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paper

BIOSECURITY FOR HIGHLY PATHOGENIC AVIAN INFLUENZA

Issues and options

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Issues and options

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Contents

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Acronyms and abbreviations

AIAO	all in, all out
DOC	day-old chick
FAO	Food and Agriculture Organization of the United Nations
HACCP	Hazard Analysis of Critical Control Points
HPAI	highly pathogenic avian influenza
IBRD	International Bank for Reconstruction and Development (World Bank)
LBM	live-bird market
OIE	World Organisation for Animal Health
POL	point of lay (the age at which laying birds start to produce eggs)
WHO	World Health Organization

Summary

Biosecurity is the implementation of measures that reduce the risk of the introduction and spread of disease agents. Biosecurity requires the adoption of a set of attitudes and behaviours by people to reduce risk in all activities involving domestic, captive exotic and wild birds and their products.

This paper moves forward from the discussion presented in the FAO/OIE/World Bank position paper on *The importance of biosecurity in reducing HPAI risk on farms and in markets*, prepared for the Inter-Ministerial Conference on Avian and Pandemic Influenza, held in New Delhi in December 2007. It draws on what we already know about biosecurity, particularly for countries endemically infected with HPAI or at high risk of introduction, identifies problems, proposes solutions and outlines a future course of action.

Among others, it looks at the basic principles of biosecurity within the overall framework of disease control, discusses species- and sector-specific issues, stresses the importance of situating biosecurity in appropriate economic and cultural settings, and makes the case for the role of communication.

THE FUNDAMENTAL PRINCIPLES

Taking as its starting point the definition of biosecurity as "implementation of practices that create barriers in order to reduce the risk of the introduction and spread of disease agents", the paper stresses that people are key to correct implementation but that this must be formulated in terms of measures that are hard to avoid and easy to comply with.
The three principle elements of biosecurity are:

1) Segregation — The creation and maintenance of barriers to limit the potential opportunities for infected animals and contaminated materials to enter an uninfected site. This step, properly applied, will prevent most infection.

2) Cleaning — Materials (e.g. vehicles, equipment) that have to enter (or leave) a site must be thoroughly cleaned to remove visible dirt. This will remove most of the virus that is contaminating the materials.

3) Disinfection — Properly applied, disinfection will inactivate any virus that is present on materials that have already been thoroughly cleaned.

The details of how biosecurity is applied will depend on the type of poultry production unit in question: for farms and villages, for example, the emphasis should be on "bioexclusion" (keeping disease agents out), for markets it should be on "biocontainment" (keeping disease agents in), and for duck flocks it is a question of both.

Appropriate disease control methods will depend heavily on identifying the mechanisms through which HPAI is maintained and spread. Here much still remains to be learned about the potential role of wild birds as a reservoir of infection (so far, no long-term reservoir outside live animals has been identified) but a very clear reservoir has been identified in domestic poultry (particularly ducks) and possibly in other captive wild birds.

Studies have also shown that live infected domestic poultry can produce virus for several days or weeks without clear clinical signs. Infected domestic birds are the most dangerous source of virus and inanimate objects (fomites) contaminated with secretions (in particular faeces) from infected birds are the next most dangerous source of virus and air-borne spread is not significant. The disease is mostly spread by the actions of man, moving either infected birds or contaminated materials.

GENERAL ISSUES

In no country is poultry keeping or production homogenous:

- The sector is made up of many different types of domestic[1] and non-domestic captive birds; besides poultry, people keep other types of bird, including fighting cocks, breeding and show birds, birds of prey and related species, decoy birds for hunting and captive exotic wild birds.
- Many people other than keepers form part of the domestic and captive bird sector; these include traders, live-bird market (LBM) workers, animal health workers, feed sellers and transporters.

The more complex the production and marketing chain (i.e. the more steps and people involved), the harder it seems to be to control and eradicate H5N1 HPAI – but, when devising and recommending biosecurity measures, all stages in the chain must be taken into account.

Currently, there are many known biosecurity measures, but these have been developed mostly for large-scale commercial production systems in the so-called "developed world". This raises three major issues:

- Large-scale commercial farms in the "developing world" should be encouraged to adopt the measures.
- Few of the commonly-recommended measures are appropriate for small-scale commercial systems or for scavenging poultry.
- Biosecurity measures have not been designed for intermediaries and service providers, non-domestic poultry, hunters, etc.

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[1] In 2004, FAO identified four poultry production sectors:
Sector 1 - industrial integrated production with birds or products marketed commercially.
Sector 2 - commercial poultry production with birds or products sold through slaughterhouses or live poultry markets.
Sector 3 - smallholder commercial poultry production, including water fowl, with birds or products usually sold through live-bird markets.
Sector 4 - village or backyard production with birds or products consumed locally.

Where they do not exist, appropriate biosecurity measures have to be designed and implemented; where they do exist, they may not be sufficiently effective or implemented widely enough. In either case, the bottom line is that any biosecurity measure must be practical and proportionate to the risk for which it was developed.

