,600,000 $114,660,000	$5,418,483 $313,977	$26,460,000 $11,466,000	$185,220,000 $80,262,000
		Total	$379,260,000	**$5,732,460**	**$37,926,000**	**$265,482,000**
7	Value of eggs at ~$2.18 (layers only) and meat (old lay value at ~$4.36/bird) per annum	Eggs Meat	$601,549,200 $164,808,000	$15,974,720 $3,374,941	$60,154,920 $16,480,800	$421,084,440 $115,365,600
		Total	$944,899,200	**$19,349,661**	**$76,635,720**	**$536,450,040**
8	Value of chicks expected		$294,163,424	$1,074,023	$29,416,342	$205,914,397
9	Proportion in production		75 %	75 %	75 %	75 %
10	Mean egg price per tray*		N280 ($2.18)	N260 ($2.02)	N200 ($1.56)	≤ N150 ($1.16)
11	Delay in next production		Pre-outbreak period	6 months	6 months	6 months

* Average egg price derived from field data collected before, during and after the crises period of outbreak. Note that egg price per tray of 30 eggs was progressively dropping as outbreak situation worsened. Layer represents commercial layers, Bbeeders represents layer breeders. Other data were derived from UNDP 2006

Other funds and materials acknowledged by the government include monetary and non-monetary income.

Monetary income

1. World Bank Special Emergency Fund = \$50,000,000 (of which \$7,000,000 has been released (WHO 2006)
2. Three banks = \$171,206

Non-monetary income

3. DFID = 15 000 protective personnel equipment (PPE)
4. FAO = 7 500 protective personnel equipment and 750 ℓ (Diskol)
5. WHO = 10 000 doses of Tamiflu
6. USAID = 1 425 protective personnel equipment
7. Israel Government = 1.5 tonnes of medical equipment

Expenditure

Items 3–7 were assessed in monetary value as below:

1. DFID = 15 000 protective personnel equipment = \$1,781,250 (at \$118.75/PPE*)
2. FAO = 7 500 protective personnel equipment and 750 ℓ (Diskol) (~\$20/ℓ†) = \$905,625
3. WHO = 10 000 doses of Tamiflu = \$800,000 (at \$80 per dose of ten tablets§)
4. USAID = 1 425 protective personnel equipment = \$169,219
5. Israel Government = 1.5 tonnes of medical equipment = \$?? (details not available to do actual costing)

Total = \$2,856,094

* *http://www.gallawaysafety.com/disposableprotectiveclothing-c-76.html*

§ *http://www.coreynahman.com/tamiflu.html*

† *Price of comparable virucidal (disinfectant) (Onderstepoort Veterinary Animal Hospital)*

Other organisations, including EU and UNICEF, were also acknowledged by the government. Assuming that all other donations is included in the government spending,

$PS\gamma$ **=** 50 % (expenditure items a, b, c, d) + 100 % (expenditure item e) + reported compensation + non-monetary expenditure

* *Note that items a–e are listed in Table 3*

$PS\gamma$ = \$108,655 + \$155,642 + \$182,640 + \$2,856,094

$PS\gamma$ = **\$3,303,031**

$PS\gamma 1 = PS\gamma 2 = PS\gamma 3$

It is impossible to correlate government spending to the scale of the outbreak; this amount was left unchanged for all scenarios. It seems reasonable to assume that this spending would in fact increase in the event of more severe outbreak.

$PS\gamma = PS\gamma 1 = PS\gamma 2 = PS\gamma 3$ = **\$3,303,031**

RESULTS

Using the above values, the total cost implication was calculated as follows:

$Ci = PS\mho + PS\beta + PS\delta + PS\gamma$

Actual cost implication

Ci = {\$6,806,483 + \$42,068,373 + \$3,516,156 + \$3,303,031}
Ci = \$55,694,043

Scenario A (mild generalised outbreaks 10 % commercial flock)

Ci = {\$67,342,342 + \$154,612,296 + \$18,798,906 + \$3,303,031}
Ci A = \$244,056,575

Scenario B (severe generalised outbreaks 70 % commercial flock)

Ci = {\$471,396,397 + \$83,748,327 + \$131,592,341 + \$3,303,031}
Ci B = \$690,040,096

TABLE 3 Budgets and allocations for 2005 fiscal year

Department	Classification no.	Expenditure items	2005 allocation	% estimated to be spent on HPNAI
FMA&RD	06200002501004	Publicity and advertisement (a)	\$22,757	50
FMA&RD	02500002000240	Animal disease control (b)	\$77,821	50
FMA&RD	02500002000241	National veterinary quarantine services (c)	\$77,821	50
NVRI	02500002000202	Strengthening of central and outstation laboratories (d)	\$38,911	50
NVRI	02500002000205	Research and studies (avian influenza) (e)	\$155,642	100
Total			**\$372,952**	**\$264,297**

