DOI: 10.1002/vms3.15

Original Article

Assessment of practices, capacities and incentives of poultry chain actors in implementation of highly pathogenic avian influenza mitigation measures in Ghana

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Abstract

The animal health services-seeking behaviour of animal owners related to prevention and control of animal diseases may influence their decisions as to whether or not to use services provided by the public or private sectors. The specific objective of this paper was to assess the practices, capacities and incentives of actors involved in highly pathogenic avian influenza (HPAI) control to provide information for prevention and control in Ghana. Questionnaires were designed based on specific practices, incentives and capacities associated with each mitigation measure that was being assessed. Two peacetime preventive mitigation measures (biosecurity and reporting) and two outbreak containment measures (culling with compensation and movement control) were selected for evaluation. Supply chain actors were characterised based on baseline information. Tables were generated showing proportions of respondents in the various response categories in Likert-scale type itemised questionnaire. Mean scores (and their standard deviations) for the various actors with regard to mitigation measures were calculated. Pair-wise comparisons were done using *t*-ratio statistic and significance of differences were determined at a Bonferroni adjusted *P*-value of 0.0024. The study found statistically significant differences between certain actors for practices (biosecurity, reporting, culling and compensation and movement controls), incentives (reporting and movement control) and capacities (reporting and movement control). The findings provide lessons to help improve education and messages on HPAI and to help provide technical assistance targeted at specific actors to prevent and control future HPAI H5N1 outbreaks in Ghana.

Keywords: Poultry value chain, HPAI, biosecurity, movement control, Ghana, practices.

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Introduction

Ghana experienced three outbreaks of highly pathogenic avian influenza (HPAI) H5N1 in 2007. The mitigation measures instituted by the Veterinary Services Directorate (VSD) included a ban on the movement and sale of poultry and poultry products in and out of infected areas; closure of wet poultry markets in infected areas; quarantine of infected farms; active search/surveillance of the disease in the outbreak area and beyond and disinfection of infected premises and farm machinery and equipment. Other measures were promotion of biosecurity measures and procedures; culling of affected and in-contact birds on the infected farms; culling of all poultry within a 3-km radius which was extended in one case to 5 km and then 8 km; destruction of eggs and feed present on affected premises and compensation for culled birds (Turkson *et al.* 2010). These were in accordance with Food and Agriculture Organisation (FAO) recommendations on the prevention, control and eradication of HPAI (FAO 2004). All the control measures reduce risk but none used in isolation is sufficient (FAO 2004).

According to de Rooij *et al.* (2007), governments are not the only actors in animal disease control as the private sector actors are normally the implementers, beneficiaries and risk-takers in control measures and have core strategies and roles to play if HPAI control measures are to be effective. Disease control and prevention is a shared responsibility between government and the private sector as the private sector tends to be the main investor in livestock enterprises and will need to be engaged by government to ensure that it manages the risk of disease and reports of any disease outbreak to the government (Interministerial Conference on Animal and Pandemic Influenza. Ha Noi (IMCAPI) 2010). It has been suggested that individual farmers have better information about their own preferences, disease risks and responsiveness to various incentives than policy makers, presenting difficulties when public actions alone are used to try to control HPAI efficiently (Beach *et al.* 2006).

The behaviour of actors involved in HPAI control is influenced by factors related to the interaction between the nature of their poultry-related activities, the nature of the disease and risk of its transmission, and the nature of mitigation measures and how they are implemented (Turkson *et al.* 2010). This behaviour is also influenced by the practices, incentives and capacities of actors. Studies in many countries have shown that practices and attitudes for prevention and control of HPAI disease spread and outbreaks have not changed, even though there is some level of awareness or knowledge about HPAI (Fielding *et al.* 2005; Maton *et al.* 2007; Di Giuseppe *et al.* 2008; Leslie *et al.* 2008). Understanding a person's knowledge, attitude, practices and perceptions of and towards risk is a necessary step in determining which cost-effective measure(s) ought to be adopted (Yakhshilikov *et al.* 2009). Beach *et al.* (2006) noted that knowledge of farm behaviour is critical in understanding the distribution of impacts, the extent and cost of private disease prevention behaviour, the spread of HPAI and the effectiveness of public disease control programmes. National Academy of Sciences (NAS) (2009) suggested that capacity assessment information for animal health is critical as it is useful in devising national and local incentives, in establishing a disease surveillance system and in timely disease reporting by local and national stakeholders to protect human and animal health and livelihoods.

The effectiveness of public disease prevention and control measures on the spread of a disease have been shown to depend on how much private prevention behaviour responds to disease prevalence, disease impacts and the economic incentives created by public policy measures (Philipson 2000), as depicted in cases of infectious animal diseases (McCarthy *et al.* 2003). Animal health measures are often influenced by private strategies set at farm level by individuals, at company level by vertically integrated operations or nationally by stakeholders (national associations including traders and processors) (de Rooij *et al.* 2007). The key to success in controlling disease is often the collective decisions of these actors to participate in mitigation measures. Across the value chain, dominant actors may set strategies that essentially govern how these chains operate as found in situations where dominant market actors aim for bigger market share and sustainable growth (de Rooij *et al.* 2007).

