The Journal of Animal & Plant Sciences, 26(5): 2016, Page: 1418-1428
ISSN: 1018-7081

DETERMINANTS OF WILLINGNESS TO PAY FOR BIOSECURITY MEASURES AMONG POULTRY FARMERS: A MITIGATION RESPONSE TO BIRD FLU INCIDENCE IN NIGERIA

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ABSTRACT

In February 2006, the first confirmed case of bird flu in Nigeria was reported at Sambawa Farms. Recently in 2015, there was another outbreak of bird flu in Lagos and other states in Nigeria. The majority of the subsequent outbreaks occurred in Commercial and Semi-Commercial poultry with few outbreaks in the village/rural poultry farms. Nigerian government took measures to curtail the outbreaks and to prevent re-occurrence through culling the infected birds and training on the use of biosecurity measures. Many of these measures were possible through donor funds, which is mostly one-off assistance. However, after withdrawal of this assistance, the sustainability of use of biosecurity measures depends on the farmers' ability and willingness to pay. Many researches have been conducted on poultry diseases in Nigeria, little or none of these researches has been able to examine the farmers' willingness to pay for biosecurity measures. This is very critical and important in sustainability of bird flu preventive measures when the assistance of government, donors and NGOs are withdrawn. Thus in orders to achieve the broad objectives of this study, many questions were asked: what factors encourage or discourage farmers' willingness to pay for biosecurity measures? What determines willingness to pay for biosecurity measures across scales of poultry operations? The major findings of the study include that willingness to pay for biosecurity measures varied across the flock size and adoption of biosecurity measures was positively associated with scale of poultry operation and education of the farmer. The major recommendation of this study is that policy makers should consider socioeconomic characteristics of the farmer and the flock size in setting price for payment of biosecurity measures. Thus, study provided a useful insight on how to make the poor participate in their country efforts to control the disease.

JEL Code: C21, D12, I15 and N57.

Key words: Willingness to pay, Poultry, Biosecurity measures

INTRODUCTION

The incidence of bird flu H5N1 attracted considerable public and media attention because the viruses have shown to be capable of causing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the greatest impact of the disease on income of highly diverse poultry industries in Nigeria. In response to this, bird flu control measures have so far focused on implementing prevention, control and eradication measures in poultry populations in Nigeria (Biro *et al*., 2013).

Nigeria has an estimated 274 million birds in 2013 (NBS, 2014). The largest poultry producing states are Kano, Bauchi and Kebbi and the states with the highest poultry density are Anambra, Imo and Lagos (AICP, 2014). The types of poultry commonly reared in Nigeria are chickens, ducks, guinea fowls, turkeys, pigeons and ostriches. The poultry that are of major economic importance in Nigeria are chickens, guinea fowls and turkeys. Poultry is raised under two distinct production systems based on scale, stock, husbandry and productivity. They are extensive system, consists of rural free roaming poultry, which is about 85% of total poultry stock in Nigeria as well as the intensive system consisting about 15% mainly grown in urban cities or own by wealthy poultry merchants living in urban Nigeria (Aruma, 2011; NBS, 2014; Jeong, *et al*, 2014). Backyard (intensive) poultry producers are widely distributed in the peri-urban areas. The commercial production systems based on large, dense and uniform stocks of exotic poultry breeds. The extensive systems tend to be free range and usually local breeds and/or mixed strains are used with little or no veterinary inputs. The literature on the number of poultry farms in the commercial, semi-commercial and village production systems by zone shows that village production system of poultry production are more prevalent in Northern Nigeria, the major producers of semi-commercial and commercial system of poultry production are located in Southern part of Nigeria (Obi *et al*. 2009). The Nigerian poultry subsector has been widely affected by the Bird flu outbreaks. Numerous outbreaks between January 2006 and July 2008 as well as re-occurrence in 2015 rendered the bird flu disease status in the country as endemic. The outbreaks occurred in all poultry production systems, including backyard/village extensive systems (Obi *et al*. 2008, Alexander, 2007; Guardian, 2015). The economic costs of adopting and practicing the biosecurity measures are not well known to stakeholders in poultry value chain (UNDP 2006; Obi *et al*, 2008, OIE, 2014). In addition, in view of the fact that poultry population is dominated by smallholder farmers, the use of biosecurity measures will be probably reduced because of level of poverty and ignorance. In Nigeria, government in collaboration with donors and other stakeholders advocated some control measures called biosecurity. These biosecurity are six. They are; containment measures from soft material (e.g. netting or cages), footbaths and containment measures from soft material, containment measures from hard material (such as wood, bricks or mud), regular disinfection and containment measures from hard material (e.g., bricks, wood), vaccination and regular monitoring by the veterinary services or by the poultry input supplier (see section of methodology for their description). When the households decide to make out-of-pocket payments for biosecurity measures is usually difficult especially for the poor poultry farmers. This is because biosecurity payment is not expected to exceed a certain threshold of household income. In most circumstances, smallholder poultry farmers face payment of biosecurity that exceed their production capabilities, which has created low use of biosecurity. This has become a major source of concern and worry about the sustainability of preventive zoonosis disease advocated by the Nigeria and other similar low and middle-income countries (LMICs) where bird flu incidence has occurred.

