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Efficacy and Adoption of Strategies for Avian Flu Control in Developing Countries

A Delphi Study

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ABSTRACT

In this paper, we present the results of a two-stage expert elicitation (Delphi) study conducted to provide input to contingent valuation (CV) studies. These CV studies are designed to estimate the benefits of various public and private strategies for the control of Highly Pathogenic Avian Influenza (HPAI) across the study countries of Ethiopia, Ghana, Indonesia, Kenya, and Nigeria. The results of these CV studies are expected to feed into the cost-benefit and cost-effectiveness analyzes, which will be conducted to identify the effective HPAI control strategies in each study country. The information gathered through the Delphi study included (1) definitions of the small-scale producers (noncommercial/semicommercial and commercial) across the study countries, (2) estimations of the efficacy of various private and public control strategies in HPAI control, and (3) estimates of the proportion of poultry producers who are expected to adopt these control strategies under different scenarios. In this Delphi study, we collected data from 23 experts and analyzed the data by using statistical analysis methods. The results reveal that small-scale flocks are significantly larger in Indonesia, compared to the four African countries. The efficacy levels of both private and public HPAI control strategies investigated are significantly higher for commercial producers than for their noncommercial/semicommercial counterparts. Across private strategies and study countries, regular monitoring is thought to have the highest efficacy for those in the noncommercial/semicommercial sector, whereas regular disinfection and containment in hard material (as a combined strategy) was found to be the most effective strategy in minimizing risk in the commercial sector. Across public strategies and study countries, experts see surveillance by veterinary services as the most effective public sector HPAI control strategy in both the noncommercial/semicommercial and commercial sectors. Finally, according to the experts, small-scale poultry producers' likelihood of adoption is low overall, although adoption rates are higher for commercial producers than for noncommercial/semicommercial producers.

Keywords: expert elicitation, Delphi study, Highly Pathogenic Avian Influenza, HPAI, small-scale poultry producers, noncommercial/semicommercial sector, commercial sector, disease risk introduction and spread, private disease risk minimization strategies, public disease risk minimization strategies, efficacy, adoption

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1. INTRODUCTION

One of the key outputs of the Pro-Poor Highly Pathogenic Avian Influenza (HPAI) Control Strategies research project (www.hpai-research.net) is the identification of cost-effective control strategies that may be easily adoptable by resource-poor, small-scale poultry producers in developing countries. To identify these strategies, the researchers in this project are currently developing cost-benefit and cost-effectiveness analyses (CBA and CEA) models (Narrod 2008; Tiongco 2008). To implement these models, three key pieces of information are needed. These include

1. the identification of the full set of possible control strategies that may be implemented either by the small-scale poultry producers themselves or by the public authorities, or both, to minimize HPAI introduction and spread risks in small-scale poultry production,
2. the efficacy of these control strategies, when implemented correctly, in minimizing HPAI introduction and spread risks, and
3. the proportion of poultry producers who are expected to adopt these control strategies under different circumstances.

In addition to these data, information on economic benefits that may be generated by the adoption of these control strategies is a fundamental input required, especially for the CBA. Because small-scale poultry producers in developing countries are unlikely to have these strategies already in place, stated preference methods are deemed suitable to capture the value of these economic benefits. These methods, which include the contingent valuation method, depend on construction of hypothetical markets in which respondents state their willingness to pay (as an indicator of the economic benefits they would derive from the adoption) for each hypothetical good presented to them. In this project, the goods that are to be sold in the hypothetical markets are the various control strategies, which must to be defined in terms of the efficacy they would provide in minimizing HPAI risks. Therefore, information on control strategies is a paramount input for the construction of these hypothetical markets as a means to estimate the economic benefits of the control strategies.

Unfortunately, data on the three pieces of critical information (strategies, efficacy, and use) are scarce at the best of times and often nonexistent, especially in the cases of developing countries. In order to generate this data, specifically the data on efficacy and use, a two-stage expert elicitation (Delphi) study was conducted. Prior to the Delphi study, background research was conducted to draw a list of potential control strategies that may be adoptable by small-scale poultry producers in developing countries and to identify factors that would affect the adoption of these strategies. Background studies included thorough literature reviews and discussions with key stakeholders (for example, epidemiologists, field veterinarians, technocrats from veterinary services, leaders of poultry producer associations, and poultry producers) at the multistakeholder workshops organized in each of the study countries. The study countries include Ghana and Nigeria in West Africa, Ethiopia and Kenya in East Africa, and Indonesia. Among these, HPAI has endemic status in Nigeria and Indonesia, whereas three outbreaks have occurred in Ghana. East African countries have not yet experienced any HPAI outbreaks.

Following this background work, six private control strategies that may be implemented by small-scale (noncommercial/semicommercial and commercial) poultry producers and five public strategies that may be implemented by the study countries' veterinary services were identified. In addition to the private control strategies, two factors were identified as impacting the small-scale poultry producers' adoption of identified private control strategies. These factors are training by veterinary services (public sector) and government subsidies to facilitate the adoption of these control strategies.

In the first stage of the Delphi study, a structured survey instrument was sent electronically to selected experts based in or working on each study country. The list of experts was compiled with the help of the core project team and included those who participated in the multistakeholder workshops, those from a wide-range search conducted on the Internet, and those suggested by the wider project team. The structured survey instrument collected data on (1) the respondents' characteristics (for example, fields of expertise and years of experience), (2) flock size for small-scale (noncommercial/semicommercial and commercial) poultry producers, (3) efficacy of various control strategies that may be undertaken by the poultry producers or by the public sector (veterinary services), and (4) small-scale (noncommercial/ semicommercial and commercial) poultry producers' adoption rate of control measures under different scenarios (for example, of their own accord, as a result of training by veterinary services, or with subsidy from public authorities). Data were collected on minimum, maximum, and most likely values for (2), (3), and (4) as well as on the experts' confidence in their answers to these questions.

In total, 80 experts were contacted and 23 of those (29 percent) participated in the first round. Because an expert could have experience in more than one country, there were 10 experts each for Ethiopia, Kenya, and Nigeria, 6 experts for Ghana, and 11 for Indonesia. The experts' responses to each question were used to derive BetaPert distributions for each answer. Individual distributions were then combined into pooled distributions using individual-specific variables (years of experience and country of primary experience) and experts' level of confidence in their own answer as weighing factors (Vose 2000; Stark, Horst, and Kelly 2000; Costard et al. 2009).

In the second and final stage, the same survey instrument was sent to the 23 experts along with the results of the second round. This round enabled the experts to adjust or revise their answers based on their peers' answers. In total, 16 of the 23 respondents participated in this final round. Experts' responses to the second stage were analyzed using the same method as in the first stage.

This two-stage Delphi study reveals four main results. First, noncommercial/semicommercial small-scale poultry flocks are smaller in the African countries (with 30–50 birds) than in Indonesia (170 birds). According to the experts, commercial small-scale poultry flocks are significantly larger, ranging from 900–1,900 birds in Nigeria, Kenya, and Ethiopia, as many as 8,000 birds in Ghana, and approximately 10,000 birds in Indonesia.

Second, according to the experts' valuations, the efficacy levels of the private HPAI control strategies investigated are significantly higher for commercial producers than for their noncommercial/semicommercial counterparts. This result may be explained by the fact that commercial producers are specialized in poultry production and derive larger proportions of their incomes from this activity; hence, they have higher incentives to invest in (that is, use and implement effectively) these strategies. The results of the experts' answers reveal that, across private strategies and study countries, regular monitoring supports the highest efficacy level for the noncommercial/semicommercial sector, whereas the combined strategy of regular disinfection and containment in hard material exhibits the highest efficacy level in minimizing HPAI risk in the noncommercial/semicommercial small-scale sector.

Third, efficacy levels of the public HPAI control strategies investigated are significantly higher for commercial small-scale poultry producers than for their noncommercial/semicommercial small-scale counterparts. This result can be explained by the fact that, compared to the noncommercial/ semicommercial sector, the commercial sector is a more organized and formal sector with fewer producers; therefore, the monitoring and enforcement of public control strategies are expected to be more effective for this sector. Across strategies, countries, and sectors, experts stated surveillance to be the most effective public-sector HPAI control strategy.

Fourth, regarding adoption rates of private control measures, experts suggest that small-scale poultry producers' likelihood of adoption is generally low, although adoption rates are higher for commercial producers than for noncommercial/semicommercial ones. For both sectors, however, the adoption rates increase as a result of public interventions (training or subsidy), and the estimated adoption rates are the highest when government subsidies are provided.

The rest of the paper unfolds as follows. Section 2 introduces the expert elicitation (Delphi) method as well as its advantages, caveats, and various uses as stated in the literature. This section also presents the statistical approach used to analyze the data. In Section 3, we explain in detail the two-stage Delphi study and present the profiles of the experts who participated in this elicitation exercise. Section 4 presents the results of the data collected through the second stage of the Delphi study, and Section 5 concludes the paper with a summary and discussions of the study findings.

2. METHODOLOGY

Expert Elicitation (Delphi) Technique

The Delphi method is a systematic approach to the collection of information from a panel of experts (Groom, Kontoleon, and Swanson 2007). This method involves an iterative process in which an issue is discussed or a questionnaire is distributed to an expert panel in a series of rounds. In each new round, the experts are also provided with the entire panel's responses to the questions/issues of the previous round. The expert elicitation (Delphi) technique can be a useful and cost-effective option for providing information to be used in forecasting, decisionmaking, and assessing risks (for example, Clemen and Winkler 1999; Angus et al. 2003).

This method is commonly used when (1) hard data are missing or of limited availability, (2) larger-scale surveys over long timeframes are not practical to perform because they are either too costly or the data or information are needed in a shorter timeframe, (3) the decision in question does not lend itself to precise theory or analytical techniques but can benefit from subjective judgments of experts on a collective basis, and (4) a random sample of respondents may be unable to handle the complex issues investigated in a Delphi study, and the experts needed to contribute to the examination of the particular problem come from diverse backgrounds with respect to expertise and experience (for example, Stark et al. 1997; Clemen and Winkler 1999; Stark, Horst, and Kelly 2000; Vose, 2000; Linstone and Turoff 2002; Angus et al. 2003; Kuhnert et al. 2005; O'Hagan et al. 2006; Groom, Kontoleon, and Swanson 2007).

The main features of the Delphi method are that (1) experts only interact through the feedback mechanism provided by the research team so as to avoid group dynamics effects (that is, the effect of domineering personalities or unwillingness to contradict individuals in higher positions) and (2) that answers are anonymous, thus providing the experts with the greatest degree of individuality and freedom from restrictions on their expressions (O'Hagan, 1998; Groom, Kontoleon, and Swanson 2007).

The Delphi method has been widely used in risk assessment studies to provide input for quantitative risk models, especially when no other data are available or when empirical data cannot be obtained directly with high precision from field studies (Stark, Horst, and Kelly 2000). This method has been applied to various livestock diseases to quantify risk factors as inputs to quantitative risk assessment models. Some recent examples include Horst's (1998) study on swine fever and foot and mouth disease, Van der Fels-Klerx, Horst, and Dijkhuizen's (2000) study on bovine respiratory disease, the Stark et al. (1997) study on classical swine fever, Binns, Green, and Smith's (2000) study on ovine caseous lymphadenitis, Stark, Horst, and Kelly's (2000) study on salmonella, and the Costard et al. (2009) study on African swine fever. As it is in this paper, the Delphi method has also been applied to assess the relevance of various strategies for controlling livestock diseases at the farm level, such as in the Sorensen et al. (2002) study on control strategies and feasible combinations of these for milk fever control. Finally, again similar to the study presented here, this method has also been used to inform stated-preference contingent valuation studies. Groom, Kontoleon, and Swanson's (2007) study, for example, relies on the results of an expert elicitation study to inform a contingent valuation study.