The practical design of biosecurity measures should be grounded firmly in three key considerations:

- Biosecurity recommendations should be developed for all component parts of the domestic poultry and captive bird sector, including intermediaries and service providers.
- In most locations, the emphasis should be on preventive biosecurity to decrease the risk of infection (bioexclusion), although biocontainment remains important.
- Those who will implement biosecurity measures should be involved in their design to ensure that they are feasible and sustainable.

This latter consideration touches the core of what biosecurity is all about and without which any attempt to achieve effective and sustainable disease prevention and control will fail: stakeholder "buy-in".

Furthermore, planning for biosecurity must incorporate socio-economic analysis to help identify the social and cultural acceptability of proposed measures, the level of cost that people can afford to pay, and the regulations, incentives and penalties that may be appropriate to induce the behaviour change that will be necessary in many situations.

This analysis should address three fundamental questions:

1. To whom are poultry important?
2. What might/will people be prepared to do to improve biosecurity?
3. How much can people afford to spend on biosecurity, who should pay for what, and what should be the balance between incentives and penalties that may be needed?

Economic assessment of biosecurity measures may be based on cost-effectiveness or cost-benefit analysis. Livelihoods analysis is useful for understanding the importance of poultry and motivations of people.

If this approach identifies how people perceive their own situation and the environment in which they act, communication builds on it and crafts ways of involving the people in biosecurity planning and implementation.

At all costs, communication must not be prescriptive, laying down rules on behaviours to practise and behaviours to avoid, but should take into account the complex interplay between risk perception, response, behavioural intent and message design.

One of the major contributions communication can make to the development of biosecurity lies in encouraging a shift from the *naturalistic* to the *contagion/contamination* approach to poultry sickness. Effective behaviour change communication must come to terms with and overcome the widespread perception that poultry sickness and death are natural, a perception that leads to lack of reporting sick and dead birds, lack of hygiene when handling poultry, and the consumption of sick and dead poultry.

At the same time, awareness of *why* the behaviour being promoted *makes sense* to the receiver of the message is key to behaviour change and must form part of any communication strategy. To make sense to a farmer, communication messages must be couched more in terms of personal values such as the *wellbeing and prosperity* of the family than in terms of technical rationale alone.

Furthermore, communication has a major role to play in the "enabling environment" that must be created around biosecurity. It is an instrument of advocacy, stimulating policy-makers and media to rally round the importance of biosecurity, helping to create the supportive institutional framework within which individuals and communities can play their role.

SPECIFIC ISSUES AND OPTIONS

While the paper looks at issues and solutions for different sectors in the poultry production and marketing chain, the lists are not exhaustive nor are they intended to be. They highlight a number of critical areas that should be addressed by biosecurity planners in these sectors: among the large- and small-scale producers, in the hatcheries, in the scavenging poultry context, in the duck raising units, in the LBMs, among the intermediaries and service providers, among the poultry fanciers, keepers of fighting cocks, exotic birds and birds of prey, and in the hunting communities.

Biosecurity for large-scale commercial producers (sectors 1 and 2)

- There are strong incentives for large-scale commercial producers to adopt biosecurity measures; where necessary, governments can strengthen these incentives through regulation requiring that a given level of biosecurity be achieved in order to have access to markets.
- Detailed methodologies for biosecurity at large-scale commercial farms are available from many sources; governments (perhaps in conjunction with producer associations where they exist) should work with producers to adapt these methodologies for the national context.
- Governments should develop and maintain a database of large-scale commercial producers.
- Governments and the poultry industry should work together to establish a system of compartmentalization where this is justified.

Biosecurity for small-scale commercial producers (sector 3)

- Biosecurity should emphasize the creation of physical barriers against infection and to control access; this may require some public funding.
- Cleaning of inanimate objects should be the second step.
- Participatory field work is required to establish which biosecurity measures are feasible and sustainable, to produce and disseminate extension messages, and to monitor and report on uptake and impact of these messages.

Biosecurity for hatcheries

- Day-old chicks (DOCs) are not infected at hatching but may be infected after hatching if biosecurity at the hatchery is poor.
- Hatcheries are an essential part of the production and marketing chain; their continued operation is vital to commercial production, particularly of broiler chickens.
- All hatcheries above a certain size should be registered and licensed.
- Strict biosecurity is required because of the potential for wide dissemination of infection from a single hatchery.

Biosecurity for keepers of scavenging poultry

- Scavenging poultry are by far the most numerous type of poultry flock, have been the type of flock most frequently affected by H5N1 HPAI, and have been a source of human illness - however, the risk of an individual flock being infected is no greater than for commercial flocks and in some situations, may be less.
- Keepers of scavenging poultry cannot introduce effective biosecurity measures acting alone; community-led initiatives are necessary.
- Any measure that is introduced must be locally sustainable (i.e. without repeated inputs from outside agencies) and with a minimum possible burden, in terms of costs and time, and in terms of initial and ongoing requirements.
- Segregation will be difficult to implement in a system where poultry are free to roam, but housing scavenging poultry fundamentally changes the production system.
- Sustainable use of disinfectants is unlikely.
- Biosecurity will need to rely on cleaning.
- Field work is needed to formulate recommendations that keepers of scavenging poultry will implement, taking into account their perception of risk and ability to invest resources in biosecurity; this is a challenge and should not be underestimated.