Understanding these factors affecting behavior is important in sustaining disease preventive measures in developing countries with similar disease outbreak. Therefore, investigation into the determinants of willingness to pay for biosecurity options becomes a compelling necessity.

This study tried to provide insight into factors influencing poor producer's behavior in Nigeria so as to help regulatory decision makers evaluate risk management options in terms of their costs and benefits especially as it concerns the biosecurity measures in poultry industry in Nigeria.

MATERIALS AND METHODS

This study was conducted in Nigeria using survey design. The survey was conducted in three states. Kano State, Anambra State, and Lagos State, which were considered high and medium risk areas for Bird Flu introduction and transmission based on the risk maps developed in the project. There are seven states classified as high and medium bird flu disease risk in terms of transmission and introduction. The high risk areas are Kano State, Borono State, Sokoto State, lagos State, while medium risk areas are Anambra, Rivers. Kastina. All other states in Nigeria are classified as low risk areas in bird flu introduction and transmission (NBS, 2014; AICP, 2014). The choice of these three states was informed based on the fact that population of poultry producers in these states accounted for 67.5% of poultry producers in Nigeria 2013. In addition, the incidence of bird flu accounted for 80% of the entire disease incidence in Nigeria (NBS, 2014). Given the focus of the project was on the poor, the distribution of enumeration areas was skewed to rural areas. Following the UNDP (2009) definitions of poultry production system, Nigeria poultry industry is classified into four production systems (backyard/free-range (BY), and small scale (SS), and medium scale (MS) and large scale (LS). The sampling unit was household because 97% and 75% of rural and urban household rear/own poultry respectively in Nigeria (Obi, *et al*, 2009). A complete listing of housing units and households in each selected enumeration area provided the frames of households (HHs) for the second stage selection in selected EAs. The total of 30 enumeration areas were sampled in each state based on poultry population, which was provided by Poultry Association of Nigeria (PAN) and Avian Influenza Controlled Project Office (AICP) in each of the selected state. Given the focus of the project was on the poor, the distribution of enumeration areas was skewed to rural areas. Therefore, 23 enumeration areas were selected in rural areas or peri-urban areas and 7 enumeration areas were selected in urban areas. From each of the enumeration areas 8 housing unit were selected from each state creating a sample of 240 housing unit.

A random selection of producers within each production system was made. Ideally, this was done by selecting randomly from a list of poultry producers in each category. The final sample size was (after non-response and other data quality issues) 611 households out of which 73% (or 445) were located in rural or peri-urban areas. Table 1 below provides a distribution of households sampled across the states.

Table 1. Number of Local Government Areas, Enumeration Areas and Housing Units in Selected States

S/N	STATE	LGAs	EAs	HHs
1	Kano	44	440	4400
2	Anambra	21	210	2100
3	Lagos	20	200	2000
	Total	85	850	8500

Source: National Bureau of Statistics, 2014.

Note: LGAs =Local Government Areas; EAs = Enumeration Areas; HHs = Households

Table 2. Sample Size in Different Categories of Poultry Production System

	Free Range (<= 50 birds)	Small Scale (51 - 999 birds)	Medium Scale (1000 - 5000 birds)	Large Scale (> 5000 birds)	All Households
Anambra	163	34	5	1	203
Lagos	121	49	23	15	208
Kano	95	66	22	17	200
Total	379	149	50	33	611

Source: 2014 Field Survey

Specification of the econometric model and estimation method: A contingent valuation method was used to capture the stated preference or willingness to pay of poultry producers for control measures that would reduce the risk of bird flu infection and spread. In this method, a hypothetical market for a non-market good or novel product is suggested, where a group of subjects is invited to transact in that market, and the transaction results are recorded. The values generated through the use of the hypothetical market are treated as estimates of the value of the non-market good or service, contingent upon the particular hypothetical market (Mitchell and Carson, 1989). The elicitation method used in Nigeria is open ended (OE), where the respondent is asked "How much are you willing to pay?" The respondent is therefore free to state a maximum amount they would be willing to pay for the specified good or service (c.f. Brookshire, *et al*, 1983).