A study was done in Ghana in 2009 to assess factors that influence the behaviour of various poultry value chain actors expected to comply with, or be responsible for implementing HPAI control measures in backyard and small-scale broiler and layer chicken production and marketing systems in Ghana (Turkson *et al.* 2010). The objective of this paper, an offshoot of the study, was to assess the practices, capacities and incentives of actors involved in HPAI control in Ghana. This, it was hoped, would provide information to stakeholders to improve the implementation of mitigation measures for HPAI prevention and control in Ghana. The lessons learnt could be useful in future control or used for the control and prevention of other infectious diseases.

Methodology

The study used a supply chain as the unit of analysis rather than individual actors. This was to address the difficulty of designing a sampling strategy that provided a representative distribution numerically and spatially of all relevant poultry supply chain actors. Live bird supply chains were used with producers as primary and fixed sampling units based on which other more mobile actors, particularly transporters, traders and retailers were identified. The study focused on backyard, small-scale broiler and layer live-bird supply chains because live birds represent the greatest risk of H5N1 HPAI virus transmission through virus shedding and contamination of inanimate materials. Four regions out of ten in the country were selected purposively because these contribute significantly to commercial poultry production (Greater Accra 36%, Brong Ahafo 16% and Ashanti 36%) and to backyard poultry production (Northern Region).

Questionnaires were designed based on specific socioeconomic factors (practices, incentives and capacities) associated with each mitigation measure that was being assessed (Kelemework *et al.* 2010; Onkundi *et al.* 2010). Two peacetime preventive mitigation measures (biosecurity and reporting) and two outbreak containment measures (culling with compensation and movement control) were selected for evaluation (Kelemework *et al.* 2010; Onkundi *et al.* 2010). The questionnaires were divided into sections. At the end of each set of questions for each mitigation measure, two open-ended questions were asked for each actor or mitigation agent to state reasons why they could or could not implement a measure. This information helped to explain some of the attitudes measured using the Likert-scale type items. The details of the dimensions representing practices, capacities and incentives influencing actors' compliance from which questions were framed for the questionnaire were similar to those reported by Onkundi *et al.* (2010) in Kenya and Kelemework *et al.* (2010) in Ethiopia.

The study used the FAO Poultry Farm categories identified in 2004 where a Sector 3 (S3) farm was defined as a commercial poultry production system with low to minimal biosecurity and with birds/products entering live bird markets, whereas a Sector 4 (S4) farm was a village or backyard production with minimal biosecurity and birds/products were consumed locally (FAO 2008).

The sampling sites for the S4 producers were generated randomly using GIS software and are shown in Figure 1.

Four points per selected region were generated randomly and for each point, the names of three communities nearest to such points were provided along with their latitudes and longitudes. The enumerators used GPS to locate the community closest to the selected point and the first poultry producer/keeper encountered in that community was chosen for questionnaire administration. The other actors in the poultry value chain who had recent transactions linked to this producer were followed using the snowball method and appropriate actor-specific questionnaires administered.

For the S3 producers, lists of layer and broiler producers in the regions were obtained from the Ghana National Poultry Farmers Association office and the Regional Offices of the Ministry of Food and Agriculture. Random numbers were generated using a random number generator and based on the number of members per region. Those producers in the list whose numbers were chosen were selected for questionnaire administration. Here also, after the initial selection of the S3 producers, the snowball method was used in locating the other actors in the value chain who had recent transactions linked to them. For the implementing agents, five veterinarians from the VSD in the 4 regions (one each from a region except Greater Accra which had two representatives) were purposively selected and questionnaires administered to them. Altogether, there were 16 S4 producers, 16 S3 broiler producers, 16 S3 layer producers, 48 traders, 48 transporters, 48 retailers and 5 implementing agency respondents.

Data were entered into a database designed using SPSS version 17.0 (SPSS, Inc., Chicago, IL, 2007) and analysed using the same software. Supply chain actors were characterised based on baseline information and simple descriptive statistics. Tables were generated showing proportions of respondents in the various combined response categories of always and often; seldom and never; strongly disagreed and disagreed; agreed and strongly agreed; very likely and likely; or unlikely and very unlikely as determined by the questionnaire. Details of the response categories