Despite its apparent advantages (for example, cost-effectiveness, generation of much-needed data when none or few are available, and the relatively short amount of time in which it can be implemented compared to field studies), researchers have expressed reservations about this approach (for example, Kuhnert et al. 2005). The main criticisms of this method include (1) the definition and selection of experts and the sample size, (2) lack of clear guidelines for selecting the issues that are included in the study, and (3) inability to validate or triangulate the findings of a Delphi study (that is, lack of a test of reliability) (for example, Clemen and Winkler 1999; Angus et al. 2003; Kunhert et al. 2005; and Groom, Kontoleon, and Swanson 2007).

Regarding the definition and selection of experts, several practitioners of the Delphi technique suggest that a study should include as many experts as possible to ensure the validity of the results (Linstone and Turoff 2002) and that it is of paramount importance to include experts from a wide range of disciplines related to the issue being considered (for example, Kuhnert et al. 2005). For studies on different sites or different countries (such as the case in the study presented in this paper), it has been argued that the experts would need to come from the study region/country, or at least be familiar with it, in order to comment about the situation on a specific region/country (Kuhnert et al. 2005). Therefore, only the responses of those experts from the same site/country can be combined to avoid any bias (Stark, Horst, and Kelly 2000).

In the Delphi study presented in this paper, we endeavored to enlist experts from a wide range of disciplines/fields, including experts who are working on the estimation of the introduction and spread of HPAI risk in the study countries, as well as those who are working to minimize these risks. These experts include scientists such as biologists, epidemiologists, virologists, and immunologists, as well as applied veterinarians (that is, field veterinary doctors) and technocrats of the veterinary services of the study countries. In addition, we tried to gather similarly sized panels across study sites, although our sample sizes (especially in the second round) were small, and several email reminders were sent to the enlisted experts.

Regarding the optimal sample size of a Delphi expert panel, there is substantial debate in the literature (Angus et al. 2003). It should be noted that the aim of a Delphi study is not to aggregate the opinions of the experts to represent any population, but rather to identify and explore relevant issues (Angus et al. 2003). Regarding the expert panel sample size, some practitioners suggest 20–30 participants to be an optimal number (for example, Adler and Ziglio 1996), whereas some state that there is no optimum number of experts for a Delphi study but suggest a minimum requirement of 4–7 respondents (for example, Linstone and Turoff 2002). In most Delphi studies, such as the one presented in this study, the research team endeavors to find a balance between the amount of information collected and the volume of material that the research team and the panel could manage, while ensuring that the panel expertise is sufficiently broad to cover the issues considered in the study (Angus et al. 2003). The studies reviewed for this paper have expert panel sizes ranging from as small as 6 experts (per country) (Stark, Horst, and Kelly 2000), to 10 experts (Angus et al. 2003), to around 20 experts—18 in Sorensen et al. (2002), 20 in Kuhnert et al. (2005), and 24 in Groom, Kontoleon, and Swanson (2007). Others feature as many as 33 (Stark et al. 1997) and 40 experts (Costard et al. 2009). In this study, the total number of experts who took part in the two rounds were 6–11 (first round), and 5–10 (second round), depending on the country. Experts from or working on different countries were not pooled together so as to avoid any bias, as discussed above.

To overcome the second criticism of the method, namely the lack of clear guidelines for selecting the issues included in a Delphi study, it is suggested that the research team should ensure that the criteria and language used in the survey instrument are well accepted and widely used (Kuo and Yu 1999; Groom, Kontoleon, and Swanson 2007). As suggested by Groom, Kontoleon, and Swanson (2007), this would minimize not only the need to provide definitions of the criteria, but also the potential for misunderstanding between the research team and the expert panel. In the study presented here, we tried to ensure that the members of the expert panel had high levels of understanding of HPAI and its control strategies as well as of their adoptability and efficacy in the selected study countries. The majority of the experts in the panel are linked to the research project and have participated in the project multistakeholder workshops; hence, they were familiar with the concepts investigated and jargon used in the structured survey instrument.

Regarding the final criticism of this method, it is often difficult, if not impossible, to validate the results of Delphi studies because the main reason that this method is implemented in the first place is that no alternative sources of data exist. The outcome of a Delphi study is the subjective opinion of the expert performing the assessment, which by definition is neither true nor false and therefore—strictly speaking—cannot be validated (Stark et al. 1997). There are, however, a couple of studies that triangulated the Delphi study results with those from actual survey data. For example, Stark et al. (1997) and Kuhnert et al. (2005) both found that the findings from the survey data are consistent with expert opinion, and therefore, they concluded that using the expert elicitation approach could yield faster results, especially if data are scarce or limited.

Methodology for Combining Experts' Responses

Collection of data from multiple experts requires their responses to be combined systematically. Moreover, answers to most of the questions posed in the Delphi study presented here (for example, the efficacy of various control measures in risk minimization) are difficult to estimate, as there can be biological variability of the values (Stark, Horst, and Kelly 2000). Consequently, for such questions, experts are asked about their probability distributions in the form of the minimum, maximum, and most likely values, as well as their confidence levels in their answers. Such data are often analyzed using statistical approaches in which experts' confidence in their estimates and their experience are used as weighing factors, with the possible caveat that such weighting could actually bias the results (Costard et al. 2009).

In this study, following Stark, Horst, and Kelly (2000) and Costard et al. (2009), we use @Risk software (Version 4.0 Palisade Corp., Newfield, NY) and experts' responses on minimum, maximum, and most likely values to derive individual BetaPert distributions for flock size, efficacy of private and public control strategies, and adoption rates of private control strategies by noncommercial/semicommercial and commercial poultry producers under different scenarios (for example, with training or with subsidy). Individual experts' distributions are then weighted and summed together to generate combined pooled distributions for each question, following Clemen and Winkler's (1999) linear opinion pool aggregation:

$$p(\theta) = \sum_{i=1}^{n} w_i p_i(\theta) , \qquad (1)$$

where n is the number of experts, $p_i(\theta)$is expert i's BetaPert distribution for question θ, $p(\theta)$ is the combined probability distribution, and the weights, w_i , sum to one. These weights are calculated from the level of the expert's confidence in his/her response, the expert's years of experience, and his/her choice of country of expertise. Heavy scale (3) is assigned to those experts who chose a respective country as the first country of expertise. Lighter scale (2) is assigned to experts who chose a respective country as the second country of expertise. Light scale (1) is given to experts who chose a respective country as their third country of expertise. Years of experience are categorized into four groups—1 = fewer than 10 years of experience, 2 = 11–20 years of experience, 3 = 21–30 years of experience, and 4 = more than 31 years of experience. Expert's confidence level for his/her response to each question is recorded on a confidence scale ranging from 0–10, where 0 indicates "no confidence" and 10 means the expert has very "high confidence" in his/her response.

For those experts who identified a country as their second and third country of expertise, additional adjustments are made when estimating individual distributions. Experts were asked to define on a 5-point scale whether the answers that they gave for the first country of expertise were the same (3) in the case of the second/third country of expertise, lower (2), significantly lower (1), higher (4), or significantly higher (5). Whenever the expert said that the minimum, maximum, and most likely values for the question of interest for a second or third country were the same as his/her answers for the first country of the expertise, then the responses for the first country are used to derive distributions. In cases where experts stated that their answers for their secondary or tertiary countries of expertise would differ from their answers for their primary country of expertise (per the 5-point scale described above), new distributions are generated, such that at each percentile point (5 percent step), one standard deviation is added for a respondent who stated that his/her answers for the secondary or tertiary country of expertise were higher (4) and two standard deviations are added if the respondent said that his/her answers for the secondary or tertiary country of expertise were significantly higher (5) than that of his/her answers to questions about the primary country of expertise. In the same way, though in a reverse order, this procedure is followed whenever experts said that their answers for their secondary or tertiary countries of expertise were lower (2) or significantly lower (1) than those regarding their primary country of expertise. Thus, new data points are generated where minimum, maximum, mean, and median values were considered for generating the BetaPert distribution. These updated distributions are then further used to generate an aggregated linear combination of distributions.

3. DATA AND SURVEY ADMINISTRATION

Background Work to Develop the Structured Survey Instrument

The background work conducted for the development of the structured survey instrument included a review of the published and gray material on HPAI control strategies and discussions conducted in the multistakeholder workshops that were held in each one of the study countries during the months of June and July 2008. These workshops included the key stakeholders in HPAI risk control and minimization efforts (for example, epidemiologists, field veterinarians, technocrats from the veterinary services, and directorates of the ministries of agriculture), as well as those stakeholders who were affected by the HPAI outbreaks or scares that took place in the study countries (that is, leaders of poultry producer associations and poultry producers)[2].

This background work enabled

1. the compilation of a list of private HPAI control strategies that may be adoptable by small-scale poultry producers,
2. the compilation of a list of public HPAI control strategies that are or may be implemented by the veterinary services directorates of the study countries,
3. the unearthing of the fact that in each study country there is a lack of consensus about what flock size constitutes a small-scale poultry producer,
4. the identification of the factors that would affect the adoption rates of private HPAI control strategies by small-scale producers, and
5. the identification of potential experts that may be called upon to participate in the expert elicitation study.

Following this background work, six private control strategies and combinations of strategies that may be implemented by small-scale (noncommercial/ semi-commercial and commercial) poultry producers were identified. These include

1. containment measures from soft material (for example, netting, cages, or both),
2. footbaths and containment measures from soft material,
3. containment measures from hard material (for example, brick, wood),
4. regular disinfection and containment measures from hard material,
5. vaccination, and
6. regular monitoring by the public or the private sector for a fee.

Similarly, nine public strategies that may be implemented by the study countries' veterinary services were identified. These include

1. culling within a 1 km radius,
2. culling within a 5 km radius,
3. culling within a 10 km radius,
4. allowing for restocking of culled flock three weeks after the outbreak is controlled in the infected area,
5. allowing for restocking of culled flock two months after the outbreak is controlled in the infected area,
6. allowing for restocking of culled flock three months after the outbreak is controlled in the infected area,
7. biosecurity training of small-scale poultry producers,
8. surveillance, and
9. movement control.

[2] Please visit the project website (www.hpai-research.net) for multistakeholder workshop reports and other related material.

Finally, two factors were identified as impacting the small-scale poultry producers' adoption rates of private control strategies. These factors are training by veterinary services (public sector) and government subsidies to facilitate the adoption of these control strategies.

The Structured Survey Instrument

Using this information, a structured survey instrument was developed to include five sections. In the first section of the questionnaire, general information on the experts including their field(s) of expertise, countries of expertise, and education is presented. Experts also indicate the HPAI study country (out of the five) with which they are most familiar, as well as their second and third countries of expertise (if applicable). In this way, they consequently self-select to be a part of a country's panel.