We estimate the determinants of WTP using the stated maximum willingness to pay for six proposed bird flu prevention options. The dependent variable is log of the maximum price $(\log(WTP_i))$ that the household is willing to pay for each *'i'* control option. Since the error terms are likely correlated across the six estimation equations, we use Zellner's seemingly unrelated regression (SUR) (see Mitchell and Carson, 1989). Each estimation equation includes the same explanatory variables as in the estimation models of determinants of actual biosecurity actions (Table 8). In addition, the number of actual biosecurity actions currently taken (biotic) is included in each estimation equation to test the correlation between the WTP for hypothetical control options and actual biosecurity actions. The six-equation system is estimated using generalized least squares, expressed as follows:

$$\log(WTP_i) = \alpha + \beta_i X_i + \varepsilon_i, \qquad i = 1,2,3,4,5,6$$

where X_i's are composed of cognitive factors such as knowledge about Bird Flu symptoms, beliefs on safe practices and handling of poultry and poultry products, and perceptions on disease transmission risk; socio-economic variables such as household size, years of experience in poultry raising, level of education, presence of children under 5 years old, household income, poultry flock size, and other variables defined in section 4.2; ε_i are error terms that links the 6 equations.

Control measures evaluated in terms of smallholders WTP: Next in the surveys households were asked about their willingness to pay for implementing six hypothetical control measures listed below.

1. **Containment measures from soft material (e.g. netting or cages):** This measure refers to the use of soft material to enclose poultry in order to avoid scavenging and contact with other (wild or domesticated) birds.
2. **Footbaths and containment measures from soft material:** This measure assumes that in addition to measure 1 above, a footbath is used for poultry keepers to wash and disinfect their feet in before entering the enclosed area.
3. **Containment measures from hard material (such as wood, bricks or mud):** This measure refers to the use of hard material to build a coop to enclose poultry in order to avoid scavenging and contact with other (wild or domesticated) birds as well as with rodents and other contaminants.
4. **Regular disinfection and containment measures from hard material (e.g., bricks, wood):** This measure assumes that a coop made of hard material (as described in measure 3 above) is used and in addition, the coop is disinfected by using soapy water and disinfectant after each grow out cycle.
5. **Vaccination:** This measure includes vaccination of the flock against flu once every cycle (i.e. every four months) either by the public sector (Veterinary Services or Para veterinary service in the district) or by the private sector (poultry input supplier).
6. **Regular Monitoring by the Veterinary Services or by the poultry input supplier:** This measure involves the monitoring of the poultry farm once a month for disease; ensuring the control measures (if any used) are implemented appropriately and providing advice on how to adopt/improve the use of the control measures. These services would be provided either by the public sector (Veterinary Services or Para veterinary service in the district) or by the private sector (poultry input supplier).

RESULTS AND DISCUSSION

Profile of sample poultry households: The survey shows that the majority of the households raised either native chick or hybrid broiler and used a free-range style of production. The result shows that the total income per capita, coops housing expenditure, coops health and sanitation expenditure increased by size of operation. The average poultry income per capita was N1788 ($13) for free range producers compared to N5851 (($42) for large scale producers. Health and sanitations expenses increased by size of producers. As expected the total poultry income and poultry income per capita increased as the flock sizes increased. This implies the importance of poultry income to the livelihood of poultry farmers (see Table 3).

Biosecurity: Biosecurity related activities commonly carried out are checking poultry house daily for dead or sick birds, quarantined new purchased poultry, checked the symptoms of diseases before purchase and frequently cleaned floors and cages from poultry droppings. These practices are not necessarily specific to bird flu. Table 4 reports type of biosecurity measured reported being used by flock size in 2014. As expected, more small scale, medium scale and large scale producers reported keeping the doors closed at all times, while less of the free range producers followed this practice. Over 70% of all producers regardless of size checked their poultry houses regularly for dead or sick animals. Sixty percent of all size producers reported quarantining new birds prior to having them join the flock, which increases with the size of flocks. Further analysis shows that more dominant safety practices by farmers are frequently clean floors and cages from feces (80.5%), check symptoms of diseases before purchase (80.9%) and check poultry house daily for dead or sick birds (86.9%). However, the unpopular practices are visitors cleaning the coops with disinfectant (38.4%) and visitors changing clothes before attending to the birds in coops (29.6%). This low application of these controls attributed to cost of performing these activities.