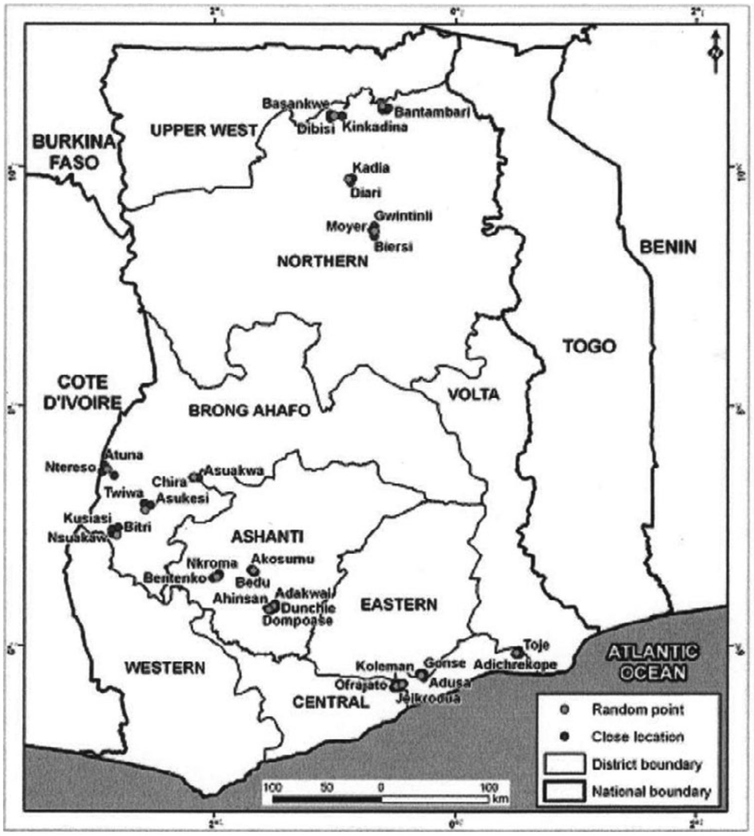

Figure 1 Map of Ghana showing selected points for sampling of S4 producers.

may be obtained from the first author. Mean scores and standard deviations of the Likert-scale items for the various actors for the mitigation measures were calculated in SPSS. The responses to the open-ended questions were transcribed, summarised and grouped.

Multiple comparisons between levels of the same effect were calculated in Microsoft Excel using a *t*-ratio statistic (mean A − mean B/standard error of difference between means), referred to a *t*-distribution with t degrees of freedom, where t = degrees of freedom at the actor level (Kelemework *et al.* 2010; Onkundi *et al.* 2010). The degrees of freedom in a *t*-ratio is $[(n_1 - 1) + (n_2 - 1)]$ where n_1 is the total number of sample A and n_2 is total number of sample B. A Bonferroni adjustment (significance level = alpha/n where n = number of comparisons) was used to adjust the significance level to reduce the false-positive error rate caused by multiple comparisons (Kelemework *et al.* 2010; Onkundi *et al.* 2010). In our case, the chosen alpha was 0.05 and the number of comparisons, n, was 21 giving an adjusted *P*-value of 0.0024.

Results

Table 1 shows the mean scores (±SD) for practices, capacities and incentives of poultry chain actors in Ghana for various mitigation measures (biosecurity, reporting, culling and compensation and movement control). In general, when the mean score for a mitigation measure was higher for an actor compared with another, it meant that the actor with the higher mean score was of the opinion that that measure was more likely to influence compliant with the dimension than the other actor with a lower mean score.

Biosecurity scores among actors for practices ranged from 2.3 for transporters to 3.1 for retailers. For capacities, the biosecurity scores ranged from 2.9 (transporters) to 3.6 (implementing agencies)

Table 1. Mean scores (±SD) for practices, capacities and incentives of poultry chain actors for mitigation measures

Actor	Biosecurity	Reporting	Culling and compensation	Movement control
Practices				
S4 producer	2.8 (±0.6)	2.2 (±0.5)	2.9 (±0.5)	2.5 (±0.9)
S3 broiler producer	2.7 (±0.8)	3.1 (±0.6)	2.7 (±0.7)	4.2 (±0.4)
S3 layer producer	2.4 (±0.4)	3.0 (±0.4)	2.9 (±0.8)	4.1 (±0.4)
Trader	3.1 (±0.5)	3.0 (±0.5)	3.2 (±0.8)	3.2 (±0.8)
Transporter	2.3 (±0.6)	2.5 (±1.0)	n.a	3.2 (±0.7)
Retailer	3.1 (±0.4)	3.0 (±0.7)	2.9 (±0.6'	2.6 (±0.8)
Implementing Agency	3.0 (±0.5)	4.4 (±0.4)	2.0 (±0.7)	2.8 (±0.4)
Total	2.8 (±0.6)	2.9 (±0.8)	3.0 (±0.7)	3.1 (±0.9)
Capacities				
S4 Producer	3.0 (±0.8)	2.7 (±0.6)	2.9 (±0.8)	3.3 (±0.6)
S3 broiler producer	3.2 (±0.6)	3.1 (±0.7)	3.0 (±0.9)	3.1 (±0.6)
S3 layer producer	3.1 (±0.5)	2.8 (±0.8)	3.2 (±0.6)	3.1 (±0.6)
Trader	3.0 (±0.7)	2.9 (±0.8)	2.7 (±0.7)	2.6 (±0.9)
Transporter	2.9 (±0.9)	2.6 (±0.9)	n.a	2.9 (±0.5)
Retailer	3.1 (±0.8)	3.1 (±0.7)	2.7 (±0.7)	2.8 (±0.8)
Implementing Agency	3.6 (±0.5)	2.7 (±0.4)	2.9 (±0.5)	3.1 (±0.3)
Total	3.0 (±0.7)	2.9 (±0.8)	2.9 (±0.7)	2.9 (±0.7)
Incentives				
S4 Producer	3.3 (±0.5)	2.8 (±0.7)	3.2 (±0.9)	2.7 (±0.8)
S3 broiler producer	3.2 (±0.4)	3.2 (±0.7)	2.9 (±1.0)	3.4 (±0.5)
S3 layer producer	2.9 (±0.6)	3.3 (±0.4)	2.9 (±0.8)	3.3 (±0.5)
Trader	2.9 (±0.7)	2.8 (±0.6)	3.1 (±0.9)	3.0 (±0.6)
Transporter	3.0 (±0.5)	2.8 (±0.5)	n.a.	2.5 (±0.7)
Retailer	2.8 (±0.8)	3.0 (±0.5)	3.0 (±1.1)	3.2 (±0.6)
Implementing Agency	2.5 (±0.7)	2.6 (±0.4)	2.5 (±0.4)	2.8 (±0.2)
Total	2.9 (±0.6)	2.9 (±0.6)	3.0 (±1.0)	3.0 (±0.7)