Biosecurity for domestic duck keepers

- Duck keepers must implement the same bioexclusion measures as other poultry keepers.
- They will also need to practise routine biocontainment because of the possibility of undetected infection.
- Effective biosecurity for duck flocks that are part of the duck/rice system is probably not possible; biosecurity measures should be supplemented by licensing, movement control and vaccination.

Biosecurity for LBMs

- LBMs have been major contributors to H5N1 outbreaks, both as key mixing points and sources of disease spread; they have also been sources of human disease.
- Biocontainment of infection is vital at these sites.
- Biosecurity measures such as introducing rest days, limiting the species which can be sold at a market and the use of cleanable cages have been shown to have an impact on reducing the persistence of infection in LBMs.
- LBMs can play a positive role in the control of H5N1 HPAI by acting as places where information can be disseminated and gathered, and active surveillance for disease/virus can be carried out.
- Closing LBMs should be undertaken with care because it could create informal and unknown markets, worsening the disease situation.

Biosecurity for intermediaries and service providers

- Intermediaries and service providers have an interest in maintaining their own businesses and those of whom they work with.
- They create links between different segments of the domestic poultry and captive

bird sector, and constitute a key disease spread risk; they must implement adequate biosecurity measures.

- Intermediaries and service providers have contacts with many producers and are often trusted sources of information; they can therefore act as disseminators of biosecurity messages and advocates for biosecurity plans.
- There is a need to development appropriate and sustainable biosecurity measures to be applied by intermediaries and service providers, and to monitor their uptake and impact.
- Regulation of intermediaries and service providers may be appropriate and should be considered.

Biosecurity for poultry fanciers, and keepers of fighting cocks, exotic birds and birds of prey

- These bird keepers must be involved in any biosecurity programme.
- Many are based in villages or peri-urban areas and should be part of the measures developed for small-scale commercial and/or scavenging poultry.
- The trade in captured wild birds is large and difficult to regulate, and birds may become infected at any point after capture, including in markets; they should be regarded as an integral part of the domestic poultry and live-bird production and marketing chains, and included in biosecurity measures for these chains.

Biosecurity for hunters

- Hunted wild birds have recently been shown to have played a role in introducing virus into domestic poultry; this finding requires further examination through detailed outbreak investigation.
- Public awareness messages need to be produced both for hunters and their families and partners about this risk and how to avoid it.
- Awareness messages should focus on advising hunters that the remains (feathers and internal organs) of hunted wild birds should be disposed of by burning or burying; they should not be disposed of in the environment where they could act as sources of infection for domestic poultry.

TOWARDS PRACTICAL AND SUSTAINABLE BIOSECURITY

If one recommendation were to sum up all the recommendations in this paper, this would be that biosecurity must be practical and sustainable for all – for producers, for traders, for intermediaries and service providers and for all those pursuing activities that could contain the seed of risk.

Designing feasible programmes of biosecurity will require working with all stakeholders to ensure that this happens and that those who will have to implement the measures accept the need to do so and see the benefits in doing so.

This will require veterinary technical expertise, but also the equally important contributions of socio-economists and communication specialists if practical and sustainable improvements in today's standards of biosecurity are to be achieved.

Introduction

This paper moves forward from the discussion presented in the FAO/OIE/World Bank position paper on *The importance of biosecurity in reducing HPAI risk on farms and in markets*, prepared for the Inter-Ministerial Conference on Avian and Pandemic Influenza, held in New Delhi in December 2007. It aims to:

- describe in detail the current situation of and state of knowledge about biosecurity in relation to H5N1 HPAI, particularly for countries endemically infected with HPAI or at a high risk of introduction;
- highlight specific issues and propose possible options for biosecurity in important parts of the domestic poultry and captive bird sector

Disease in poultry and humans caused by H5N1 HPAI has now been present for over a decade. It has involved commercial flocks of all sizes and species as well as scavenging poultry (also often called backyard poultry[2])

During that time, our understanding of how H5N1 HPAI spreads has increased. It is now clear from epidemiological analysis and molecular biology studies that while wild birds play a role in the spread of disease, they are responsible for a relatively small proportion of the overall volume of disease transmission worldwide, although in Europe, the majority of infections have been detected in dead wild birds. The majority of cases are due to local secondary spread between domestic poultry after initial introduction. This is particularly true in endemically-infected countries.

Most secondary spread is largely human-mediated. People create spread directly by moving live birds (domestic and captive species), indirectly through contaminated materials (fomites), and in some cases through hunting activities. In some countries, live-bird markets (LBMs) have been one of the important elements in maintaining and spreading the virus, and have been the source of infection in humans.