Section two of the questionnaire is aimed at defining the small-scale poultry production within the context of each study country. As explained above, the discussions in the multistakeholder workshops and a thorough review of the relevant literature reveals that there is currently a lack of consensus concerning the definition of poultry production systems and average poultry flock sizes maintained in the various systems. In Kenya, for example, the classification of poultry production is based on the level of commercialization, biosecurity, and other characteristics in accordance with the Food and Agriculture Organization of the United Nations classification of poultry production systems (Omiti and Okuthe 2008). In other study countries, poultry-keeping is defined based on capacity of poultry housing. In Ghana, for example, a distinction is made between "commercial poultry farmers," who hold flock sizes ranging anywhere from 50– 10,000 birds, and smaller "poultry keepers" with flock sizes ranging between 3–500 birds (Aning, Turkson, and Asuming-Brempong 2008). An apparent problem is the fact that flock sizes in the two categories overlap, thereby resulting in classification groups that are not mutually exclusive from one another. Still, in other study countries such as Indonesia and Ethiopia, characteristics such as poultry breed type are used, sometimes in combination with one or both of the aforementioned classifications, to classify poultry systems (for example, Alemu et al. 2008; Suniarto and Arifin 2008). Moreover, inconsistencies in defining poultry systems arise not only among countries, but also among poultry specialists from different disciplines within the same country.

In an attempt to curb the problem of having multiple classifications of poultry production systems, this study restricts the definition of small-scale poultry producers to two broad groups that are defined by the experts themselves—*noncommercial/semicommercial* (or backyard extensive or village scavenging) producers, which include mainly household producers who keep poultry for household consumption and occasional sales, and *commercial* (including backyard intensive) who produce poultry for market sales. In the *definition of small-scale poultry producers* question included in section 2 of the survey instrument, experts provide their estimates on minimum, maximum, and most likely flock sizes that would constitute each small-scale poultry production system (that is, noncommercial/semicommercial small-scale producers or commercial small-scale producers). For each one of their answers, the experts are asked to state their confidence level, ranging from 0, which implies that they are not at all confident in their answer, to 10, which implies that they are very confident in their answer.

In section 3 of the questionnaire, experts are asked to evaluate the efficacy of each one of the private and public control measures described above, *if correctly implemented,* in the study country within which they are most familiar. The efficacy of these control measures are assessed for both noncommercial/semicommercial producers and commercial producers. The measure of efficacy ranges from 0–10, where 0 is indicative of no efficacy at all (that is, the risk of HPAI remains the same) and 10 is indicative of complete efficacy (that is, the risk of HPAI would be almost 0) if the specific measure were correctly implemented. The definitions of control measures that can be undertaken by poultry producers and those that can be undertaken by veterinary services, as given to the experts, are presented in Boxes A.1 and A.2 in the Appendix.

In section 4 of the survey instrument, the likelihood of adoption of private control measures by small-scale poultry producers (both noncommercial/semicommercial producers and commercial producers) is assessed. Adoption rates are assessed for three different scenarios—(1) business-as-usual, that is, poultry producers adopting the measures of their own accord, (2) poultry producers adopting the control measures as a result of training from veterinary services, and (3) poultry producers adopting the control measures as a result of a subsidy from the government. The specifics of scenarios 2 and 3 are not defined in detail in the survey instrument, as they may involve interventions of different scales and scopes in different countries. Therefore, the experts' perceptions of these interventions are left to their own experiences and prior knowledge of such public interventions in their countries of expertise. Possible implications of lack of definition of these interventions are discussed in the final section. Similar to the items in Sections 2 and 3, the questions in section 4 asks experts to state what are the minimum, maximum, and most likely proportion (as a percentage) of small-scale poultry producers who would adopt the control measure under each scenario. Also similar to the previous two questions, these items ask experts to state their level of confidence on a 0–10 scale.

The structure of the questionnaire differs slightly in each round of the survey. In the first round of the Delphi study, there is a fifth section in which experts provide information on efficacy and adoption of control strategies for the study countries they defined as their second and third countries of expertise, if applicable. These are assessed relative to their first country of expertise. In other words, for secondary and tertiary countries of expertise, experts state whether the efficacy of control measures or the rates of adoption are likely to be significantly higher, the same, or lower (on a 5-point scale) than the answers they provided in sections 3 and 4 for the country with which they are most familiar.

In the second round of the Delphi study, section five does not exist. Experts are provided with the panel average for each study country for which they provided information and with the answers they gave in the first round for their primary country of expertise. They are then asked to re-evaluate their responses based on the panel results from the first round. In this second round, the experts were not provided with the answers given in the first round for their secondary and tertiary countries of expertise, since their answers to these were given in relation to their primary country of expertise, as explained above.

Summary of Survey Administration

As explained above, experts who participated in the Delphi study were identified and selected following the multistakeholder workshops in each study country, further e-consultations with selected key experts, and a detailed Internet search. The experts for this Delphi study include those individuals who work in scientific and regulatory fields related to the measurement/estimation and minimization of HPAI introduction and spread risks in the study countries. Consequently, the list of experts includes those from various disciplines, including epidemiologists, veterinary officers, avian pathologists, biologists, and virologists, among others. Correspondence was made via email throughout the Delphi study; experts were sent electronic questionnaires and asked to email the completed questionnaires back to us. They were also told to contact the research team if they needed any clarifications or had any technical problems with the electronic survey instrument.

In the first round of the Delphi study, a total of 80 experts were identified and contacted. Twenty-three experts returned their completed questionnaires. This figure translates to an overall response rate of 29 percent. Of the 23 respondents, 19 returned their filled-in questionnaires after the first reminder, and four experts returned their answers before the first reminder was sent out. This response rate is low despite the two reminders that were sent and the expected interest and involvement of many of the respondents in HPAI control in general and in the research project in particular. This low response rate may be attributable to the length of the survey instrument and the unreliability of Internet connections in many of the study countries. The first round took a month to administer and was carried out over July and August 2009.

In the third and second round of the Delphi study, the rate of response (out of the 23 experts from the first round) was 70 percent, or 16 experts. In this round, the respondents were sent the same questionnaire (except for section 5) with their answers to the first round for their primary country of expertise and with the results of the country-specific panel's responses. For each country, the panel consisted of all those who stated to be primary, secondary, or tertiary experts of that country. It was assumed that the remaining six experts who did not provide feedback in the second round did not change their evaluations from the first round. As such, their first-round responses were re-evaluated together with the second round data received from the 16 experts. It is possible that this assumption may cause bias, in case these six experts would have changed their evaluations in the second round. However, given the already small size of the country panels, we opted to keep these experts in our final samples for each study country. Administration of this final round also took place over a month between September and October 2009. Two-thirds of the experts in this final round were sent reminders before their completed questionnaires were returned.

Table 1 presents the composition of the expert panel in terms of their fields of expertise, countries of expertise, years of education, and experience. As can be seen, a great majority of the panel was composed of epidemiologists and field veterinarians. Across countries, few experts (6) stated that Ghana was their primary, secondary, or tertiary country of expertise, and 11 stated to be experts on Indonesia. The other three study countries (Ethiopia, Kenya, and Nigeria) had 10 experts each.

Since the country panel sizes are small, we cannot conduct statistical tests to investigate whether or not the country panels are similar in terms of years of education or experience and composition of fields or disciplines of expertise. A comparison of the statistics for average years of postsecondary education across country panels reveals that country panels have similar average years of education (around 10 years). The average years of experience is different, however, across countries, with the experts that compose the Nigeria and Ghana panels having higher years of experience than their counterparts in other countries' panels. Finally, in terms of the composition of disciplines/expertise in the country panels, we see that the majority of experts in each country panel are from epidemiology and field veterinary medicine fields/disciplines, followed by the veterinary services of the study countries. Therefore, overall we can conclude that the expert panels are similar across study countries, with the exception of Ghana and Nigeria experts having higher years of experience.

Table 1. Total number of experts that took part and their distribution across countries and disciplines

Expertise in Discipline/Field†		Expertise in HPAI Study Country* ETHIOPIA	KENYA	GHANA	NIGERIA	INDONESIA	Total number of experts in discipline	Years of Post-secondary education Mean(std dev) Min - Max	Years of experience in field Mean (std dev) Min - max
Biology		0	1	1	1	0	**1**	7 (.) 7	30 (.) 30
Epidemiology		7	10	3	5	7	**15**	9.9 (3.1) 6 - 17	17.5 (9.0) 3 - 33
Field veterinary medicine		6	8	5	7	7	**14**	9.3 (3.1) 6 - 17	19.7 (8.1) 6 - 33
Immunology		2	1	1	3	2	**4**	10.8 (4.2) 8 - 17	20 (9.3) 12 - 33
Laboratory diagnostics		5	1	3	3	5	**9**	9.3 (2.4) 6 - 13	15.6 (7.4) 6 - 28
Veterinary services		5	3	3	4	3	**9**	8.1 (2.6) 6 - 14	20.1 (8.1) 9 - 30
Virology		2	1	1	3	2	**4**	10.8 (4.2) 8 - 17	20 (9.3) 12 - 33
Other		2	0	1	2	0	**3**	11 (2.8) 9 - 13	26 (10.1) 15 - 35
Total number of experts in country		**10**	**10**	**6**	**10**	**11**			
Total number of primary country experts		**6**	**4**	**3**	**5**	**5**	**23**		
Years of postsecondary education	Mean (std. dev)	9.8 (3.3)	10.2 (3.6)	9.8 (3.2)	9.7 (4.0)	9.7 (2.0)		**9.4 (3.0)**	
	Min - Max	6 - 17	6 - 17	6 - 14	6 - 17	6 - 13		**6 - 17**	
Years of experience	Mean (std. dev)	17 (9.7)	17.4 (10.6)	21.8 (8.7)	25.6 (7.4)	17.1 (8.7)			**19.5 (9.3)**
	Min - Max	5 - 33	3 - 33	10 - 30	12 - 35	3 - 28			**15 - 35**

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).
* Note that experts could state more than one country as country of expertise
† Note that experts could list more than one area of expertise

4. RESULTS

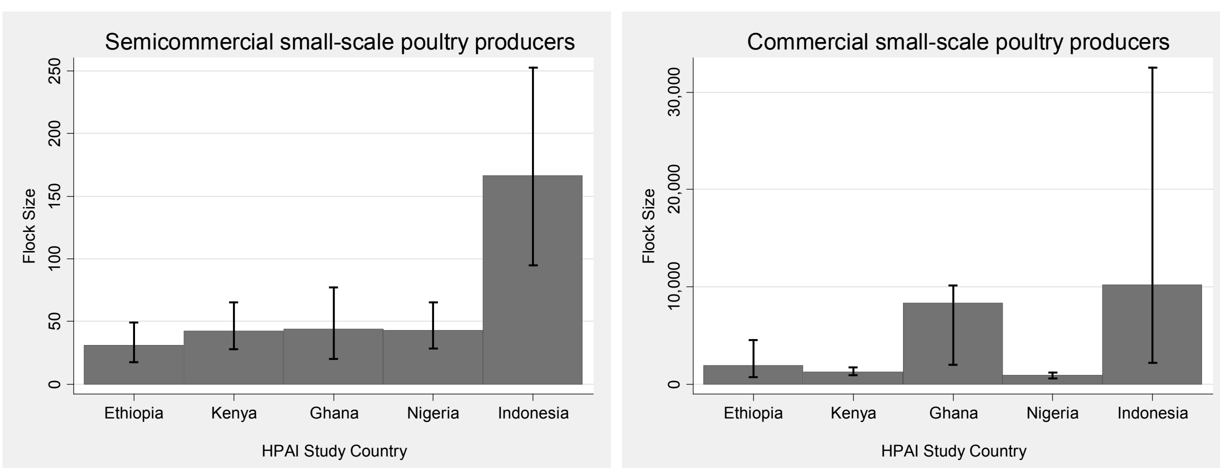
Following Groom, Kontoleon, and Swanson (2007), in this paper we present the results from the second and final round of the Delphi study. In the final round, we observe that knowledge regarding the opinion of the other panel members allows experts to reduce uncertainty about their judgments, as represented by the general drop in the variance compared to the previous round. Therefore, similar to the results of Groom, Kontoleon, and Swanson (2007), the final round exhibits a deeper consensus compared to the previous round.