Table 3. Importance of Poultry in Terms of Income Share to Total Household Income

Variables	Free Range (<= 50 birds)		Small Scale (51-999 birds)		Medium Scale (1000-5000 birds)		Large Scale (>5000 birds)		All Households	
Total household income	Naira	USD	Naira	USD	Naira	USD	Naira	USD	Naira	USD
	N532025	$3800	N69514	$4965	N2153147	$15380	N7549105	$53922	N1083455	$7739
Total income per capita	125228	894	179041	1278	733531	5240	1684288	12031	272365	1945
Total poultry income	4668	33	4845	35	12015	86	14703	105	5854.63	42
Poultry income per capita	1788	13	1836	13	4318	31	5851	42	2226	16
Crop agriculture income per capita	78758	563	132735	948	634251	4530	1619536	11568	220595	1576
Non-Ag income per capita	33322	238	347512	248	53804	384	50954	364	36299	259
Household expenditures	196273	1402	192972	1378	279217	1994	608734	4349	224474	1603
Per capita expenditures	55634	397	54240	387	95719	684	204292	1459	66638	476
Food expenditures	65527	468	69772	498	76685	548	170724	1219	73059	522
Utilities expenditures	33177	237	40478	289	57619	412	118647	847	41556	297
Housing expenditures	2942	21	2103	15	2928	21	11690	84	3202	23
Education expenditures	9239	66	5281	38	7198	51	23276	166	8858	63
Health and sanitation expenditures	13160	94	17060	122	25781	184	39586	283	16584	118

Source: Field Survey, 2014

Table 4. Biosecurity measures amongst poultry producers in Nigeria by flock size

Biosecurity Measure	Free Range (<= 50 birds)	Small Scale (51 - 999 birds)	Medium Scale (1000 - 5000 birds)	Large Scale (> 5000 birds)	All Households
Closed doors in poultry house all the time	55.4% (0.50)	75.0% (0.43)	80.4% (0.40)	76.7% (0.43)	63.5% (0.48)
Check poultry house daily for dead or sick birds	83.4% (0.37)	92.0% (0.25)	93.5% (0.25)	92.9% (0.26)	86.9% (0.34)
Kept same poultry cage during the outbreak in village	71.0% (0.45)	82.9% (0.38)	82.2% (0.39)	82.1% (0.39)	75.5% (0.43)
Quarantined newly purchased poultry	56.4% (0.50)	68.3% (0.47)	72.3% (0.45)	78.5% (0.42)	62.0% (0.49)
Check the symptoms of diseases before purchase	78.4% (0.41)	84.1% (0.37)	87.0% (0.34)	86.2% (0.35)	80.9% (0.39)
Used all in and all out method for each type of poultry	57.3% (0.50)	72.7% (0.45)	80.6% (0.40)	73.7% (0.45)	64.8% (0.48)
Monitored contact between your's and neighbors' poultry	50% (0.50)	67.6% (0.47)	79.5% (0.41)	73.1% (0.45)	58.3% (0.49)
Monitored contact between your's and wild poultry	47.8% (0.50)	70.9% (0.46)	81.6% (0.39)	64.3% (0.49)	57.8% (0.49)
All visitors cleaned with disinfectant	29.3% (0.46)	42.2% (0.50)	65.8% (0.48)	56.7% (0.50)	38.4% (0.49)
All visitors changed clothes	26.0% (0.44)	31.7% (0.47)	42.1% (0.50)	33.3% (0.48)	29.6% (0.46)
Frequently cleaned floors and cages from feces	77.6% (0.42)	84.6% (0.36)	86.0% (0.35)	85.2% (0.36)	80.5% (0.39)
Total number of biosecurity measures implemented	4.92 (2.97)	6.23 (2.66)	7.20 (2.68)	8.89 (2.26)	5.52 (2.95)

Source: Field Survey, 2014; Figure in parentheses are standard deviation

Table 5 describes the willingness to pay of different size producers for six types of hypothetical biosecurity measures that can be implemented to prevent the spread of Bird Flu. The table was able to identify that poultry farmers' willingness to pay maximum of N3871.84 or USD $28, N14006.21 or USD $100, N17435.34 or USD $125 for cage/netting, coops construction/disinfection for one year and construction of coop from local materials respectively. Further analysis shows that the farmers priced vaccination and monthly monitoring low. Construction of coop and disinfection willingness to pay increased as the scale of poultry operation increases.