Any disease spread primarily through human activities is susceptible to biosecurity control measures along the production and marketing chain. It is this that makes biosecurity such an important tool for the control and eradication of H5N1 HPAI. The focus is on changing the behaviours of people in such a way that the risk of disease transmission is decreased.

In its own constant reassessment of the global and regional H5N1 HPAI situation and in their joint FAO/OIE global strategy for its prevention and control), FAO and OIE recognize that improvement in biosecurity at all stages is an indispensable step for the prevention and control of HPAI, particularly in the long term.

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[2] The term "scavenging poultry" is used in this paper instead of the more frequent "backyard poultry". This is to avoid the confusion that arises in some countries where backyard poultry may be taken to include small-scale commercial poultry which are often also kept in the backyard and may or may not be permanently housed.

It is not the intention that this paper be a manual of biosecurity techniques; these already exist in profusion, especially for commercial farms. There is no technical barrier to biosecurity in theory, but experience has shown that manuals produced without an understanding of the structure and problems of the poultry sector do not achieve their goal. *Biosecurity for HPAI: Issues and options* aims to set biosecurity in the context of the field situation and to propose options for improving biosecurity and the next steps to take to improve biosecurity in the field.

Methodology

This paper has been developed using information from the many field studies carried out by FAO and other organizations, as well as from papers in both formal and informal literature. In some cases, reports of studies or papers were used to examine the biosecurity situation in the poultry sector of a given country or region; in others, they were used for various different purposes (e.g. poultry sector reviews, production and marketing chain analyses or Knowledge, Attitudes, Practices [KAP] studies, biosecurity manuals). The documents consulted are listed in Annexes 1 and 2.

The paper has also drawn on information supplied by FAO field teams on the basis of their experience with biosecurity in various countries and regions (e.g. Egypt, Indonesia, Viet Nam and West Africa).

The reports consulted contain valuable information about the structure of countries' domestic poultry (mainly chicken) sectors and about networks within these sectors. They cover many countries, primarily in west, east and southern Africa, the Near East, Europe and Southeast Asia. They cover many sectors of the poultry system, including LBMs, and contain a wealth of information on the structure and complexity of the domestic poultry and captive bird sectors. Where appropriate, they contain information on the current levels of biosecurity being implemented and recommendations for measures to be implemented.

Various reports have addressed the issue of the relative costs and practicalities of different biosecurity measures, and on this basis have identified measures that could be proposed for small–scale commercial and scavenging poultry units. Some studies have started relatively recently, mostly in Southeast Asia, to identify practical and sustainable biosecurity measures for small-scale commercial and scavenging poultry systems but the results are not yet formally available.

The literature search revealed that while there are numerous reports and publications that make recommendations for improving biosecurity, these are mainly aimed at poultry producers, in all sectors, and some at LBMs, although the actual audience is unclear. However, many of the recommendations made for small-scale commercial and scavenging poultry keepers, while technically correct, are impractical under actual field conditions.

There are very few recommendations that take into account the potential role of intermediaries and service providers (traders, animal health personnel, etc.), owners of fighting cocks, those who capture, trade and keep wild birds, or hunters (including the role of decoy duck keepers).

To date, there has been little work completed on the role of improved biosecurity in slowing down the spread of HPAI or on how sustainable biosecurity measures are likely to be. There has been little involvement of those who will have to implement biosecurity to assess which, if any, measures are practical and sustainable, or whether enhanced biosecurity is likely to be adopted. There are few examples of best practices or results of trials.

These are all key areas that need to be addressed.

In the time and with the resources available, it was not possible to commission any specific studies on biosecurity for HPAI. Such trials require careful planning and a long-term approach in order to evaluate their impact. In this context, one of the objectives of this paper is to propose potential solutions to the problems identified and establish a programme to address them.

Section 1

The importance of biosecurity for HPAI

THE FUNDAMENTAL PRINCIPLES OF BIOSECURITY

Biosecurity has many definitions.

The somewhat broad definition FAO used in its position paper for the Inter-Ministerial Conference on Avian and Pandemic Influenza, held in New Delhi in December 2007, was: *Biosecurity refers to those measures that should be taken to minimize the risk of incursion of HPAI into individual production units (bioexclusion) and the risk of outward transmission (biocontainment) and onward transmission through the production and marketing chain*.

This definition can theoretically include many activities, including vaccination. For the purposes of this paper, a slightly narrower definition is taken:

Biosecurity is the implementation of measures that reduce the risk of the introduction and spread of disease agents; it requires the adoption of a set of attitudes and behaviours by people to reduce risk in all activities involving domestic, captive exotic and wild birds and their products.

Although there is often an emphasis on structures, equipment and materials such as disinfectants, biosecurity is put in place and carried out by people, often acting in concert. To be effective, it must part of daily routine, and both hard to avoid and easy to comply with. Even the most sophisticated biosecurity measures can be breached by human error. The key is to persuade people of the need for and advantages of adopting biosecurity and to develop with them sets of practices and behaviours that are seen by them as possible, practical and sustainable.

Crucially, any biosecurity measure that is recommended must take into account the socio-economic realities of those who will be expected to implement it.