Further comparisons of the country panel averages from the first round responses to those from the second round reveal that, for a great majority of the questions, the averages are statistically significantly different at less than 1% significance level, across the two rounds. For Nigeria, 78% of the panel's responses are statistically significantly different across two rounds, whereas this figure is 90% for Ethiopia, 94% for Kenya, 96% for Indonesia, and 97% for Ghana. The results of the first round and the results of the t-test comparing the first and second round results are available from the authors upon request. The following subsections present the final round results for each one of the research questions investigated. The results are presented in figures below; for presentation of the results in tables, please see the Appendix.

Definition of Small-Scale Poultry Producers

The results of the second round reveal that both the largest noncommercial/semicommercial small-scale poultry flocks and the largest commercial small-scale flocks are in Indonesia, with an average of 166 and 10,213 birds, respectively (Figure 1). Figure 1 also reveals that across the African countries studied, the noncommercial/semicommercial flock sizes are very similar (all less than 50 birds), although there is significant variation across the African countries' commercial small-scale flocks. Ghanaian commercial small-scale producers have the largest flocks (with significant variation) with an average of 8,351 birds. This value is 903 in Nigeria, 1,268 in Kenya, and 1,897 in Ethiopia.

Figure 1. Noncommercial/Semicommercial (left) and commercial (right) small-scale poultry flock sizes



Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Efficacy of Private and Public Control Measures

Efficacy of Control Measures That Can Be Implemented by Poultry Producers

Experts' opinions on the efficacy of private control strategies that may be implemented by small-scale producers are reported in Figure 2. In the noncommercial/semicommercial small-scale poultry production sector, we observe that across countries, the first control strategy (containment from soft material) has the lowest efficacy in Ethiopia (reducing the risk by 23 percent) and the highest in Indonesia, where the reduction in HPAI risk is as high as 45 percent. Similarly, the second control strategy, footbaths combined with containment from soft material, performs the worst in Ethiopia, reducing risk by only 19 percent, and the best in Indonesia and Ghana, reducing the risk by almost 40 percent in both of these countries. As expected, the third strategy, containment measures from hard material, is more effective in risk reduction compared to the first strategy (that is, containment measure from soft material). With the use of the hard material for housing, the efficacy of risk reduction varies from 31 percent in Ethiopia to as high as 51 and 52 percent in Nigeria and Indonesia, respectively.

The efficacy of the fourth strategy, regular disinfection combined with containment from hard material, ranges from 27 percent in Ethiopia to as high as 55 percent in Indonesia. The efficacy of the fifth strategy, vaccination, is significantly different across the study countries. Experts think that this strategy would not work in Ghana (reducing risk by only 4 percent), whereas it could reduce risk by 21 percent in Nigeria, 37 percent in Indonesia, 41 percent in Kenya, and almost 50 percent in Ethiopia. According to the experts, the final strategy, regular monitoring, would work the best in Kenya and Nigeria, reducing HPAI risk by 60 and 56 percent, respectively. In fact, across strategies and countries, this last strategy (regular monitoring) is thought to be the most effective. Across countries, we observe that a majority of the strategies are expected to have the lowest efficacy in Ethiopia, where there have not been any HPAI outbreaks, and the highest efficacy in Indonesia, where HPAI has endemic status.

For each one of the private control strategies that can be implemented by the small-scale poultry producers, we see that across countries and across strategies, the efficacies of each one of the strategies are higher in the commercial sector than in the noncommercial/semicommercial sector. This may be explained by the fact that these two sectors have different management and contact characteristics, resulting in different risk introduction and spread levels, which may result in different efficacy levels for the HPAI control strategies studied.

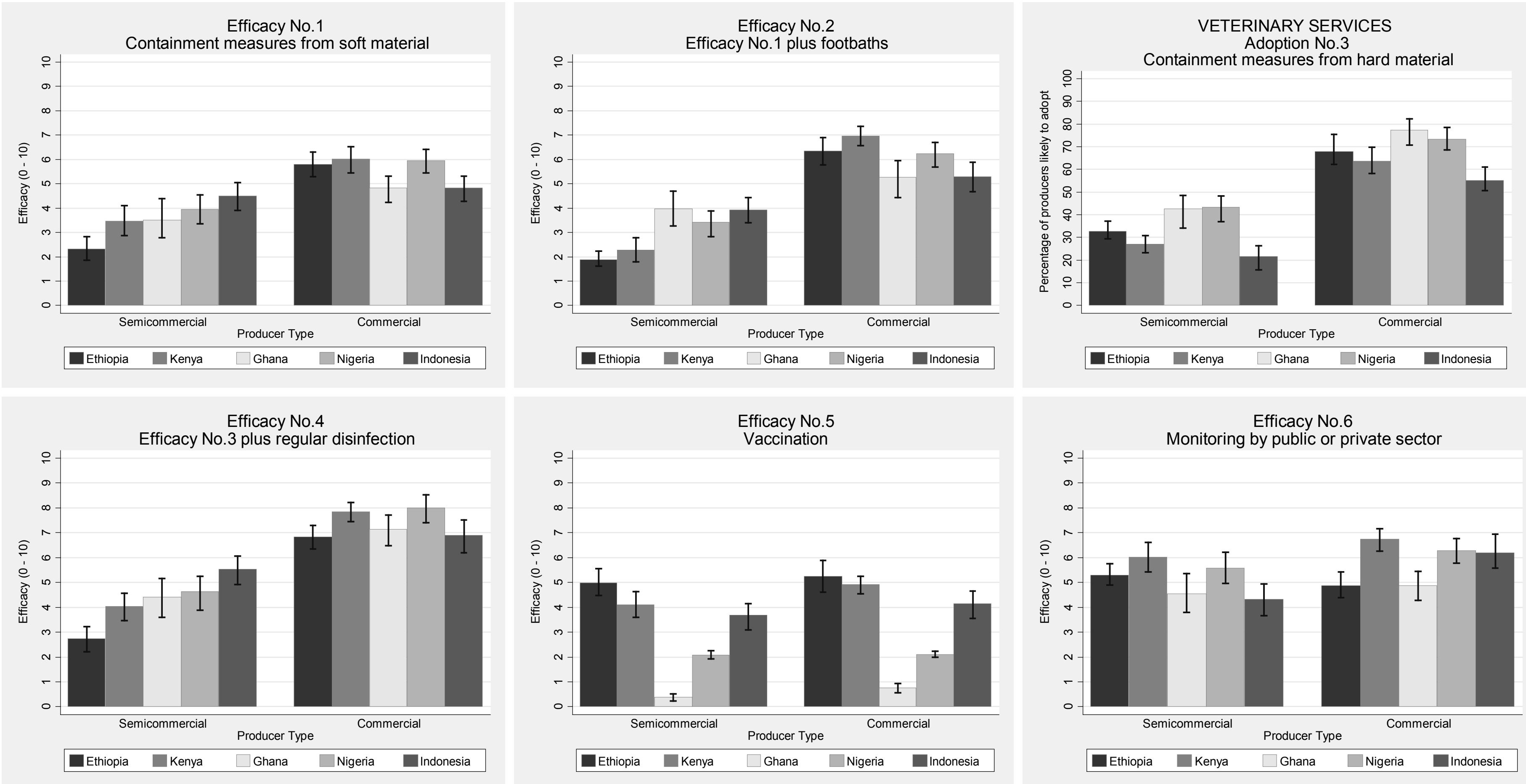
The discrepancy between the efficacy levels of the control strategies for the two sectors could also stem from other sources. Although experts were told to assume that the strategies are correctly implemented before assessing their efficacy, it is possible that they may have considered the following possibilities when making their assessment:

- The commercial sector's more organized and resource-endowed nature may facilitate more effective use of these strategies. This sector is also more vulnerable to HPAI risk in terms of income (profit) loss, and therefore, producers in this sector may have more incentives to implement these measures correctly.
- The noncommercial/semicommercial sector has limited capacity (for example, in terms of financial resources, knowledge, and skill) to implement these measures correctly. This sector is also likely to have fewer incentives to implement these strategies correctly because with their small flock sizes, these producers are likely to derive only a very small proportion of their income from poultry.

These considerations indicating differing levels of motivation or ability, or both, could increase the efficacy gap between these two sectors.

Among the commercial small-scale poultry producers across countries, the efficacies of the first three strategies are lower in Ghana and Indonesia, where the commercial flocks are larger. Therefore, it is likely that these strategies are not as suitable for commercial producers in these two countries as in the others. Similar to their responses about noncommercial/semicommercial producers, Ghana experts think the efficacy of vaccination would be low for commercial small-scale poultry producers in that country. As with the result for noncommercial/semicommercial producers, regular monitoring of the flocks is one of the strategies that supports the highest efficacy rate across countries. Regular monitoring is expected to reduce the HPAI risk by one-half to two-thirds, depending on the country. Another strategy that is expected to have an even higher level of efficacy across countries is regular disinfection combined with containment of poultry in housing made by hard materials (the fourth strategy). This measure is expected to reduce the HPAI risk rate in the commercial sector by almost 70 percent in Ethiopia, Ghana, and Indonesia and as much as 80 percent in Kenya and Nigeria.

Figure 2. Efficacy of private control measures if implemented correctly by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers



Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Efficacy of Control Measures That Can Be Implemented by Veterinary Services

Figure 3 reports the expert panel's opinions on the efficacy of public control strategies that may be implemented by veterinary services to minimize HPAI risk among small-scale producers. Similar to the results on the efficacy of private control measures reported in the previous section, for each one of the public control strategies that can be implemented by veterinary services of each country, the efficacies of the strategies are higher in the commercial sector than in the noncommercial/semicommercial one. This discrepancy may be a result of the different risk introduction and spread patterns stemming from different management and contact profiles across these two sectors. In addition to this, the more organized and formal nature of the commercial sector, as well as the fewer number of actors in this sector, may facilitate veterinary services' enforcement and monitoring of control strategies in the commercial sector compared with the noncommercial/semicommercial sector, which includes numerous informal producers that may be more difficult to identify and control.