For those who are not willing to pay, Table 6 provides explanation for any given hypothetical biosecurity measures. For improved cage or netting or coop build from local material nearly 35% of respondents said they could not afford to pay for increased measures. Slightly over 40% felt they could not afford the cost of adding improved cage, netting, and disinfectant liquid for feet washings. Less of those interviews (27%) or less reported that they could not afford the cost of disinfectant once a year by vet services, vaccinate one a month, or vet monitoring once a month. Over 32% felt it was the government's responsibility to pay for that measure.

Determinants of the Willingness to Pay for Biosecurity Measures: To conclude the factors that influenced the decision of poultry farmers to adopt six biosecurity measures, we estimate the determinants of actual biosecurity practices currently adopted by the producers. Using the responses to the questions regarding the six biosecurity measures, we implement two regressions. First, we construct a count variable that represents the total number of biosecurity actions among the six that the producers currently implement (biotitic). Using the count variable as the dependent variable, a count model is estimated. Second, by stacking the binary responses (yes or no) to all of the six biosecurity actions, we implement panel-data probit (random-effects probit) to estimate what influences the probability that the producers adopt the six biosecurity practices. In this regression each producer has six observations.

Table 5. Mean of the stated willingness to pay for selected control measures (in USD).

	Free Range (<=50 birds) (N = 379)	Small Scale (51 - 999 birds) (N = 149)	Medium Scale (1000 - 5000 birds) (N = 50)	Large Scale (>5000 birds) (N = 33)	All Households (N = 611)
WTP (price) for	$14.30	$14.38	$5.89	$6.81	$20.37
Cage or netting	($23.06)	($38.86)	($20.83)	($22.38)	($27.65)
WTP (price) for	7.57	7.80	2.97	2.79	6.99
Cage/netting + disinfectant liquid for feet washing	(12.36)	(17.69)	(6.85)	(5.12)	(13.35)
WTP (price) for	34.90	35.68	36.00	38.87	40.62
Coop from local materials	(86.29)	(121.25)	(117.79)	(109.12)	(100.04)
WTP (price) for	56.54	76.73	94.46	43.51	63.86
Coop + disinfection by vet service once a year	(106.85)	(143.85)	(186.91)	(91.16)	(124.54)
WTP (price) for	4.31	4.90	2.45	8.73	4.54
Vaccinate poultry once a cycle (once/4 months)	(8.78)	(8.72)	(4.44)	(17.89)	(9.27)
WTP (price) for	2.54	2.65	1.55	3.73	2.55
Monthly vet service monitoring	(4.97)	(4.07)	(2.98)	(4.37)	(4.61)

Note: Values in parenthesis are maximum willingness to pay in United States Dollars as reported by farmers.
Source: Field Survey, 2014

Table 6. Reasons for not willing to pay for hypothetical control measures

	Cage or netting	Cage or netting + disinfectant liquid for washing feet	Coop from local materials	Disinfectant once a year by vet services	Vaccinate poultry once a month	Vet monitoring once a month
I cannot afford to pay anything	36.3%	41.5%	34.5%	21.7%	26.5%	23.7%
I'd buy it if I had credit	38.0%	32.6%	33.0%	27.9%	33.4%	24.9%
The reduction in risk/probability is too small	30.2%	30.3%	23.3%	26.7%	25.6%	34.3%
I think that BIRD FLU is not a priority among poultry diseases	31.1%	28.8%	38.6%	41.9%	36.7%	31.7%
Not interested in poultry production	21.9%	32.0%	28.6%	22.6%	29.6%	30.3%
If others in the village so it then I'll do it too	28.7%	27.9%	28.7%	28.7%	27.1%	25.7%
I don't believe the measure will have effect	31.8%	33.1%	36.3%	29.4%	37.3%	35.2%
The government should pay for it	32.4%	46.6%	45.1%	37.8%	37.9%	32.2%
Need more information to answer	43.2%	42.8%	38.1%	27.8%	39.0%	39.0%
Too complicated/ do not have much time	18.5%	21.6%	23.1%	26.1%	22.7%	22.6%

Note: Values reported in percentage of sample that agrees or strongly agrees with each statement.
Source: Field Survey, 2014

Both sets of models included the same set of explanatory variables. First, all three KAP indices are included in the estimation model to analyze how knowledge, beliefs, and perception about disease and disease risks influence actual biosecurity decisions. For the random-effects probit estimation, we also include dummy variables representing each of the biosecurity actions. The endogeneity of actual biosecurity (biotitic) and the past poultry disease experience was again tested and rejected.