It is usually not feasible to achieve perfect biosecurity that prevents all spread. The aim should be for a level of biosecurity that contributes to reducing spread to below a certain threshold. *It is an established principle that if on average an infected site infects less than one uninfected site, disease control will be achieved*. In these circumstances, the disease will eventually die out. The number of uninfected premises that an infected premise infects is often described as the reproductive rate, 'R'; for a disease to be eradicated, 'R' does not have to be zero, but reliably less than 1.

In terms of an epidemic, spread matters as much as the initial infection and biosecurity is one of the key pillars in slowing spread.

There are several ways of defining different elements of biosecurity. One system divides it into three goals: isolation, sanitation and traffic control. Under this system, biosecurity is achieved through three elements: conceptual, structural and operational. Although this

is technically correct, it is often too complex and apparently theoretical for practical use in the field.

A simpler way to describe biosecurity is that it consists of the following steps:

1) Segregation
2) Cleaning
3) Disinfection

Segregation is the first step. It does not refer to keeping species separately, but to keeping potentially infected animals and materials away from uninfected animals. Segregation should be expected to have the greatest impact on achieving good levels of biosecurity. If the virus does not enter a poultry holding, no infection can take place. No animals or materials should enter or leave a poultry holding unless they have to.

Segregation involves the creation of barriers and the control of what passes through them. The barriers should be physical and/or temporal where possible, and procedural where not. However, such barriers will only be effective when controlled to exclude potentially contaminated items. This includes such measures as enforcing the changing of footwear and clothing for all people crossing the barrier, and restricting the entry of vehicles.

It is instructive that even, and perhaps particularly, in large-scale highly integrated production systems, where biosecurity is more critical because of the potential impact of disease in such an intensive high input/high output/low margin system, segregation is the basis of most biosecurity measures, from the farm gate to individual poultry sheds. This is the first and most important line of defence.

The second and next most effective step in biosecurity is ***cleaning***. Most virus contamination on physical objects is contained in faecal material or in respiratory secretions that adhere to the surface. Cleaning will therefore remove most of the contaminating virus. Any materials that must pass through the segregation barrier (in either direction) should be thoroughly cleaned. This means that there should be no visible dirt on the surface of materials. Soap, water and a brush are adequate for small objects, but a high pressure washer is needed for large vehicles such as lorries or tractors (high pressure = 110-130 bar). The difficulty of properly cleaning large complex items such as lorries emphasizes the need for segregation as the first and best line of defence.

The third and final step is ***disinfection***. This is often incorrectly done and so can be regarded as the least effective step. Under ideal controlled conditions, there are many disinfectants that destroy avian influenza viruses but under field conditions they are often much less effective. Disinfectants will not necessarily penetrate into dirt in sufficiently high concentrations to be effective and many disinfectants are inactivated by organic materials such as wood or faecal material. Disinfectants are often not available in village conditions so any programme that emphasizes their use will be hampered from the start. Disinfection is important when performed consistently and correctly, but should be regarded as a final "polishing" step in biosecurity, used after effective cleaning.

In most cases, the emphasis in biosecurity for poultry flocks should be on keeping the virus out of uninfected farms and villages (i.e. ***bioexclusion***). Once an outbreak has occurred and has been detected, then post-infection ***biocontainment*** becomes the most important activity. However, because containment is difficult, prevention is the most efficient form of control.

The fundamental principles of biosecurity

- Biosecurity is about reducing the risk of the introduction and spread of infection.
- The actions of people are fundamental in applying biosecurity.
- Biosecurity consists of three major stages – segregation, cleaning and disinfection; segregation is the most effective and disinfection the least effective.

THE BASIC PRINCIPLES OF DISEASE CONTROL

Infectious disease prevention and control, although not easy to undertake, can be simply described as having three major goals, each of which has one or more methods to achieve it.

Find infection fast:	Surveillance
Kill infected animals quickly and humanely:	Targeted culling and disposal
Stop infection spreading:	Biosecurity - Vaccination

This can be shortened to: **FIND IT FAST – KILL IT QUICKLY – STOP IT SPREADING.**

Disease control is most effective and efficient when all three goals are achieved together; they are equally important acting additively to decrease infection pressure. However, while the methods to achieve these goals all decrease infection pressure, there are differences among them.

Surveillance and killing infected animals as quickly and humanely as possible are both vital tools but can only respond to infection that has already occurred. They act to limit spread by decreasing the amount of virus released from any one site, but cannot prevent it completely because some virus will have been released before culling commences, and often before the disease is detected.

Pre-emptive culling (the culling of animals before they are found to be infected) can be used to attempt to make this a more proactive measure. However, the use of widespread pre-emptive culling based on defined areas around an outbreak (1km, 3km or in some instances even 10km) has been shown to be very difficult to implement effectively in developing countries and can best be achieved by using limited and targeted risk-assessed pre-emptive culling. Widespread pre-emptive culling may also be counterproductive because it can cause birds to be moved and can result in the loss of cooperation by bird keepers; there is evidence from the field that draconian control measures have led to resentment and resistance to further control measures. As important, if not more so, is to create impediments to spread. Single introductions of HPAI are always possible but, if kept small, outbreaks are more easily dealt with; a key step therefore is to limit, slow down and stop spread.