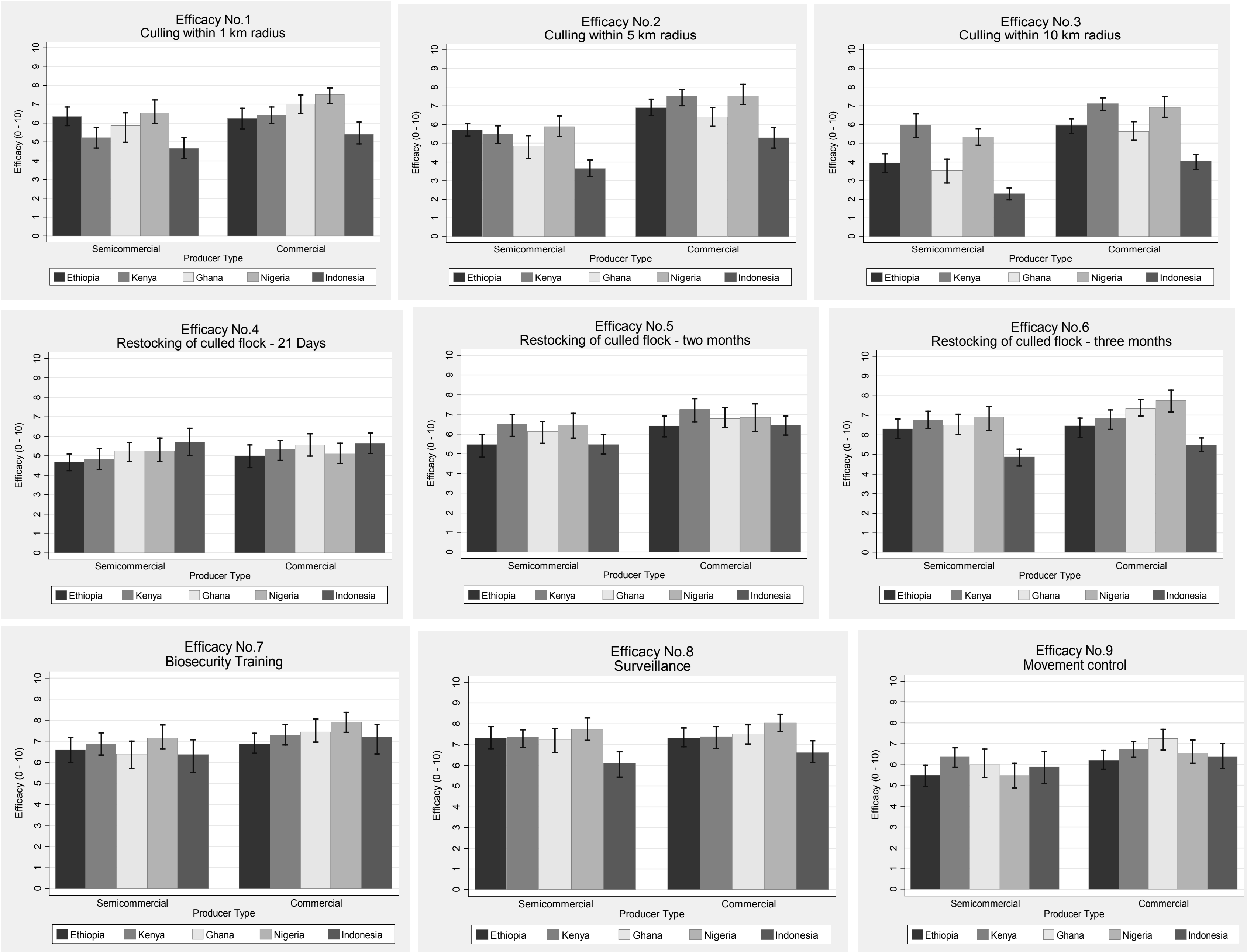
For the noncommercial/semicommercial small-scale producers across all study countries, with the exception of Kenya, the effectiveness of culling decreases with the increasing radius of the area within which the poultry are culled. In Kenya, the effectiveness of culling increases with the increasing radius although the marginal increase in the efficacy rate is very small—52 percent risk reduction for a 1 km radius, 55 percent for a 5 km radius, and 60 percent for a 10 km radius. However, efficacy of the time to restock increases with time for all African study countries—that is, the longer the time between culling and restocking, the more effective the strategy in Ethiopia, Ghana, Kenya, and Nigeria. In Indonesia, the longer the period between culling and restocking, the less effective this strategy becomes, although the marginal change is small. For example, in Indonesia, if restocking takes places 21 days after the culling, the strategy efficacy is 57 percent, after two months this efficacy falls to 55 percent, and after three months, this figure falls to 49 percent. As reported in Figure 1, Indonesia supports the largest small-scale flocks among study countries. Therefore, this latter result may be explained by the producers' trade-offs between potential disease risk efficacy and profit loss, which may tilt the balance toward concerns over profit loss and hence reduce the producers' compliance with this policy.

Across countries, biosecurity training and surveillance are two very effective strategies that may be undertaken by veterinary services to control HPAI risk in the noncommercial/semicommercial sector. According to the experts, biosecurity training is 64 percent effective for Ghana and Indonesia and 72 percent effective for Nigeria; across study countries, surveillance by veterinary services is 61 percent effective for Indonesia and as high as 77 percent effective for Nigeria in the reduction of HPAI risk. These results are especially surprising considering the financial and other resource-related challenges that may be associated with surveying and training the numerous actors that comprise this sector. The expert panel, therefore, seems to consider the veterinary services' surveillance and training to be more effective than almost all of the private measures that may be undertaken by the noncommercial/semicommercial small-scale producers themselves (Figure 2). Movement control, although a promising strategy, is not considered as effective as biosecurity training and surveillance. According to the experts, with this control strategy the HPAI risk could be reduced by 55 percent for Ethiopia and Nigeria and by a maximum of 64 percent for Kenya.

For the commercial small-scale producers in Ghana and Indonesia, which experts contend have the largest commercial flocks, the effectiveness of culling decreases as the radius of the area within which the poultry are culled increases. For the other three countries, however, effectiveness of this strategy increases from a 1km to a 5 km radius and then decreases if the radius is increased from 5 km to 10 km. Therefore, experts think a 5 km radius is optimal for HPAI risk minimization in these countries. Efficacy of the policy in terms of the time it takes to restock the birds after culling increases with time for three of the study countries—Ethiopia, Ghana, and Nigeria. In these three countries, therefore, the maximum period (three months) is the most effective in reduction of HPAI risk. In Indonesia and Kenya, however, the efficacy rates increase from 21 days to two months, after which the efficacy rates decrease from two months to three months; this latter decrease is especially significant for Indonesia. These results reveal that in these two countries, two months would be the optimal period to wait between culling and restocking. Moreover, commercial small-scale producers in Indonesia keep the largest flocks among study countries. Therefore, as with the noncommercial/semicommercial small-scale producers, it is expected that these producers may not want to wait longer to restock and may restock sooner even if not allowed to do so.

As in noncommercial/semicommercial producers, biosecurity training and surveillance are highly effective control strategies that may be applied by the veterinary services of the study countries to control HPAI among commercial small-scale producers. According to the experts, biosecurity training could reduce HPAI risk by 69 percent for Ethiopia and 79 percent for Nigeria, whereas surveillance may reduce the risk by 66 percent for Indonesia and 80 percent for Nigeria. These figures are higher than those for noncommercial/semicommercial producers. Because commercial producers are fewer in number and more organized, their surveillance and training could be more effective than those of noncommercial/semicommercial producers. Likewise, movement control proves to be a more effective strategy among commercial producers compared with noncommercial/semicommercial ones. This last measure is expected to reduce HPAI risk by 64 percent for Indonesia and as high 72 percent for Ghana.

Figure 3. Efficacy of public control measures implemented by veterinary services



Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Adoption of Control Measures

As explained previously, adoption rates of private control strategies are evaluated for three scenarios—(1) business-as-usual, that is, poultry producers adopting the measures of their own accord, (2) poultry producers adopting control measures as a result of training from veterinary services, and (3) poultry producers adopting the control measures as a result of a subsidy from the government. These three scenarios are evaluated for both noncommercial/semicommercial and commercial small-scale poultry producers. The results are reported in Figures 4–9. As can be seen, according to the experts, across strategies and countries, the adoption rates increases from scenario 1 (producers adopting the strategies of their own accord) to scenario 2 (producers adopting the strategies following training) and from scenario 2 to scenario 3 (producers adopting the strategies as a result of subsidies). This increase is more significant for noncommercial/semicommercial small-scale producers than for commercial producers.

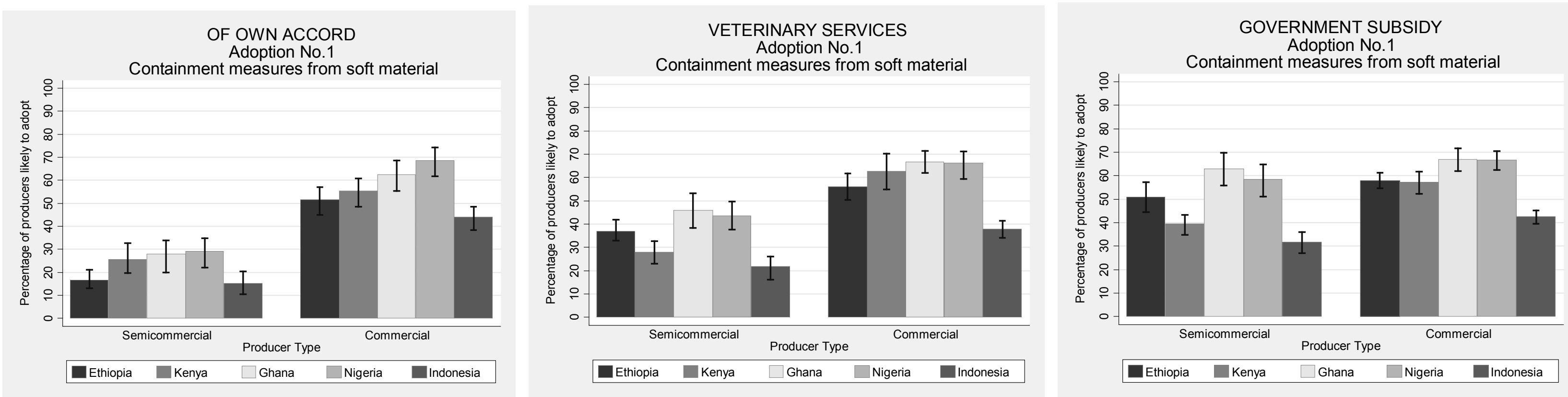
According to the experts, for noncommercial/semicommercial small-scale producers, adoption rates for all of the control strategies (except vaccination) are the highest for Nigeria, with 21–29 percent of all noncommercial/semicommercial producers adopting these strategies of their own accord. According to the experts in Indonesia, the most popular strategy would be vaccination, which would be adopted voluntarily by 24 percent of all noncommercial/semicommercial producers in that country.

Compared with the status quo (that is, producers adopting control strategies of their own accord), training by veterinary services (scenario 2) could increase adoption rates by around 1-1/2 –3 times across countries and strategies. With this intervention, Ghana and Nigeria would support the highest percentage of noncommercial/semicommercial producers that adopt the control strategies (except vaccination), with adoption rates ranging from 35–46 percent across strategies. This intervention is not expected to cause significant increases in the control-strategy adoption rates in Indonesia, with adoption rates increasing by nearly 1-1/2 times across strategies. This result may be explained by the decentralized and dispersed makeup of this country, which may render training efforts futile.

Finally, across countries and strategies, the intervention of providing government subsidies to support producers' adoption of the control strategies (scenario 3) is expected to double to quadruple adoption rates anticipated in the status quo scenario. Therefore, by and large, subsidies could be the most effective intervention to increase adoption rates. Similarly, across countries and strategies, this intervention is expected to result in a higher proportion of producers (47–63 percent) adopting the control strategies in Nigeria and Ghana. The exception to this is vaccination, which is the most popular strategy in Indonesia, where 43 percent of all noncommercial/semicommercial producers would adopt this strategy if the government subsidized it.