n.a., not applicable.

whereas for incentives the biosecurity scores ranged from 2.5 (implementing agencies) to 3.3 (S4 producers).

Reporting scores among actors for practices ranged from 2.2 (for S4 producers) to 4.4 for implementing agencies, while those for capacities ranged from 2.6 (transporter) to 3.1 (S3 producers and retailers). The reporting scores for incentives ranged from 2.6 for implementing agency to 3.2 for S3 layer producer.

For culling and compensation, the scores for practices among actors ranged from 2.0 (Implementing agency) to 3.2 (trader). The scores for capacities ranged from 2.7 (trader and retailer) to 3.2 (S3 layer producer) while those for incentives ranged from 2.5 (implementing agency) to 3.2 (S4 producer).

Movement control scores for practices ranged from 2.5 (S4 producer) to 4.2 (S3 broiler producer). The scores for capacities ranged from 2.6 (trader) to 3.3 (S4 producer) whereas those for incentives ranged from 2.5 (transporter) to 3.4 (S3 broiler producer.

Table 2 presents results of pair-wise comparisons of poultry chain actors where the *P*-values were significant at Bonferroni adjusted value of 0.0024.

Discussion

The animal health services-seeking behaviour of livestock owners related to prevention and control of animal diseases may influence their decisions as to whether or not to use services provided by the public or private sectors. In poultry production de Rooij *et al.* (2007) observed that in backyard systems (FAO poultry classification Sector 4), poultry health has been the domain of the individual producer

Table 2. Pair-wise comparisons of mean scores with *P*-values significant at Bonferroni adjusted *P*-value of 0.0024.

	m1	m2	*t*-statistic	df	*P*-value
Practice					
Biosecurity					
Trader vs. layer	3.1	2.4	5.54	62	0.0000
Retailer vs. layer	3.1	2.4	5.90	62	0.0000
Trader vs. transporter	3.1	2.3	7.02	94	0.0000
Retailer vs. transporter	3.1	2.3	7.61	94	0.0000
Reporting					
Broiler vs. S4	3.1	2.2	4.46	30	0.0001
Layer vs. S4	3	2.2	4.84	30	0.0000
Trader vs. S4	3	2.2	5.40	62	0.0000
Retailer vs. S4	3	2.2	4.86	62	0.0000
I agency vs. S4	4.4	2.2	9.24	19	0.0000
I agency vs. broiler	4.4	3.1	5.14	19	0.0000
I agency vs. layer	4.4	3	6.22	19	0.0000
Trader vs. transporter	3	2.5	3.07	94	0.0014
I agency vs. trader	4.4	3	6.58	51	0.0000
I agency vs. transporter	4.4	2.5	7.68	51	0.0000
I agency vs. retailer	4.4	3	6.23	51	0.0000
Culling					
Trader vs. I agency	3.2	2	3.25	51	0.0010
Movement control					
Broiler vs. S4	4.2	2.5	6.69	30	0.0000
Layer vs. S4	4.1	2.5	6.29	30	0.0000
Broiler vs. trader	4.2	3.2	6.42	62	0.0000
Broiler vs. transporter	4.2	3.2	6.89	62	0.0000
Broiler vs. retailer	4.2	2.6	10.27	62	0.0000
Broiler vs. I agency	4.2	2.8	6.22	19	0.0000
Layer vs. trader	4.1	3.2	5.78	62	0.0000
Layer vs. transporter	4.1	3.2	6.20	62	0.0000
Layer vs. retailer	4.1	2.6	9.63	62	0.0000
Layer vs. I agency	4.1	2.8	5.78	19	0.0000
Trader vs. retailer	3.2	2.6	3.64	94	0.0002
Transporter vs. retailer	3.2	2.6	3.87	94	0.0001
Capacities					
Reporting					
Broiler vs. transporter	3.1	2.6	3.01	94	0.0017
Retailer vs. transporter	3.1	2.6	3.01	94	0.0017
Movement control					
S4 vs. trader	3.3	2.6	3.45	62	0.0005
Incentives					
Reporting					
Layer vs. trader	3.3	2.8	3.69	62	0.0002
Layer vs. transporter	3.3	2.8	3.95	62	0.0001
Movement control					
Broiler vs. transporter	3.4	2.5	5.47	62	0.0000
Broiler vs. I agency	3.4	2.8	3.67	19	0.0008
Layer vs. transporter	3.3	2.5	4.86	62	0.0000
Trader vs. transporter	3	2.5	3.72	94	0.0002
Retailer vs. transporter	3.2	2.5	5.21	94	0.0000
Retailer vs. I agency	3.2	2.8	3.01	51	0.0020

m1, mean score A; m2, mean score B; df, degrees of freedom; S4, Sector 4 producer; broiler, S3 broiler producer; layer, S3 layer producer; I. agency, implementing agency agent.