The regression results are listed in Table 7. The results are almost similar between Poisson regression and the random-effects probit regression. One important finding from these regressions is that KAP indices are found unimportant in explaining the actual biosecurity decisions of the Nigerian poultry producers. This implies that there is some disconnect between the formation of knowledge, beliefs in good practices and perception about disease risks transmission and the biosecurity practices that the producers adopted. Understanding this disconnect seems most imperative in designing public policies intended to encourage small poultry producers to adopt biosecurity measures in Nigeria. Other findings include the following observations. As was expected, the biosecurity adoption levels and probability are positively associated with education of the household head, which did not appear significant in the KAP indices regression results. This implies that household education and outreach program is effective in influencing household biosecurity behavior. Finally, we found that producers with past experience with poultry diseases and those with layers implement more biosecurity actions or increase their subjective probability in adopting biosecurity actions. In addition, the regional dummy though positive compared to household residence in Lagos, which was insignificant. This implies that household being in a particular region has no influence in probability of adopting a particular biosecurity measures in poultry industry in Nigeria.

Table 7. Estimation results of actual biosecurity actions amongst poultry producers in Nigeria.

	Poisson Biosecurity	**Random-effects probit**
Index on knowledge on AI symptoms	0.0176	-0.0103
	(0.0237)	(0.0707)
Index on beliefs on good practices handling poultry products	-0.0055	0.0730
	(0.0307)	(0.0895)
Perception of disease risk (1 is high risk; 4 is no risk)	-0.0255	0.1367
	(0.0285)	(0.0873)
Head's years of poultry raising experience	-0.0027	0.0004
	(0.0038)	(0.0112)
Number of people in HH	0.0043	-0.0061
	(0.0123)	(0.0362)
Gender of House Hold Head (1for female; 0 other wise)	0.0895	0.0741
	(0.0734)	(0.2157)
Head's yrs of education	0.0361***	0.0672*
	(0.0137)	(0.0398)
Head's yrs of education, squared	-0.0015**	-0.0024
	(0.0007)	(0.0021)
Child: dummy-1 if HH has child <12 years old	0.0854	0.3011*
	(0.0536)	(0.1619)
Ln of total HH income	0.0097	0.0121
	(0.0076)	(0.0207)
Log of total poultry flock size	-0.0000	-0.0101
	(0.0055)	(0.0159)
Log of layer flock size	0.0096**	0.0346**
	(0.0046)	(0.0141)
Distance to nearest poultry farm	0.0005	0.0001
	(0.0006)	(0.0019)
Distance to animal health shop	-0.0001	-0.0003
	(0.0008)	(0.0023)
ifdisease: dummy =1 if there ever been an AI outbreak in the village	0.0791	0.3014*
	(0.0522)	(0.1557)
Kano: dummy=1 if HH is from Kano	-0.0487	-0.0501
	(0.1107)	(0.3183)
Anambra: dummy=1 if HH is from Anambra	-0.0594	0.0914
	(0.1107)	(0.3190)
Constant	1.5915***	
	(0.2447)	
Closed doors in poultry house all the time		1.3223***

		(0.1539)
Checked poultry house daily for dead or sick birds		2.6862***
		(0.1849)
Kept poultry in the cage during the outbreak in the village		1.7969***
		(0.1609)
Quarantined new purchased poultry		1.2388***
		(0.1551)
Checked the symptoms of diseases before purchase		1.9897***
		(0.1617)
Monitor interaction/contact between yours and neighbors' poultry		1.3345***
		(0.1600)
Monitored contact between your poultry and wild poultry		1.3554***
		(0.1624)
All visitors visiting the house or livestock farm are required to clean with disinfectant (go through foot bath)		0.2923*
		(0.1640)
Frequently cleaned floors and cages from feces		2.3099***
		(0.1702)
Operate an "all in-all out" policy for each batch/cycle		1.2967***
		(0.1736)
Constant	-1.1562	-2.0563**
	(1.0317)	(0.8031)
lnsig2u		0.0502
		(0.1419)
Constant	-0.3014***	
	(0.0750)	
Load		
Constant	8.8356*	
	(5.2360)	
Observations	611	2673
Log-likelihood	-979.0981	-1247.9915
chi2	70.4866	387.0977
chi2_c		394.7225
P	0.0000	0.0000
Sigma	-0.3014	1.0254
	(0.0750)	(0.0727)
Rho	0.9362	0.5125
	(2.3190)	(0.0354)