An essential part of this is to create an environment in which there are relatively few easily infected locations and the two main methods available for this are vaccination and biosecurity.

Vaccination is a proactive measure in that it protects animals from disease. In the field, vaccination works best when the following conditions apply:

- the population either changes slowly or changes completely at the same time ("all in, all out" methods of production) so that herd immunity can be created and either requires infrequent boosting or is maintained over the duration of the production cycle.
- one vaccine strain produces immunity against all known strains of the pathogen in a country or region so that vaccines do not need to be tailor-made for different outbreaks.
- the immunity produced by a single dose is sufficiently long lasting, preferably the lifetime of the animal.
- vaccination significantly diminishes infection, replication and shedding of the pathogen as well as disease.
- in addition to these conditions, vaccination campaigns would be easier to implement if the pathogen does not change significantly over time in terms of its antigenic makeup so that vaccines do not require significant modification, if the vaccine is heat tolerant so that cold chains are less critical, and if the vaccine can be administered via a relatively easy method such as orally or in eye drops.

Unfortunately, using currently available vaccines, vaccination against avian influenza cannot easily meet all of these conditions particularly in small-scale commercial production systems (Sector 3) and in scavenging poultry (Sector 4). This is particularly true in scavenging poultry systems, where rapid population turnover means that there are only sufficient levels of vaccinated birds to maintain flock immunity for periods of a few weeks following vaccination.

Vaccination of domestic poultry against H5N1 HPAI has been useful in some countries in preventing human infection and controlling the epizootic through limiting spread in domestic poultry, but no country that has employed it extensively has yet been able to eliminate the virus. While vaccination is certainly a useful and important tool in the control of the disease, it is never likely to be sufficient on its own to eradicate HPAI, in particular in scavenging poultry and ducks. Besides, vaccination of whole populations of domestic poultry requires political commitment and investment and this is difficult to maintain in the longer term.

The basic principles of disease control

- Disease control and prevention comprises three key goals that can be summarized as: "find it fast", "kill it quickly", "stop it spreading".
- All three goals are equally important and all must be achieved efficiently and at the same time for disease to be controlled.
- Surveillance and culling are mostly reactive in that surveillance finds disease once it has occurred and culling responds to this.
- Vaccination is proactive but there are technical and policy reasons that make it difficult to implement in some developing countries.
- Biosecurity is preventive and gives keepers the tools they need to protect their own birds; it is proactive and enabling

Properly designed and applied biosecurity not only slows the rate of disease spread by raising barriers to infection, it also enables motivated poultry keepers to take responsibility for protecting their own birds. Biosecurity is therefore preventive and enabling, and is frequently referred to as either the most or one of the most important tools for controlling HPAI.

HOW H5N1 HPAI IS MAINTAINED AND SPREAD

To design biosecurity measures for H5N1 HPAI, it is important to understand how a disease is maintained and spreads between locations.

The H5N1 HPAI virus does not have a long-term carrier status in domestic avian species and while the virus can persist in the environment for substantial periods of time (several weeks under the right conditions), it does not replicate outside the body of susceptible animals. To date, no permanent reservoir outside live animals has been identified. The role of domestic species as a reservoir of disease is clear, particularly in flocks of domestic ducks. However, the question of whether wild birds are a long-term reservoir of infection is still unresolved.

The virus is highly susceptible to detergents, high temperatures and desiccation. It is inactivated by most disinfectants so long as these are used correctly and are in contact with the virus for sufficient time.

Live infected birds multiply and can transfer the virus easily. They are the most dangerous means of spread. Chickens may shed virus for up to four days before obvious signs such as mortality are seen and ducks two weeks without showing any signs.

The second most dangerous means of spread is material contaminated with excretions, in particular faeces, from infected birds. Although viral concentrations are higher in respiratory fluids, they are released to the environment in small volumes compared with faeces which is the largest source of virus outside the bird and the main contaminant leading to spread among birds. People, vehicles (including all means of transportation) and equipment are ways in which this passive transfer of virus among sites can occur. There is a decrease in viable virus load over time, with the rate depending on the environmental conditions. Each contact via contaminated materials is less risky than a live shedding bird but, because there are often many more of these indirect contacts than movements of poultry, the overall risk may be high.

Spread may occur via wild birds which have been responsible for long distance spread and initial introduction of infection in some countries. But overall, and apart from the case of Europe, this is a relatively rare occurrence compared with spread via domestic poultry, either directly or indirectly.

Water contaminated with faeces from infected birds is an important source of infection for poultry. Commercial farms should ensure that poultry do not have access to surface water and are given treated or deep borehole water. It is not possible to prevent scavenging poultry from gaining access to potentially contaminated water.

It is theoretically possible that the virus could be spread via air over a few tens of metres but this has never been found to be important in the epidemiology of the disease.