because providing animal health services is not very profitable for the private sector and is very difficult for the public sector. On the other hand, for Sectors 3 and 2, whereas the integrated commercial poultry systems are well covered by private animal health providers, a large number of poultry are in production systems that are neither covered by public nor private animal health services. These may have serious implications for practices, incentives and capacities of poultry chain actors for disease prevention and control.

The practice of biosecurity is critical in efforts to prevent and control HPAI H5N1. Otte *et al.* (2008) noted that the effect of biosecurity measures is not only restricted to lowering the risk of HPAI introduction but also to decreasing the risk of other contagious diseases getting to the farm/flock. FAO (2008) recognised biosecurity as vital to the control of HPAI, based on the needs for segregation, cleaning and disinfection. Biosecurity, also, requires people adopting a set of attitudes and behaviours to reduce the risk of introduction and spread of disease agents in all activities involving domestic, captive exotic and wild birds and their products (FAO 2008). The mean scores for biosecurity practices were higher for traders and retailers compared with producers (Table 1). This means that the traders and retailers were more likely to be influenced to comply with these biosecurity dimensions than the producers. The practice of biosecurity should be paramount on the farms because farms have been identified as the most critical control points in Ghana (Mensah Bonsu 2010). The VSD of the Ministry of Food and Agriculture in Ghana provided biosecurity training in all ten regions and also developed a biosecurity manual targeted at poultry producers after the initial outbreak of HPAI H5N1 in 2007. The relatively lower mean scores for biosecurity practice for the producers, compared with others except transporters, may point to the lack of effectiveness of these trainings or low/poor adoption/uptake of the procedures and processes of biosecurity. Mensah Bonsu 2010) noted that even though biosecurity practices were established and enforced during the outbreak period in Ghana, these were not accompanied by incentives for the farms. Commercial poultry producers in this study explained that although the measures were supposed to be normal operational practices their enforcement had increased the farms' operational costs and were, therefore, most often ignored.

FAO (2008) noted that the details of how biosecurity is applied depend on the type of poultry production unit in question; the emphasis being placed on 'bioexclusion' for farms and villages, and 'biocontainment' for markets. The FAO observed that many known biosecurity measures currently in place have been developed mostly for large-scale commercial production systems in developed countries with few of the commonly recommended measures being appropriate for small-scale commercial systems or for rural (free-range) poultry and that biosecurity measures have not been designed for other actors in the chain and service providers. The FAO recommended that where they do not exist, appropriate biosecurity measures must be designed and implemented; where they do exist, they may not be sufficiently effective or implemented widely enough requiring re-evaluation of their effectiveness.

In Ghana, even though some biosecurity procedures were established and a manual was produced during the HPAI outbreak in 2007, the adoption of these procedures was and is very limited or perfunctory. The poultry farmers' associations advocated the adoption and use of levels of biosecurity as a classification system for farms in an effort to encourage adoption of such procedures and processes. A Delphi study in 2010 revealed that the efficacies of six private and nine public control strategies were significantly higher in the commercial than in the non-commercial/semi-commercial producers in Ghana (Birol *et al.* 2010). Biosecurity training and surveillance were identified in the Delphi study as two very effective strategies that might be undertaken by VSD to control HPAI risk in non-commercial/semi-commercial and among small-scale producers in five countries including Ghana. Movement control, on the other hand, was not considered as effective as biosecurity training and surveillance.

FAO (2008) has advised that planning for biosecurity must include socioeconomic analysis to help determine the social and cultural acceptability of proposed measures, the level of cost that people can and are willing to pay and the regulations, incentives and penalties that may be appropriate to induce the change in behaviour necessary in many situations. The decision to invest in biosecurity measures may be influenced by the perception of poultry owners of the risk of disease introduction into their flocks, the economic scale of expected losses once their flock is infected and the additional costs that would be incurred (Otte *et al.* 2008). These are yet to be investigated in Ghana.

Beach *et al.* (2006) noted that Sectors 3 and 4 are generally considered to be more susceptible to infection because of their low levels of biosecurity, as in these systems poultry are usually not confined and may come into contact or mingle freely with wild birds, greatly increasing the risk of spread of HPAI to poultry. Our study found that 75% of S4 producers never confined their chickens during the day and 69% allowed their chickens to mix with their neighbours' flock, increasing the risks for spread of disease. FAO (2008) recommended that biosecurity for S4 producers should emphasise creation of physical barriers against infection and to control access, if need be through public funding; cleaning of inanimate objects and using participatory fieldwork to establish which measures are feasible and sustainable, to produce and disseminate extension messages and to monitor and report on uptake and impact of these messages. Alhaji & Odetokun (2011) from studies in Nigeria advocated community-led initiatives to create physical barriers against infection for free-range poultry keepers because these cannot act alone. They reported that free-range flocks were at lower risk compared with small-scale commercial operators. FAO (2007) advised on the need to find a balance between biosecurity requirements and livelihood demands of affected producers.