FMA&RD Federal ministry of Agriculture and Rural Development
NVRI National Veterinary Research Institute

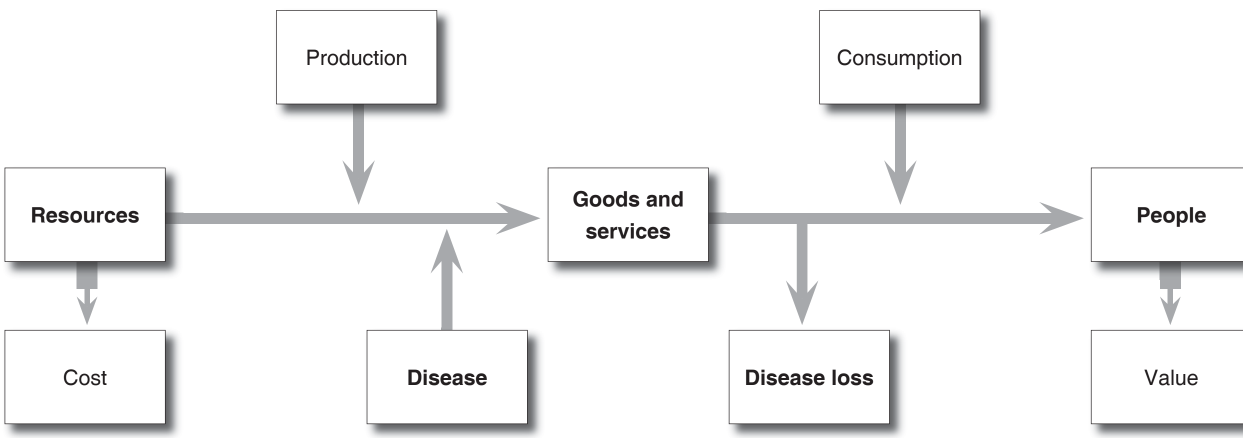
Source: Nigerian Government (2006a and b)

These costs do not include the price of medical supplies donated.

Although our analyses did not consider the broiler industry, we are aware that there was a reported monthly regional export market losses of 12 000 tonnes of poultry meat (Personal communication, Poultry Association of Nigeria 2006). These losses translated to 144,000 tonnes/annum and at an average cost of N350/kg of meat, the broiler industry in Nigeria will have recorded annual direct losses of $392,217,899.

DISCUSSION

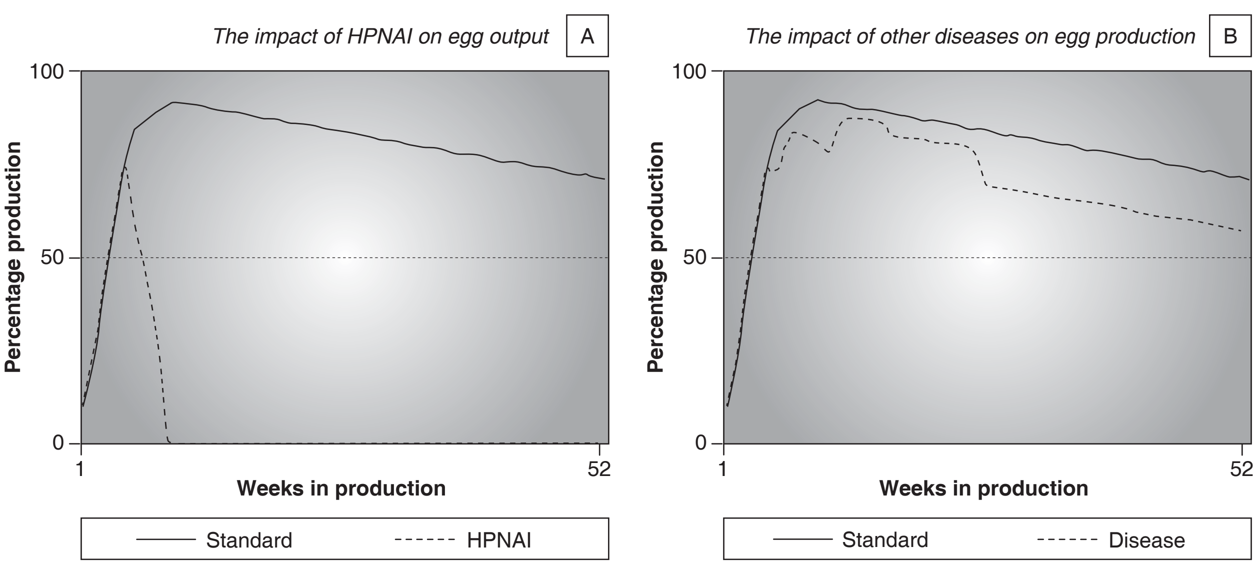
In 2004, Nigeria (West Africa's regional centre for trade and commerce) had approximately 140 million poultry of which 119 million were estimated to be laying birds (FAO 2006a). About 40% of the total poultry flock is commercial or semi-commercial and this accounts for the majority of an annual produc-