*** p<0.01, ** p<0.05, * p<0.1; Standard errors in parentheses; Source: Computed from Field Survey, 2014

Determinants of Actual Biosecurity Action: The SUR results are found in Table 8. The overall fit of each regression model in terms of R^2 value ranges between 0.281 and 0.391. Several important findings emerge. First, the households' actual biosecurity levels and their willingness to pay are negatively and significantly associated with measures one (cage/net), two (cage/net with footbath), three (Coop from local materials), and five (Vaccinate poultry once a cycle (once/4 months)). That is, holding everything else constant, those producers that took more actual biosecurity measures are likely to pay less for the proposed control options 1, 2, 3, and 5 if they become available in the market. Second, the KAP index on beliefs is negative and significant (except for measure one (cage/net) on which was not significant) with WTP indicating that households with higher KAP indexes on beliefs are willing to pay less for biosecurity measures. This implies that these farmers who believe in good practices and safe handling of poultry and poultry products think that their actual biosecurity practices would protect their flocks from bird flu risks.

The latter result needs to be contrasted with the estimation result from the determinants of actual biosecurity actions (Table 7), where we found the actual biosecurity actions was negatively and significantly associated with the village dummy variable indicating a past history of confirmed infected cases. This implies that, while those producers from villages that have experienced bird flu case implement fewer biosecurity measures or are less likely to implement each of the measures; they, at the same time are willing to pay more to protect their flocks from bird flu risks. This is the case where they are already implementing these measures because they have them already. The second result confirm this idea because they are willing to pay more for the biosecurity.

We also found that those with higher KAP knowledge on bird flu symptoms was only correlated with WTP for measures 3 and 6 (regular monitoring of vets), and those who are more concerned about disease transmission in the village (perception KAP) are willing to pay for control measure 6. Fourth, dummy variable for Anambra where consistently significant for all measures and the dummy for Kano was significant for 5 out of 6 control options (cage/net was not significant). Fifth, those producers who have experienced bird flu in the past are willing to pay for measures 2, 3 and 5, which is consistent with the estimation result from the determinants of actual biosecurity actions in Table 7, i.e., producers that have experienced bird flu in the past implement more biosecurity measures and are at the same time more willingness to pay to protect their flocks from bird flu risks.

Other important results are as follows. Producers with bigger poultry flock size are more willing to pay for measures 5 and 6. Educational attainment and income were not significantly associated with higher WTP. This indicates that there are other factors that influence the farmers' willingness to pay for the biosecurity measures other than income. Opposite coefficient signs between actual biosecurity action and WTP for hypothetical biosecurity measure 1 (cage/net) is found for households with layers: those producers with more layers was found to adopt more biosecurity actions or be more likely to adopt these actions (Table 7), and this was not consistent with the willing to pay more for measure 1 (cage/net) but was consistent with the willingness to pay for regular monitoring of vets.

Future research is needed to understand the association between cognitive factors (knowledge, beliefs, and perceptions), actual behavior, and hypothetical willingness to pay, which likely contribute to identification of the methods and the target population and location for appropriate public interventions.

Table 8. Seemingly unrelated regression results for willingness to pay for hypothetical biosecurity options

	lnmaxwtp1	Lnmaxwtp2	Lnmaxwtp3	Lnmaxwtp4	Lnmaxwtp5	Lnmaxwtp6
Index on knowledge on AI symptoms	0.1839	0.4845	1.0329**	0.2055	0.3661	1.0163***
	(0.4000)	(0.3875)	(0.4164)	(0.4075)	(0.3710)	(0.3764)
Adjusted index on beliefs on safe practices handling poultry products	-0.0057	-1.5569***	-1.9546***	-1.2526**	-1.4985***	-2.4864***
	(0.5165)	(0.5003)	(0.5376)	(0.5262)	(0.4790)	(0.4859)
Index on perceptions about the level of concern about disease spread within a village	0.5112	0.7285	0.1876	0.1139	0.5635	1.0792**
	(0.4815)	(0.4664)	(0.5012)	(0.4905)	(0.4466)	(0.4530)
Head's years of poultry raising experience	-0.0680	-0.0992	0.0059	0.0646	0.0517	0.0507
	(0.0635)	(0.0615)	(0.0661)	(0.0647)	(0.0589)	(0.0597)
Number of people in HH	-0.1557	-0.0491	0.0081	0.2395	0.1141	-0.0209
	(0.2072)	(0.2007)	(0.2157)	(0.2111)	(0.1922)	(0.1949)
Dummy=1 if household head is female	-0.0628	-1.4058	-2.1799*	-0.5677	-0.6938	-1.5104
	(1.2397)	(1.2009)	(1.2904)	(1.2629)	(1.1498)	(1.1663)
Head's yrs of education	0.0341	0.1496	0.2137	0.1646	0.1980	0.1373
	(0.2175)	(0.2107)	(0.2264)	(0.2216)	(0.2018)	(0.2047)
Head's yrs of education, squared	-0.0110	-0.0094	-0.0093	-0.0009	-0.0081	-0.0111
	(0.0110)	(0.0106)	(0.0114)	(0.0112)	(0.0102)	(0.0103)
Dummy=1 if HH has child <12 years old	1.4595	-0.0169	-1.8688*	-1.2208	-0.9607	-1.0243
	(0.9240)	(0.8951)	(0.9618)	(0.9413)	(0.8570)	(0.8693)
Log of total HH income	-0.0470	0.0315	-0.0697	0.0245	0.1461	-0.0880
	(0.1218)	(0.1180)	(0.1267)	(0.1240)	(0.1129)	(0.1146)