LBMs have been an important source of infection especially when the market always has some poultry present.

There is little information on the role of hunting wild birds, cock fighting, poultry fanciers and exotic birds in the transmission of the disease. A recent epidemiological investigation in Turkey has indicated that hunters may act as an important route of virus introduction between wild birds and domestic poultry, but there is no indication of how widespread this finding might be. Fighting cocks, poultry fanciers and exotic birds have been implicated in epidemics of Newcastle disease in the past; their potential role in HPAI should not be overlooked.

How H5N1 HPAI is maintained and spread

- H5N1 HPAI has no long-term reservoir outside live animals.
- The role of wild birds as a long-term reservoir of infection (maintaining the virus) is unclear.
- There is a very clear reservoir of the virus in domestic poultry, particularly ducks, and possibly other captive wild birds.
- Live infected birds produce virus for several days or weeks with clear clinical signs.
- Infected domestic birds are the most dangerous source of virus.
- Inanimate objects (fomites) contaminated with secretions (in particular faeces from infected birds) are the next most dangerous source of virus.
- Air-borne spread is not significant.
- Wild birds can introduce infection but this is uncommon compared with spread between domestic poultry.

Section 2

General issues of biosecurity for HPAI

STRUCTURE OF THE DOMESTIC POULTRY AND CAPTIVE BIRD SECTOR

Poultry and their products are small and easy to move. They are low value individually compared with other livestock, so entry into producing and trading in poultry on a small scale is relatively cheap. A chicken or duck makes a good single meal for a family. Unlike many animal products, eggs are easily packaged and can be transported without further preservation. There are comparatively few cultural barriers to the consumption of poultry meat or eggs. All these factors lead to large and very complex networks of producers, suppliers and traders which are important to understand for identifying the possible transmission networks and key risk nodes on which to focus biosecurity efforts.

For most low and middle income countries, information available on the poultry sector was often scarce before the current H5N1 HPAI crisis. This was because industrial and commercial poultry production were often seen as purely private enterprises with minimal or no intervention needed from the public sector and scavenging poultry production was often not given priority in countries where authorities in charge of livestock-related issues had only limited resources.

The H5N1 HPAI pandemic in poultry generated the need to know more about respective poultry sectors at national levels. A large amount of information that was previously unavailable has been collected in countries that are either at risk or where the disease is endemic; those responsible for controlling the disease now have a better understanding of the poultry sectors in many countries. Ongoing investigation of production and marketing chains has revealed just how complex these are, how many actors are involved, and how much they vary from area to area and among different types of production.

Commercial poultry

One segment of the sector is made up of large-scale commercial farms that have a dedicated site or sites and large flocks (usually over 10,000 birds). These are also referred to as **FAO** Sectors 1 and 2 farms[3]. They share many characteristics in that the birds have access to purpose-built housing and in most cases are housed 24 hours a day (although there is a growing trend in some countries towards free-range systems for both egg and meat production). The scale of the enterprises implies access to substantial financial resources. There is usually a high level of technical expertise and specialist private veterinary services and laboratories are utilized. The produce is mostly for sale at commercial markets.

The larger companies are multi-site and often have their own parent flocks and hatcheries to provide replacement chicks. The very largest commercial poultry producers are the

integrated broiler companies which control all aspects of their system including hatcheries, feed mills and slaughterhouses, as well as the growing farms (usually parent but sometimes also grandparent stock).

However, grandparent and parent stock may be separately owned by small companies for supplying other producers. Hatcheries, feed mills and slaughterhouses may also be individual enterprises rather than part of larger integrated companies.

The other commercial chicken segment of the sector comprises the small-scale commercial flocks (FAO sector 3). The minimum flock size which demarcates where this sector is said to start varies greatly from country to country and it is better to use other criteria. The maximum flock size is usually a few thousand birds, only occasionally reaching as many as 10,000. These flocks are family-run (although they may be working as contractors to a larger companies), single site and usually based on the same property as the owner's house. Many are situated in peri-urban areas or near villages in order to be close to potential markets. They usually use birds bred specifically for commercial purposes, often in a single house which may or may not be purpose-built. The birds are usually housed all day and fed on commercially prepared food.

Sales may be local, through LBMs directly by the owners or indirectly via intermediaries and service providers, or to a contractor. While many of these birds are sold near to their point of production, they may also be marketed over considerable distances in some countries. Small-scale commercial poultry keepers often own more than one type of enterprise and may be seasonal or opportunistic producers. Generally they have less money to invest in either one-off or ongoing biosecurity practices. Compared with large-scale producers, this is a highly variable sector.

While previously the size and type of commercial farm had been linked to biosecurity levels, experience has shown that even large farms can have obviously inadequate biosecurity and some small-scale farms have biosecurity which is sufficient for the level of risk that they face.

In both large- and small-scale farms of production units, flocks are usually either broilers (for meat production) or layers (producing eggs for consumption). The former have production cycles, often of a few weeks, whereas layers are kept for around one year, sometimes two.