** Adapted from McInerney 1988*

* Input of resources is expected to yield goods and services for the benefit of individuals. Animal disease situations prevent quality goods and services from reaching human and come at a huge cost and great loss of values

FIG. 1 Importance of cost of animal disease outbreak



Note: Area between standard and disease graph is the cost. HPNAI cause complete loss in poultry production either through cessation of production, death or culling. Most of the Nigerian farmers reported above 90% reduction in production and the entire flock was finally culled (100% loss)

[Analysis of the Nigerian situation]

Note: Area between standard and disease graph is the cost. Several other avian diseases cause partial loss of poultry production. However, few other diseases attract culling of the affected flock

FIG. 2 Graphs A and B showing evaluation of cost of animal diseases tion of over 476 000 metric tonnes of eggs (0.8 % of the world total) and 211 000 metric tonnes of meat (0.3 % of the world total) (FAO 2006c). Laying hens contribute huge resources to the national poultry flock and this emphasizes the importance of commercial layer flocks for Nigeria's economy. Laying hens not only have production value, but old birds (spent hens) also serve as a major source of eggs and meat for resource poor families.

The Nigerian poultry industry ranks second in importance to petroleum, the country's major source of income (Ducatez *et al*. 2006). Currently, the layer industry has lost about $60 million as a result of HPNAI H5N1 between January and August, 2006. Nigeria's gross national income was $55.9 billion and the gross domestic product was $72.1 billion as at 2004 (World Bank 2006b). This figure, therefore, is a huge economic loss by any assessment. These losses are independent of losses associated with the downstream sectors and broiler industry.

Economists suggest that the price paid for livestock disease should not be assigned monetary values alone (Hanson & Hanson 1983; Howe 1985; McInerney 1988). The cost implication of the disease is, however, important as a starting point to assessing the true effect of the outbreak (Fig. 1). Previous estimates of the cost of avian influenza outbreaks using direct costs grossly undervalue costs associated with HPNAI. A mild scenario of infection affecting 10 % of the commercial laying bird population will cost the country in the region of $245 million and a worsening situation may lead to losses of around $700 million in the layer industry alone.

From the results, any severe outbreaks of HPNAI in a country like Nigeria will mean an extremely huge economic loss and will negatively affect the agricultural industry in the subregion.

Graphical representation of the effect of highly pathogenic avian influenza (Fig. 2) proved that these previous methods may not be sufficient to estimate the cost of this disease. This study considered that the productive lifespan and the potential value of the animals involved should be taken into consideration if a comprehensive evaluation of the cost of animal disease is to be done. A point-of-lay commercial bird or a breeder chicken, although may cost less than a rooster/broiler or a turkey respectively at any point, is more valuable than the latter in term of economic benefit since the laying hen or the breeder will bring economic benefit for at least a year. "Economic value is not simply prices" (McInerney 1988).

Apart from financial losses, the HPNAI H5N1 outbreak also had severe impacts on trade and tourism, created scarcity/unavailability of animal protein due to public health misconceptions, led to higher prices for alternative and often lesser quality products, and increased the costs of livestock farming. There are concerns that HPNAI may become enzootic in the sub-region or in the African continent, which may then become a source of infection or reinfection to other parts of the world. Efforts to step up controls at the borders, surveillance and effective analysis systems are considered justified by the huge resources that will be lost due to such outbreak, if calculated over the productive life.

There is a need for restructuring of the poultry industry which aims for higher levels of biosecurity. A scientifically based contingency plan and fair compensation schemes also needs to be developed by all governments. This must be established and tested periodically before the outbreak of any disease, since time lost to decision-making during disease outbreaks has huge economic impacts.

CONCLUSION

A separate analysis of the socio-economic changes forced on the affected farmers and the costs of different control efforts is still necessary to assist the decision makers in prioritizing all efforts aimed at controlling HPNAI in Nigeria. An assessment of the effect of the HPNAI on other categories of service providers, including day-old-chick suppliers, feed millers and other input suppliers, the hospitality industry, and sole traders in poultry products as well as animal pharmaceutical industries will also be essential to comprehensively assess the overall effect of HPNAI.

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