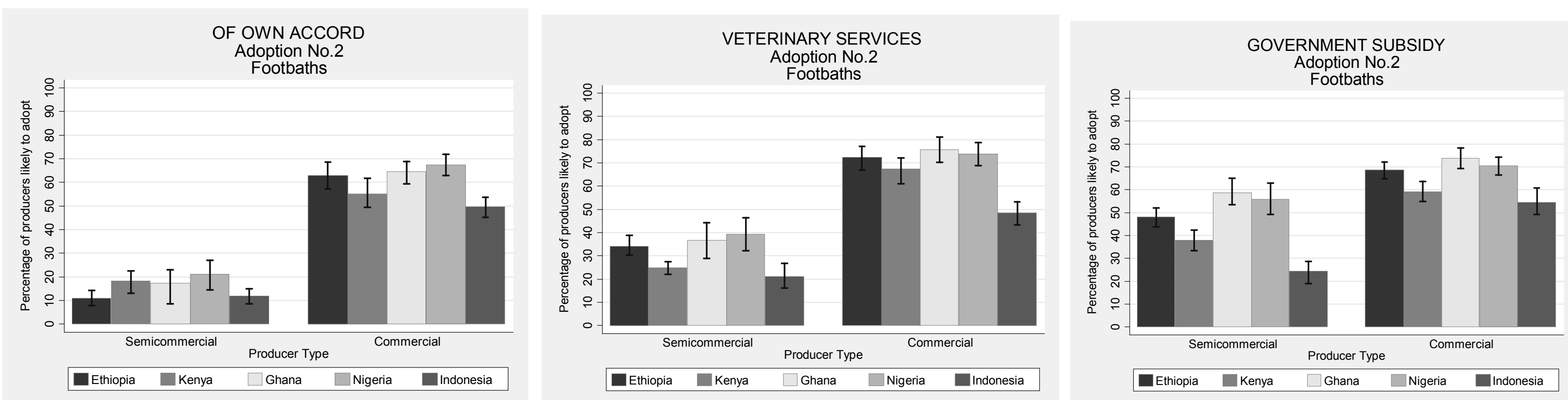
According to the experts, commercial small-scale producers have significantly higher adoption rates compared with noncommercial/semicommercial ones. As discussed previously, this result can be explained by the fact that commercial producers are more specialized in poultry production and hence rely on this activity to provide larger proportions of their incomes. Consequently, they have more incentives to adopt control strategies. The patterns for commercial producers' adoption rates across countries, strategies, and scenarios are similar to those discussed for noncommercial/semicommercial producers. The adoption rates are higher for those trained by veterinary services (scenario 2) than for those adopting of their own accord, and producers receiving subsidies are more likely to adopt interventions than their counterparts who received veterinary service training. Ghana and Nigeria are expected to have the highest overall adoption rates, followed by Kenya and Ethiopia. In Indonesia, adoption rates are significantly lower compared to the African countries. In this country, the most popular strategy (across scenarios) for commercial producers is thought to be disinfection and containment in housing made from hard material.

Figure 4. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Containment measures from soft material



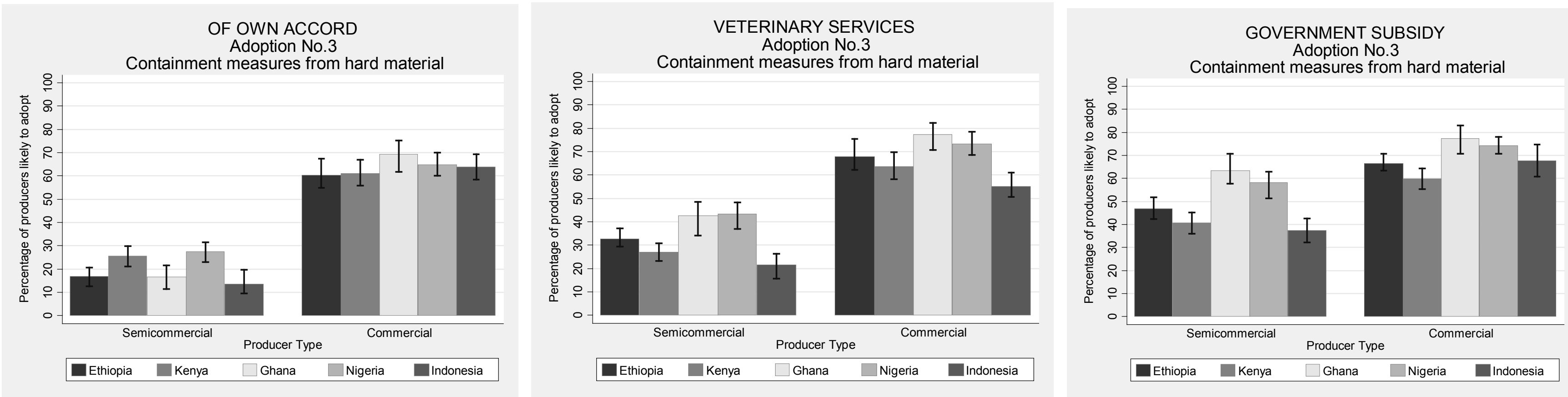
Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Figure 5. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Containment measures from soft material and footbaths



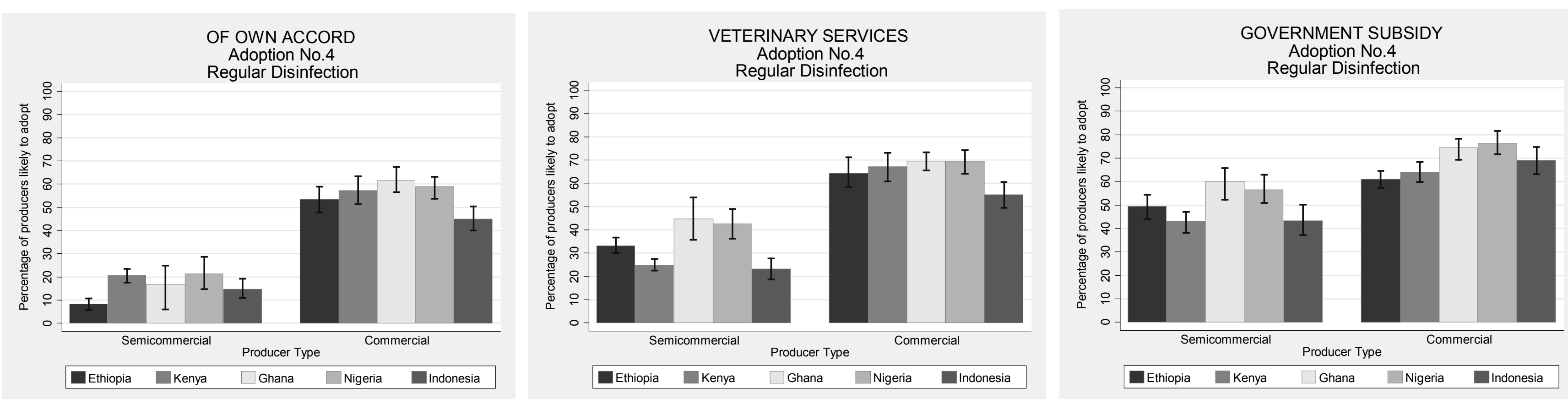
Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Figure 6. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Containment measures from hard material



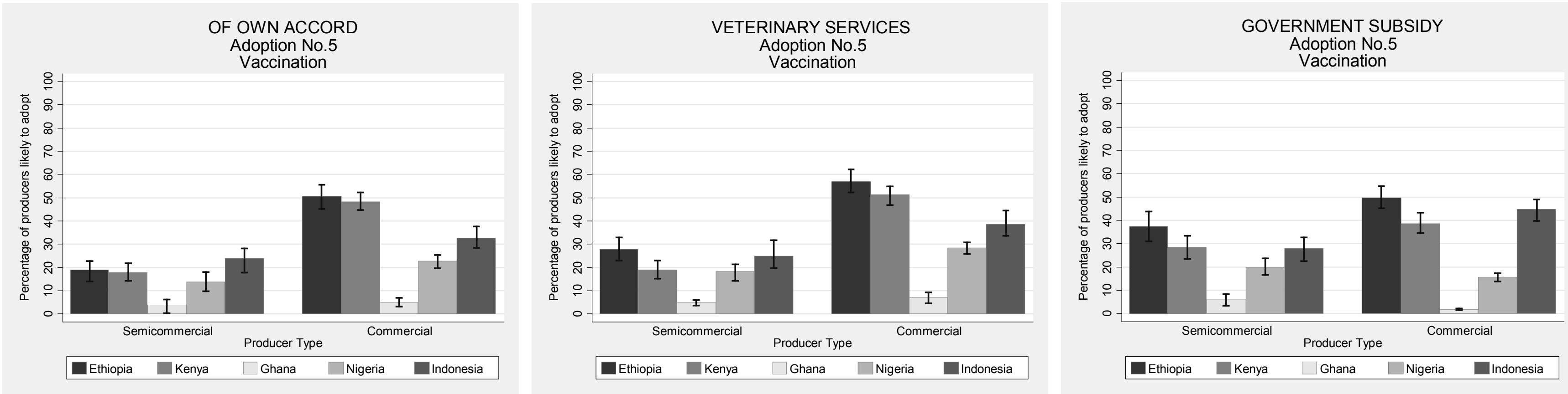
Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Figure 7. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Regular disinfection



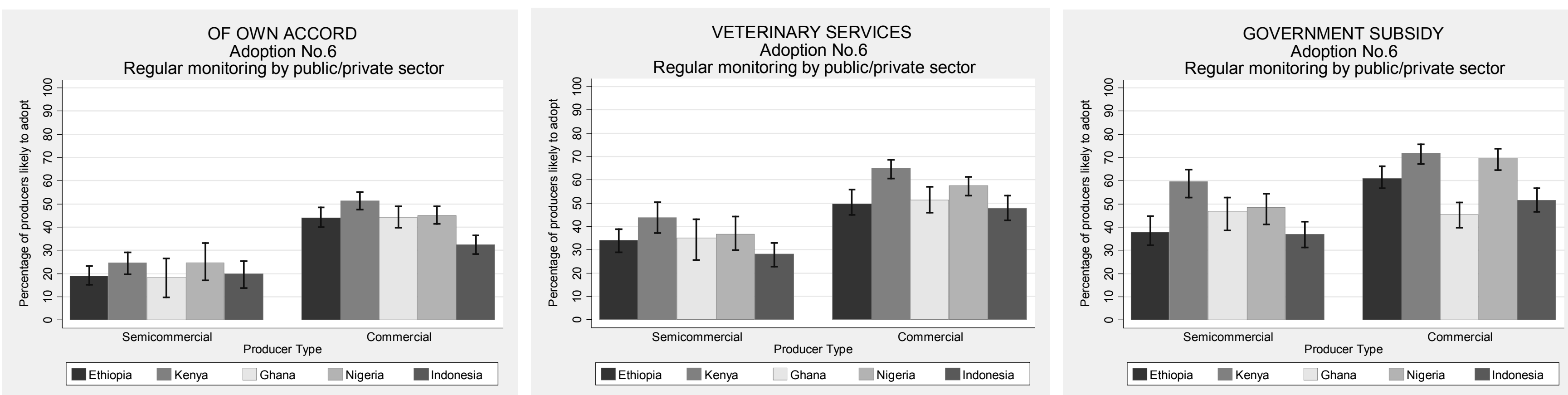
Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Figure 8. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Vaccination



Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Figure 9. Adoption of private control measures by noncommercial/semicommercial (left) vs. commercial (right) small-scale poultry producers: Regular monitoring



Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

5. CONCLUSIONS AND DISCUSSIONS

In this paper, we present the methodology and results of a two-stage expert elicitation (Delphi) study that we conducted to provide input to contingent valuation (CV) studies. These CV studies are designed to estimate the benefits of various public and private strategies for the control of Highly Pathogenic Avian Influenza (HPAI) across the study countries of Ethiopia, Ghana, Indonesia, Kenya, and Nigeria. The results of these CV studies are expected to feed into the cost-benefit and cost-effectiveness analyzes, which will be conducted to identify effective HPAI control strategies in each study country, under the auspices of the Pro-Poor HPAI Control Strategies research project (www.hpai-research.net).