Log of total poultry flock size	-0.1071	0.0663	0.0816	0.0826	0.2258***	0.1654*
	(0.0920)	(0.0891)	(0.0958)	(0.0937)	(0.0853)	(0.0866)
Log of layer flock size	-0.1836**	0.0379	-0.0425	0.0220	0.0587	0.1388*
	(0.0807)	(0.0781)	(0.0839)	(0.0822)	(0.0748)	(0.0759)
Distance to the nearest poultry farms	0.0361**	0.0048	-0.0319*	-0.0165	-0.0393**	-0.0474***
	(0.0178)	(0.0172)	(0.0185)	(0.0181)	(0.0165)	(0.0167)
Distance to the nearest animal health officer	0.0094	-0.0181	-0.0158	-0.0202	-0.0196	-0.0233*
	(0.0142)	(0.0138)	(0.0148)	(0.0145)	(0.0132)	(0.0134)
Dummy variable =1 if there has been an AI outbreak in the village	1.1802	1.7166**	1.9505**	-0.0804	1.6901**	0.1343
	(0.8977)	(0.8696)	(0.9344)	(0.9145)	(0.8326)	(0.8445)
Dummy variable=1 if state is Kano	1.3290	0.7121	6.1183***	7.8326***	5.7842***	7.4786***
	(1.8909)	(1.8317)	(1.9682)	(1.9263)	(1.7538)	(1.7790)
Dummy variable=1 if state is Anambra	8.4197***	8.8353***	13.7540***	16.6187***	10.7148***	10.4085***
	(1.8671)	(1.8086)	(1.9434)	(1.9020)	(1.7317)	(1.7566)
number of actual biosecurity measures used in the farm	-0.2547*	-0.3475**	-0.3526**	-0.2364	-0.3071**	-0.0939
	(0.1506)	(0.1458)	(0.1567)	(0.1534)	(0.1396)	(0.1416)
Constant	-2.9240	6.1288	4.8261	-2.0849	0.4162	8.9220**
	(4.1962)	(4.0647)	(4.3677)	(4.2747)	(3.8918)	(3.9477)
Observations	307	307	307	307	307	307
chi2	125.78	145.17	174.13	197.20	142.04	120.06
P	0.00	0.00	0.00	0.00	0.00	0.00
RMSE	6.701	6.752	7.256	7.101	6.465	6.558
R2	0.291	0.321	0.362	0.391	0.316	0.281

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1
Measure1: Cage or netting; Measure 4: Coop + disinfection by vet service once a year
Measure 2: Cage/netting + disinfectant liquid for feet washing; Measure 5: Vaccinate poultry once a cycle (once/4 months)
Measure 3: Coop from local materials Measure 6: Monthly vet service monitoring.

Conclusions: It was found that smaller and poorer producers adopt fewer biosecurity actions, thus they were considered to be riskier in terms of transmission risks. The biosecurity adoption levels and probability were positively associated with education and household income but not significantly. While we found that the actual biosecurity actions were influenced by KAP indices. The WTP for hypothetical control measures was in general not correlated with KAP indices, and also actual number of biosecurity actions taken is often associated with the WTP levels. In conclusion therefore, policy makers should consider socioeconomic characteristics of the farmer and the flock size in setting price for payment of biosecurity measures.

Acknowledgments: The author is grateful to IFPRI/ILRI, DFID and University of Nigeria, Nsukka for their funding.

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