Biosecurity improvements in sectors 3 and 4 are difficult to impose and enforce due to the sectors' internal diversity and low investment capacities (FAO 2007). Recommendations for improvement in animal husbandry practices that recognise local constraints and capacities have a higher chance of success and sustainability. Further, any efforts to deal with the complexity of sectors 3 and 4 by imposing strict regulations and restrictions should be undertaken with a good understanding of both epidemiological risk and the sectors' operations. This is because these producers and traders have little incentives to cooperate with authorities and often try to find illegal ways to move birds' outside restricted areas to avoid regulations (FAO 2007). These illegal movements are difficult to monitor and may represent high risks of disease transmission. IMCAPI (2010) recommended that biosecurity measures at the smallholder and village level need to be simple, cheap and cost effective, taking into consideration the existing production systems or else farmers would not be able to implement them or the costs of the measures might outweigh the benefits to the farmer.

The lowest mean score for biosecurity practice in this study (2.3) was for transporters (Table 1) meaning that they were the group least likely to institute biosecurity measures. These, generally, asserted in their responses to open-ended questions that it was not their responsibility to institute certain biosecurity procedures. Even where there were disinfection dips to be used before entering farms, 60% of the transporters said they often or always avoided these. These transporters will need to be educated on their role in the use of biosecurity as mitigation measures for HPAI control and should in future be targeted to be part of the biosecurity training programmes organised by VSD. FAO (2004) recommended that cages for carrying birds from farms to markets should be constructed of materials such as plastic or metal, easy to clean and disinfect. Also measures should be implemented during transport to reduce the risk of faecal contamination of the area around markets when cages were off-loaded. Further, facilities for cleaning and disinfection of transport cages before being taken back to the farms were necessary together with an official system for monitoring their effectiveness. These should be considered in the training of transporters in Ghana.

According to the Canadian Food Inspection Agency (2006), the key considerations for greater biosecurity include preventing exposure of poultry to wild birds by keeping poultry in closed housing and ensuring that wild birds cannot access poultry feed and water supplies; preventing exposure to potentially infected new poultry introduced into existing flocks by isolating new birds or avoiding their introduction into existing flocks; and preventing exposure to infectious agents transported by people or equipment by limiting access to poultry houses and thoroughly cleaning all clothing, shoes, and equipment before and after coming into contact with birds. These should be stressed during biosecurity training.

On reporting practices, S4 producers had the lowest mean score compared with the other actors (Table 1). This meant that they were the group least likely to comply with biosecurity practices. In open-ended questions, these producers said that there was no need to report poultry diseases or mortalities neither was it their business to report diseases. They also claimed that the process and procedures for reporting was expensive. FAO (2008) observed that a widespread perception that poultry sickness and death were natural has led to lack of reporting of sick and dead birds. According to IMCAPI (2010), other diseases that cause high mortality in poultry (including New Castle disease) occurred regularly in the past so such 'expected' losses of poultry in low-input systems may not always result in disease outbreak being reported to authorities as these are seen by poultry owners as normal, seasonal events. Also, there is a perception that promptly reporting disease outbreaks may negatively impact trade or public confidence in products resulting in incurring costs (Cash & Narasimhan 2000). NAS (2009) recommended that local authorities need effective disease surveillance to identify local outbreaks and to contain them before spreading to animals and humans, if zoonotic.

Padmawati & Nichter (2008) posited that small holder poultry farmers avoided reporting disease incidents to authorities because of fear of losing their own animals through culling and also the social risk of angering neighbours whose birds would be subject to culling within a 2–5 km radius of an outbreak location. In our study, the proportions of producers who agreed or strongly agreed that reporting would result in their chickens being killed were relatively low (31% of S4 producers, 31% of S3 broiler producers and 25% of S3 layer producers). The proportions agreeing or strongly agreeing that other poultry producers would be angry if a disease outbreak was reported were 44% of S4 producers, 44% of S3 broiler producers and 31% of S3 layer producers. These findings do not seem to suggest that producers were averse to reporting disease. IMCAPI (2010) noted that culling inhibited disease reporting because of the consequences of such reports on local communities. Trust and technical skills of government animal health workers were important in determining whether or not local stakeholders reported poultry mortalities in Asia (Kleinman *et al.* 2008). These involved trust that authorities would provide adequate and timely compensation for culled birds and trust that animal health officers would conduct appropriate diagnostic tests to ascertain HPAI H5N1 and not just act on the basis of suspicion because signs and symptoms of Newcastle disease could mimic those of HPAI H5N1. These may also be relevant in Ghana.

Reporting takes place at various levels: local (producers, traders, retailers, transporters, animal health workers, consumers), district, provincial, national, regional and global with various degrees of responsibilities. NAS (2009) stated that early reporting of a disease outbreak, even if it brings sanctions also provides opportunities for formal early intervention in containing the outbreak and thus reduce the costs of eradication. Further, providing incentives for local participation in timely disease detection and reporting could encourage farmers or other actors to declare early emergence of a disease which could, in turn, reduce the cost of containment or control. Also, to avoid problems of concealment of outbreaks, it was necessary to provide incentives for outbreak reporting by designing appropriate control measures and providing adequate compensation schemes.