The information gathered through the implementation of this Delphi study includes (1) definitions of the small-scale flocks (noncommercial/semicommercial and commercial) across the study countries, (2) estimations of the efficacy of various private and public control strategies in HPAI control, and (3) estimates of the proportion of poultry producers who are expected to adopt these control strategies under different scenarios—for example, on their own (status quo), following training by veterinary services, or as a result of subsidies by the government.

We relied on an expert elicitation (Delphi) study to capture information and generate data on these three issues because published evidence and hard data are limited, if not nonexistent, for our five study countries. Several previous studies have relied on this method to collect such data on control strategies and livestock disease risks (for example, Stark et al. 1997; Horst 1998; Binns, Green, and Smith 2000; Stark, Horst, and Kelly 2000; Van der Fels-Klerx, Horst, and Dijkhuizen 2000; Sorensen et al. 2002; Costard et al. 2009) when other methods of data collection are either too costly to implement or beyond the timeframe of the projects.

Through this Delphi study we collected data from 23 respondents who are experts in various theoretical, applied, scientific, and policy-related fields surrounding HPAI risk measurement and control. The number of experts who are experienced in our study countries range from 6 in Ghana to 10 in Ethiopia, Kenya, and Nigeria and 11 in Indonesia. Although the sample size may seem small for conventional data analysis methods, it is appropriate for expert elicitation studies (for example, Linstone and Turnoff 2002) because the aim of the expert panel is not to be representative of any target population but rather to represent a broad range of views, expertise, and experiences pertaining to the topics being investigated. With a diverse range of participants (across countries and fields) we managed to compile a panel that was able to comment on the issues presented in the Delphi study.

By using statistical analysis methods, we derived individual distributions for experts' answers and then pooled these into one cumulative distribution by using expert-specific variables (years of experience and country of primary experience) as well as their level of confidence in their own answers as weighing factors.

There are four main conclusions that may be drawn from the results of our analysis. First, in the four African countries, the size of the noncommercial/semicommercial small-scale poultry producers' flocks range between 30–50 birds, although this figure is significantly higher in Indonesia where the average noncommercial/semicommercial poultry flocks is approximately 170 birds. According to the experts, commercial poultry flocks are significantly larger, ranging from 900–1,900 birds in Nigeria, Kenya, and Ethiopia, and with as many as 8,000 birds in Ghana and approximately 10,000 in Indonesia.

Second, efficacy levels of the private HPAI control strategies investigated are significantly higher for commercial producers than for their noncommercial/semicommercial counterparts. This may be explained by the fact that these two sectors have different management and contact profiles, resulting in different risk introduction and spread levels, which may result in different efficacy levels for the HPAI control strategies studied (Costard 2010; personal communication). Another contributing factor to this result could be the experts' consideration that commercial producers are specialized in production and derive larger proportions of their incomes from this activity, and hence have higher incentives (as well as resources and skills) to implement these strategies effectively. Across private strategies and study countries, regular monitoring upon producers' request and payment is thought to have the highest efficacy for those in the noncommercial/semicommercial sector, whereas regular disinfection and containment in hard material (as a combined strategy) is found to be the most effective strategy in minimizing risk in the commercial sector.

Third, efficacy levels of the public HPAI control strategies are significantly higher for commercial producers than for their noncommercial/semicommercial counterparts. As with the second point above, in addition to the different risk introduction and spread patterns stemming from different management and contact profiles across these two sectors, this finding can also be attributed to the experts' consideration that the commercial sector is more organized and formal with fewer actors compared with the noncommercial/semicommercial sector, which is informal and comprised of numerous producers. Therefore, naturally, the monitoring and enforcement of public control strategies are expected to be more effective for the commercial sector. Across strategies, countries, and sectors, experts state that surveillance by veterinary services is the most effective public sector HPAI control strategy.

Fourth, regarding adoption rates of private control measures, according to the experts, small-scale poultry producers' likelihood of adoption is low overall, although adoption rates are higher for commercial producers than for the noncommercial/semicommercial ones, as expected, due to the reasons explained above. For both sectors, however, the adoption rates increase as a result of interventions, and the adoption rates are the highest when government subsidies are provided.

The results presented here may entail five potential biases, some of which will be tackled in future research. First, the inclusion of experts' confidence levels in the weighing of individual responses may bias the results toward the most confident experts within the country panels (Costard 2010; personal communication). A comparison of the results with and without confidence levels as weighting factors in the pooled distributions is therefore warranted. Moreover, it is also worth investigating whether experts from certain disciplines or those with a certain number of years of education or experience have higher confidence levels than others. A preliminary investigation of the average confidence levels across country panels reveals that, overall, experts that comprise the Nigeria and Ghana panels have significantly higher confidence levels than those from other countries, for each one of the results reported in Figures 2–9 Means and standard deviations of confidence levels for each country panel and for each question are available from authors upon request. This finding may, for example, be as a result of Ghana and Nigeria expert panels having higher education levels (Table 1) than other countries' panels. Further investigation of the relationship between confidence levels and other expert level characteristics are therefore warranted.

Second, there were six experts who participated in the first round but did not provide feedback in the second round. Given the already small size of the country panels, we opted to keep these experts in the second round and assume that they did not change their evaluations from the first round; hence, we re-evaluated their first round responses together with the second round data received from the remaining 16 experts. It is possible that this assumption may cause bias, in case these six experts would have changed their evaluations in the second round. Given that the 16 experts who participated in both rounds did make significant changes to their answers in the second round, a comparison of the results with and without these six experts' answers is therefore warranted to test for potential biases that may arise from inclusion of these in the final data analysis.

Third, in the second round of the Delphi study, experts were provided with the panel average for each study country for which they provided information and with the answers they gave in the first round for their primary country of expertise. However, experts were not provided with the answers they gave in the first round for their secondary and tertiary countries of expertise, since their answers to these were given in relation to their primary country of expertise, as explained in Section 3. This structure of questioning for the secondary and tertiary countries of expertise may have biased the results. For example, experts who couldn't see their original answers to their secondary and/or tertiary countries of expertise might have provided answers that confirmed the panel averages, rather than informed revisions of their previous answers. Therefore, an analysis of the results focusing only on experts' primary countries of expertise and comparison of these with the wider panel (which includes experts' secondary and tertiary countries of expertise) is warranted.

Fourth, the adoption rates for the private control measures were asked for three different scenarios—(1) business-as-usual, that is, poultry producers adopting the measures of their own accord, (2) poultry producers adopting the control measures as a result of training from veterinary services, and (3) poultry producers adopting the control measures as a result of a subsidy from the government. The details of scenarios 2 and 3 were not presented in the survey instrument since it was assumed that these interventions could be of different scales and scopes in different countries. Therefore, without prior knowledge of the contacted experts' country(ies) of expertise, inclusion of such detailed information for each study country could have rendered the survey instrument longer than it already was. As a result the experts' perceptions of these interventions were left to their own experiences and prior knowledge of such public interventions in their countries of expertise. This lack of detailed definition is expected to have caused a bias in the results since different experts with different experiences or different levels of knowledge regarding such public interventions in the study countries could have evaluated the success of these interventions in affecting adoption rates differently. This bias could be controlled for to some degree through an investigation of the relationships between expert level characteristics and adoption rates stated under each scenario. In future Delphi studies, care will be taken to define such interventions in greater detail to ensure a uniform level of understanding across experts.

Fifth, the results suggest that, for any given strategy, there are significant discrepancies in efficacy across sectors within a country (noncommercial/semicommercial vs. commercial) or across countries within a sector. Some of the discrepancies could be explained by the different risk introduction and spread patterns stemming from different management and contact profiles across sectors and countries. It is, however, possible that the experts may have considered different levels of implementation when providing answers, although they were asked to state their estimated efficacy levels "if measures were appropriately [or correctly] implemented." Future research will be conducted to decipher the extent to which these discrepancies across sectors/countries can be explained by the differences in poultry management and risk levels on the one hand and by experts' consideration of different levels of implementation on the other.

APPENDIX: SUPPLEMENTARY BOXES AND TABLES

Box A.1. Definition of control measures that can be undertaken by poultry producers

1. **Containment measures from soft material (for example, netting or cages):** This measure refers to the use of soft material to enclose poultry 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 soft material containment (measure 1) described above, a footbath is used for poultry keepers to wash and disinfect their feet 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 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 (for example, bricks, wood, and mud):** 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 (that is, every four months) either by the public sector (national veterinary services or paraveterinary service in districts) or by the private sector (poultry input supplier).
6. **Regular monitoring by 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 (national veterinary services or paraveterinary service in the district) or by the private sector (poultry input supplier) and requires the producers to call for and make a payment for these services.

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Box A.2. Definition of control measures that can be undertaken by veterinary services

1. **Preemptive culling:** This measure involves the slaughtering of all poultry that is infected or potentially infected by HPAI within a defined radius. This radius could be within 1–10 km of the outbreak farm(s) (that is, farm(s) that tested positive for HPAI virus) in the center.
2. **Timing for the restocking of the culled flock:** This measure refers to the time allowed by veterinary services for poultry producers to restock after the flock is culled, satisfactory cleaning and disinfection is completed, and the outbreak has been controlled in the infected area. This period could range from a minimum of 21 days to a maximum of three months.
3. **Movement control:** This measure refers to those interventions aimed at limiting the movement of suspicious poultry within a country. It involves posting warning signs around the infected zone, setting up disinfection stations in the transportation entrances of infected zones to disinfect vehicles and items entering and exiting these zones, and controlling the movement of all susceptible live birds and their products.
4. **Biosecurity training of the poultry producers:** This measure refers to the training of poultry producers by veterinary services on the cumulative measures that can or should be taken to keep disease (viruses, bacteria, fungi, protozoa, and parasites) from a farm and to prevent the transmission of disease (by humans, insects, rodents, and wild birds/animals) from an infected farm to neighboring farms.
5. **Surveillance:** This measure refers to the continuous collection and laboratory evaluation of samples from domestic and wild birds to detect the occurrence of HPAI, to identify locations of avian influenza viral strains, to identify genetic changes in virus isolates, to improve knowledge regarding the links between domestic poultry and wild bird distribution and migration, and to provide early warning systems for regional and global spread of HPAI.

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.1. Definition of small-scale poultry producers

		Noncommercial/Semicommercial flock size	Commercial flock size
	Min	17.56	701.66
Ethiopia	Mean	30.81	1,897.41
	Max	49.24	4,517.24
	Min	27.71	897.99
Kenya	Mean	42.28	1,267.46
	Max	65.46	1,711.79
	Min	20.10	1,985.53
Ghana	Mean	43.87	8,351.45
	Max	77.19	10,107.99
	Min	28.14	592.32
Nigeria	Mean	42.79	903.80
	Max	65.14	1,159.14
	Min	94.60	2,155.24
Indonesia	Mean	166.61	10,213.01
	Max	252.55	32,501.56

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.2. Efficacy of control measures implemented—noncommercial/semicommercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment measures—soft material	1.85	2.32	2.82	2.86	3.46	4.10	2.79	3.50	4.39	3.35	3.94	4.53	3.91	4.49	5.05
Footbaths and containment measures (soft material)	1.61	1.89	2.22	1.79	2.28	2.79	3.26	3.96	4.70	2.83	3.41	3.87	3.39	3.92	4.43
Containment measures—hard material	2.67	3.13	3.50	3.69	4.28	4.95	3.30	3.97	4.71	4.58	5.13	5.67	4.59	5.17	5.75
Regular disinfection and containment measures (hard material)	2.20	2.73	3.23	3.47	4.04	4.56	3.60	4.40	5.16	3.87	4.63	5.24	4.91	5.52	6.05
Vaccination	4.48	4.98	5.55	3.59	4.11	4.62	0.23	0.39	0.51	1.92	2.08	2.26	3.08	3.69	4.15
Regular monitoring by public/private sector	4.89	5.29	5.76	5.43	6.01	6.60	3.79	4.55	5.35	4.96	5.57	6.21	3.67	4.33	4.93

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.3. Efficacy of control measures implemented—commercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment measures—soft material	5.29	5.79	6.29	5.45	6.01	6.53	4.24	4.82	5.32	5.45	5.94	6.42	4.28	4.82	5.31
Footbaths and containment measures (soft material)	5.78	6.35	6.90	6.57	6.95	7.36	4.44	5.26	5.95	5.69	6.23	6.70	4.67	5.28	5.88
Containment measures—hard material	5.77	6.28	6.74	6.93	7.29	7.67	5.60	6.28	7.04	6.93	7.49	8.17	5.74	6.25	6.87
Regular disinfection and containment measures (hard material)	6.34	6.83	7.30	7.44	7.83	8.21	6.47	7.13	7.70	7.41	7.99	8.53	6.19	6.90	7.52
Vaccination	4.60	5.24	5.88	4.55	4.92	5.24	0.55	0.75	0.94	1.98	2.09	2.22	3.55	4.15	4.64
Regular monitoring by public/private sector	4.39	4.86	5.41	6.26	6.75	7.16	4.28	4.87	5.45	5.77	6.28	6.76	5.58	6.19	6.93

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.4. Efficacy of control measures implemented by veterinary services—noncommercial/semicommercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Culling —1-km radius	5.85	6.35	6.86	4.68	5.23	5.75	4.98	5.86	6.54	5.98	6.55	7.22	4.13	4.66	5.24
Culling —5-km radius	5.37	5.70	6.06	4.97	5.49	5.93	4.16	4.85	5.40	5.35	5.88	6.46	3.23	3.63	4.11
Culling —10-km radius	3.45	3.92	4.42	5.30	5.96	6.56	2.86	3.52	4.15	4.90	5.33	5.78	1.96	2.29	2.61
Restocking of culled birds after 21 days	4.23	4.67	5.09	4.29	4.81	5.37	4.70	5.24	5.69	4.71	5.25	5.90	5.01	5.71	6.40
Restocking of culled birds after 2 months	4.82	5.47	6.00	5.89	6.53	7.01	5.52	6.12	6.63	5.79	6.45	7.07	4.99	5.46	5.98
Restocking of culled birds after 3 months	5.82	6.30	6.81	6.32	6.77	7.20	6.01	6.50	7.05	6.23	6.92	7.44	4.40	4.86	5.26
Biosecurity training	5.99	6.58	7.17	6.34	6.86	7.41	5.70	6.38	7.01	6.62	7.16	7.78	5.50	6.37	7.07
Surveillance	6.79	7.31	7.86	6.84	7.35	7.71	6.60	7.22	7.78	7.21	7.72	8.29	5.42	6.10	6.65
Movement control	4.94	5.48	5.97	5.85	6.36	6.80	5.37	6.00	6.75	4.88	5.47	6.06	5.09	5.88	6.63

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.5. Efficacy of control measures implemented by veterinary services—commercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Culling—1-km radius	5.69	6.24	6.79	5.99	6.38	6.84	6.53	7.01	7.49	7.05	7.50	7.87	4.90	5.40	6.05
Culling —5-km radius	6.48	6.90	7.36	7.00	7.51	7.87	5.91	6.40	6.89	7.06	7.54	8.15	4.74	5.28	5.83
Culling —10-km radius	5.50	5.94	6.31	6.77	7.11	7.42	5.16	5.62	6.15	6.38	6.91	7.50	3.60	4.06	4.41
Restocking of culled birds after 21 days	4.38	4.97	5.55	4.77	5.30	5.78	4.98	5.55	6.12	4.60	5.09	5.63	5.11	5.63	6.16
Restocking of culled birds after 2 months	5.86	6.40	6.91	6.60	7.25	7.80	6.35	6.79	7.34	6.13	6.85	7.53	5.95	6.45	6.92
Restocking of culled birds after 3 months	5.85	6.46	6.85	6.28	6.82	7.26	6.95	7.34	7.79	7.16	7.75	8.29	5.16	5.49	5.83
Biosecurity training	6.44	6.88	7.37	6.83	7.27	7.79	6.95	7.45	8.06	7.43	7.91	8.37	6.39	7.21	7.79
Surveillance	6.90	7.31	7.80	6.81	7.38	7.87	7.02	7.50	7.95	7.62	8.03	8.46	6.13	6.60	7.17
Movement control	5.77	6.20	6.68	6.34	6.71	7.10	6.70	7.24	7.68	6.06	6.55	7.17	5.81	6.37	7.01

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.6. Adoption of control measures without any intervention—noncommercial/Semicommercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	13.03	16.72	21.05	19.81	25.63	32.78	19.90	27.96	33.77	21.96	29.07	34.84	10.49	15.20	20.38
Footbaths	7.82	11.05	14.17	13.19	18.30	22.51	8.53	17.27	22.92	14.63	21.24	26.94	8.66	11.80	14.92
Containment in hard material	12.64	16.89	20.70	21.12	25.67	29.86	11.56	16.72	21.49	22.99	27.42	31.58	9.46	13.56	19.75
Regular disinfection	5.82	8.28	10.64	17.55	20.74	23.55	5.92	16.78	24.93	14.82	21.39	28.69	11.00	14.64	19.30
Vaccination	14.09	18.93	22.74	14.19	17.86	21.78	0.25	3.81	6.16	9.73	13.83	18.13	17.77	24.07	28.23
Regular monitoring by public/private sector	15.30	19.07	23.21	19.62	24.75	29.26	9.80	18.36	26.62	17.01	24.70	33.09	13.85	19.99	25.33

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.7. Adoption of control measures without any intervention—commercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	44.94	51.59	57.04	48.65	55.42	60.70	55.45	62.50	68.66	61.69	68.59	74.17	38.41	44.15	48.58
Footbaths	57.38	62.87	68.52	49.43	55.10	61.77	59.50	64.50	68.88	62.97	67.39	71.99	45.29	49.76	53.84
Containment in hard material	54.88	60.31	67.54	55.97	60.99	66.90	61.78	69.24	75.13	60.17	64.94	70.00	58.53	63.88	69.44
Regular disinfection	47.92	53.38	58.98	51.34	57.38	63.32	56.65	61.50	67.50	53.78	58.83	63.11	39.92	44.93	50.41
Vaccination	45.30	50.73	55.54	44.82	48.25	52.31	3.21	5.13	7.00	19.71	22.89	25.42	28.35	32.75	37.70
Regular monitoring by public/private sector	40.13	44.14	48.53	47.63	51.45	55.18	39.70	44.24	49.09	41.47	44.96	49.01	28.49	32.48	36.52

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.8. Adoption of control measures as a result of training by veterinary services—noncommercial/semicommercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	32.88	36.88	41.95	23.05	28.01	32.72	38.37	45.95	53.28	37.71	43.59	49.72	16.11	21.76	26.13
Footbaths	30.39	34.17	38.74	21.98	24.91	27.59	28.91	36.73	44.19	32.34	39.25	46.43	16.23	21.10	26.81
Containment in hard material	29.30	32.81	37.17	23.31	27.12	30.79	34.14	42.52	48.49	36.96	43.45	48.35	15.75	21.49	26.25
Regular disinfection	30.22	33.11	36.70	22.44	25.02	27.47	35.67	44.87	54.00	36.22	42.70	48.97	18.87	23.28	27.80
Vaccination	23.03	27.78	32.86	15.14	19.04	23.02	3.67	4.82	5.96	14.23	18.37	21.45	19.80	24.99	31.88
Regular monitoring by public/private sector	28.97	34.06	38.92	37.20	43.88	50.48	25.73	35.09	43.08	29.81	36.77	44.20	22.88	28.31	32.94

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.9. Adoption of control measures as a result of training by veterinary services—commercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	50.33	56.15	61.68	54.86	62.82	70.21	61.97	66.78	71.53	59.29	66.25	71.23	34.13	37.86	41.35
Footbaths	66.92	72.34	77.05	60.97	67.32	72.14	70.23	75.79	81.04	68.91	73.81	78.70	43.35	48.56	53.33
Containment in hard material	62.18	67.95	75.39	58.16	63.69	69.81	70.70	77.40	82.34	68.61	73.45	78.51	50.62	55.22	61.12
Regular disinfection	58.40	64.36	71.16	60.92	67.14	73.14	65.66	69.51	73.36	64.19	69.66	74.27	49.38	55.21	60.53
Vaccination	52.29	57.02	62.23	46.95	51.31	54.95	4.48	7.10	9.24	25.76	28.49	30.82	33.56	38.53	44.56
Regular monitoring by public/private sector	44.97	49.82	55.77	60.51	65.08	68.69	45.85	51.40	56.95	53.25	57.48	61.18	42.68	47.80	53.33

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.10. Adoption of control measures as a result of subsidy from the government—noncommercial/semicommercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	44.58	50.81	57.29	34.85	39.45	43.42	55.89	62.95	69.84	51.20	58.50	64.88	26.93	31.87	35.93
Footbaths	43.83	48.00	52.18	33.40	38.00	42.37	53.42	58.72	65.15	49.15	55.77	62.97	19.02	24.35	28.72
Containment in hard material	42.48	46.90	51.86	35.91	40.69	45.11	57.76	63.40	70.69	51.27	58.19	62.89	32.29	37.45	42.66
Regular disinfection	43.98	49.45	54.45	38.14	43.12	47.23	52.24	60.05	65.78	51.00	56.45	62.85	37.20	43.33	50.15
Vaccination	31.16	37.45	43.75	23.47	28.47	33.35	3.53	6.14	8.34	16.53	19.93	23.61	22.52	27.90	32.70
Regular monitoring by public/private sector	32.35	37.88	44.68	52.74	59.66	64.76	38.52	46.89	52.75	41.21	48.52	54.32	31.19	36.98	42.29

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

Table A.11. Adoption of control measures as a result of subsidy from the government—commercial small-scale poultry producers

	Ethiopia			Kenya			Ghana			Nigeria			Indonesia		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Containment in soft material	54.59	57.87	61.39	52.28	57.36	61.84	62.03	66.87	71.75	62.41	66.83	70.50	39.48	42.57	45.29
Footbaths	64.89	68.62	72.23	54.81	59.21	63.70	69.29	73.77	78.20	66.41	70.59	74.36	49.35	54.37	60.79
Containment in hard material	63.37	66.60	70.84	55.44	59.95	64.34	70.74	77.31	83.09	70.69	74.33	77.97	60.90	67.56	74.79
Regular disinfection	57.16	61.03	64.50	59.77	63.95	68.36	69.25	74.60	78.30	71.80	76.38	81.63	63.15	69.04	74.70
Vaccination	45.22	49.74	54.61	34.67	38.51	43.39	1.53	1.87	2.22	13.69	15.80	17.40	39.89	44.85	48.94
Regular monitoring by public/private sector	56.79	61.09	66.15	67.31	71.82	75.64	39.89	45.48	50.66	64.67	69.82	73.86	46.71	51.65	56.83

Source: Delphi Survey on the Efficacy of Control Measures in HPAI Risk Minimization and Adoption of Control Measures in Small-Scale Poultry (2009).

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