FAO (2007) noted that the level of compensation was a determining factor for the rate of reporting. Too low levels induce producers to hide animals from culling and too high levels would encourage the introduction of animals from outside the region (NAS 2009). Beach *et al.* (2006) said that the level of compensation is very important as a policy lever influencing producer behaviour because if compensation is set too low producers are likely to conduct less disease surveillance and may attempt to hide the disease rather than report it. On the other hand, if it is set too high then producers will have little incentive to invest in costly control measures. The World Bank has recommended compensation rates between 75% and 90% of market value before the disease outbreak for live animals and lower rates for dead animals. In Ghana, compensation rates ranged from 50% for table eggs to 90% for broilers, layers and day-old chicks (Aning *et al.* 2008). NAS (2009) reported that farmers, at the farm level, may delay reporting because of fears of economic sanctions or inadequate or delayed compensation so it is important especially for smallholders not only to address the rate of compensation but also the timeliness and reliability of payment.

From Table 2, the mean score for culling practices for traders (3.2) was significantly higher than that for implementing agencies (2.0) which was surprising, but could be expected. This is because traders were more likely to benefit from cheaper producer prices (because producers would want to get rid of their birds) or higher retail prices (due to scarcity of products as a result of enforcement of control measures). FAO (2007) noted that culling results in loss of livelihoods, discourages reporting and encourages panic selling. In our study, various actors identified prevention of diseases as a reason why they would be willing and able to cooperate with the culling of chickens during a disease outbreak. As to why they would not be willing or able to cooperate, the major reasons cited were no/inadequate compensation or economic/financial losses. Beach *et al.* (2006) observed that low or no compensation for culled birds was a major barrier to disease reporting necessary to identify outbreaks and producer cooperation with depopulation of infected and exposed birds. Further, the absence of adequate veterinary expertise to aid in proper culling was a key factor affecting the effectiveness of the depopulation programmes. The implementing agents, in our study, cited inappropriate culling process/procedures or disposal facilities as a reason why agents would not do a good job implementing culling during disease outbreaks. Schiffer *et al.* (2009) reported that the actual destruction of thousands of birds with limited technical infrastructure and in hot tropical climate took a toll on the veterinary staff members in Ghana charged with the culling process. In addition, there was no well thought-out plan for culling and disposal of carcasses raising questions about its effectiveness.

For movement control practice, the mean scores for S3 producers (layer and broiler) were statistically significantly higher than those for the rest of the actors (Table 2). These producers are most at risk to lose economically when there is disease outbreak and may be more amenable to compliance than others. FAO (2007) noted that sector 3 producers are those especially hard hit by HPAI regulations because the sector combines low biosecurity with relatively larger flock sizes and may be considered a high risk sector. Therefore, complying with movement control to stem disease spread may be better welcomed by S3 producers. Birol *et al.* (2010) reported that movement control was considered to be a more effective strategy among commercial producers than among non-commercial/semi-commercial producers in 5 countries including Ghana. The S4 producers in our study had the lowest scores for movement control practice (Table 1) because they were least inclined to confine birds as their practice is to allow birds to roam freely (free-range). FAO (2007) observed that confinement to enclosed spaces, which is an essential aspect of movement control, has been found to be most difficult implementing by S4 producers as what is attractive and cost effective for S4 producers is the free-range nature of the production system. Otte *et al.* (2008) noted that S4 producers will require special consideration in national HPAI control programme because they are used to recurring poultry losses, have little incentives to comply with disease control programmes or to invest in biosecurity and cannot be effectively policed by public animal health agencies. VSD will have to target these producers for extension purposes.

VSD (2007) stated that because of the artificial boundaries and the mix of socio-cultural relations that exist in the West African sub-region, it is almost impossible enforcing quarantine measures in one country in the event of the outbreak of trans-boundary diseases and uncontrolled movement of live poultry and poultry products within and across borders in the sub-region posed a serious threat to animal health. Furthermore, producers of poultry products (eggs and spent layers) on S3 farms often sell their products to traders moving from farm to farm in hired vehicles in search of poultry products to buy and may oftentimes introduce infection onto healthy farms. In Ghana, even though the movement of poultry requires movement permit by law (Diseases of Animal Act 1961), it is common to see poultry being moved without permit or the law on movement not being enforced. The proportions of producers in our study who agreed or strongly agreed that even if they did not comply with movement ban, no action would be taken against them were 44% of S4 producers, 50% of S3 broiler producers and 44% of S3 layer producers. This points to a worrying situation where people may flout the law knowing very well that they would escape punishment. The transporters said it was not their responsibility to obtain permits when moving poultry but rather that of the poultry owners (the producers, traders or retailers). The various actors in the study cited bribery or corruption and lack of or low motivation as major reasons why government workers might not want or be able to do a good job in ensuring that movement controls were fully enforced. These claims may need to be investigated further if movement control measures are to be effective.

Our study found statistically significant differences among certain actors for capacities for reporting (between mean scores for broiler producers and transporters and between transporters and retailers) and movement controls (between mean scores for S4 producers and traders)(Table 2). Whether or not the capacities were adequate for preventing or mitigating HPAI H5N1 outbreaks were not ascertained. At the producer level, 69% of the S4 producers indicated that they could get credit if they thought it was important to build better housing for their poultry, implying that they had capacity to confine their birds if they so wished. A high proportion (75%) of the layer producers were of the opinion that it was not difficult to control vehicles in and out of their premises, compared with 50% of broiler producers. Thus, they had some capacity to institute certain biosecurity measures. A larger proportion (75%) of S4 producers said they could provide feed and water during confinement of chickens. The capacity to store chickens till movement restrictions were lifted were limited in the broiler producers compared with layer producers. Traders (75%) and retailers (69%) were unlikely or very unlikely to have other sources of income to rely on when trade in chicken was suspended during movement control. It is necessary to identify and address the shortfalls in capacities of the various actors for the mitigation measures if their effectiveness is to be improved.

With regard to capacity for mitigation measures at the implementing agency level, FAO (2004) noted that official veterinary services are key players in the definition and implementation of control measures and their extent and efficiency do have a major bearing on the capacity of countries to deal with HPAI. The outbreak of Avian Influenza in Ghana in 2007 resulted in some major investments by government and donors to improve the quality of veterinary services. Many animal health staff members at district, regional and national levels were trained in areas related to disease control, reporting and investigation whereas selected poultry farmers and stakeholders were trained in biosecurity at all the regional capitals. There were also major investments in laboratory facilities, diagnostic equipment, reagents and training of personnel, with funding from international agencies and donors resulting in enhancement of the capacities and capabilities of the laboratories. As noted by IMCAPI (2010) for Vietnam, which could also be true for Ghana, these investments built on a relatively low base and may not have immediate impact but may contribute over many years to VSD meeting the quality standards for veterinary services defined and measured in OIE's veterinary assessment process (PVS). FAO (2004) recommended a strong chain of command and scientific capabilities and infrastructure to deal with disease diagnosis, surveillance, data analysis, reporting and disease control which must be continually reinforced and augmented, in partnership with industry, the private sector, the veterinary profession and other stakeholders.

On incentives, Beach *et al.* (2006) observed that farmers play a key role in implementing control measures and may need technical and financial support as incentives to adopt prevention and control measures at socially optimal levels. FAO (2007) stated that compensation schemes provide incentives to report disease outbreaks and at the same time reduce the economic damage caused to producers by culling. However, farmers in Sector 3 and 4 may not benefit much from such schemes because their record keeping is minimal; birds may be indigenous with different market values; and farmers often need immediate cash compensation. Anecdotal information from Ghana during the outbreaks seems to support these observations (Aning *et al.* 2008).

Otte *et al.* (2008) noted that depending on incentives or disincentives for disease reporting such as compensation or culling, the real incidence and impact of HPAI may be under or over-reported. In the absence of proper incentives in place for reporting suspected cases of disease to authorities, producers may hide suspected cases due to concerns about their economic losses in the face of quarantine or culling of their flock, as evidenced by reports of low or no compensation being a significant impediment to disease reporting in some Asian countries (Beach *et al.* 2006). Further, some sick birds were likely to be consumed or sold rather than destroyed while producers might try to sell exposed birds that appear healthy before signs of illness appear. Beach *et al.* (2006) said these actions were likely to delay public response to an outbreak, allowing the disease time to spread or potentially contribute directly to disease spread if sick birds were transported or sold. This made it more difficult and costly to bring the outbreak under control, hence the development of endemicity. In our study, a high proportion (81%) of S4 producers was of the opinion that farmers often or always took chickens to market when birds were sick or dying. This finding has serious implications for disease spread and prevention. There is the need for intensive education to reduce this practice to stem disease spread.

IMCAPI (2010) observed that farmers have to see the benefits in making changes and if they do not, no changes will occur. Recommendations which may be technically sound but result in dramatic change in production system may not be attractive, as at the moment 'many farmers do not see AI as a significant threat in part because the disease has been contained which also makes communicating the need for behavioural change challenging' (IMCAPI 2010). This needs to be considered in designing and implementation of mitigation measures.

In conclusion, our study found some significant differences between poultry chain actors in practices for biosecurity, reporting and movement controls and in capacities and incentives for reporting and movement control. These findings may be used to enable targeting of classical epidemiological investigations, strengthening linkages in the value chain and providing valuable insights to help tailor future interventions as suggested by other authors (Azhar *et al.* 2010; Catley *et al.* 2012.).

Acknowledgements

We thank Dr Tom Randolph and Dr Bernard Bett of ILRI, Nairobi, Kenya for the assistance in the development of the questionnaires and methodology. We are grateful to all the enumerators and respondents for their contribution.

Source of Funding

The work was funded by the International Food Policy Research Institute based in Washington, DC, USA.

Conflict of Interest

The authors declare that there is no conflict of interest.

Contributions

The authors declare that there is no conflict of interest.

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