There are also specialist commercial flocks of turkeys, geese and quail. The first two may be housed or managed in a free-ranging form, taken to pasture during the day and housed

[3] In 2004, FAO identified four poultry production sectors:
Sector 1 - industrial integrated production with birds or products marketed commercially.
Sector 2 - commercial poultry production with birds or products sold through slaughterhouses or live poultry markets.
Sector 3 - smallholder commercial poultry production, including water fowl, with birds or products usually sold through live-bird markets.
Sector 4 - village or backyard production with birds or products consumed locally.
Note that these descriptions do not refer to the level of biosecurity in each sector. The original FAO definition of Sectors 1-4 drawn up in 2004 linked farm size with biosecurity levels, but experience has shown that the links between size and biosecurity are not always automatic: even some very large commercial poultry enterprises may demonstrate strikingly inadequate biosecurity, no better than in many small-scale commercial production units.

at night, but quail are always housed. There are also specialist pigeon flocks which may be very large in some countries.

There are some large-scale permanently housed duck flocks, and even some integrated production companies specializing in ducks, but these are less common. Commercial ducks are kept for both meat and eggs. Flock size and purpose of keeping them vary as much as they do for chickens.

Hatcheries

Hatcheries also constitute a highly variable group of producers, although they all share the common role of supplying day-old chicks (DOCs) to poultry keepers, mostly in the commercial sector. As noted above, they may form part of a large commercial company or operate separately. They may use complex technology or relatively simple traditional methods. Some are very large, perhaps holding over one million eggs at any one time, whereas others may be small village-based units incubating a few hundred eggs. Some specialize in hatching a single species, others offer a mixture of species. Some incubate eggs from a single source, others from a range of sources.

Scavenging poultry

Scavenging poultry (Sector 4) constitute the most widespread form of livestock keeping. In most developing countries, they are by far the most numerous type of poultry flock and contain the majority of domestic birds. Chicken is the most common species kept, but there are many mixed species flocks in which turkeys, geese, ducks, Muscovy ducks, pigeons, guinea fowl and so on mix freely and are housed together.

They are kept as a low input-low output system using the locally-available scavenging feed base, supplemented by their keepers with food scraps and some grain. They may be confined in the owner's yard during the day, but often are not (indeed, in some cases there is no yard) and roam freely. They are almost always housed at night, often in a relatively small coop, to protect them against theft and predators. This creates favourable conditions for disease spread within the flock.

In general, they are self-replacing, with eggs being incubated as well as consumed, but there is always some movement of birds, both chicks and older (cockerels in particular). The birds and their products are mainly consumed by their owners but some may be sold or used as gifts.

In some countries (e.g. Egypt), a segment of the poultry sector is kept on rooftops, resembling in many ways scavenging poultry in that they are small, often mixed, flocks kept mostly for home consumption. However, they are dependent on of the supply of feed and water, and are permanently enclosed, which gives them biosecurity status similar to that of small-scale commercial flocks.

In many countries, there is a form of scavenging duck rearing in which domestic ducks are fed by being allowed access to recently harvested rice paddies. These systems may involve long distance movements to follow the harvesting of rice although most involve grazing fields locally. Other duck systems involve keeping ducks on ponds or channels and some combine pond rearing with pig and/or fish rearing on the same site.

Other birds

In addition to domestic poultry kept for consumption, several other types of birds kept by people can play a significant role in the spread of H5N1 HPAI.

Fighting cocks are kept in many parts of the world and can be very valuable animals, both culturally and financially. Cockerels may also have other cultural roles including religious purposes. Fighting cocks are moved to and from arranged bouts and are a potentially important source of spread. In some countries, there is a tradition of keeping, breeding and showing poultry, a pastime referred to in some countries as the "poultry fancy". This may be more common in developed countries than developing ones, but should not be overlooked in any country. These birds may also have a high genetic value if they are part of an uncommon breed.

The trade in exotic birds, both captured from the wild and captive bred, is widespread, large and complex, with much of it conducted informally or illegally. It has already shown potential to spread HPAI. In some countries, exotic birds are bought in markets and released for religious purposes. In other countries, there is a very large trade in captured wild birds for export. Any study of the sector must also include this trade, as should biosecurity.

A further segment of the sector that is a cause of concern is that of birds of prey (raptors) kept for hunting and sometimes the specialist prey species which are kept to be hunted. In some countries, these birds may have played a role in introduction and maintenance of disease. They are valuable animals, particularly the birds of prey (a single bird may be worth over USD 100,000), and may be traded over long distances. Birds of prey may also be moved long distances for hunting trips, which can pose a risk of introduction in the countries of destination or when they return home. In the country where they are kept, there may be overlap (and therefore risk of cross-infection) among the raptors, prey birds and domestic poultry kept on the same site.

Live-bird markets (LBMs)

The most important mixing points for all birds kept by people are LBMs. There are many different types of LBM, ranging from large wholesale to small local markets that operate only occasionally. Some markets are specialist and others undertake a range of functions from sale of poultry for subsequent rearing to slaughter of poultry for consumers. Birds of all types (species and source) may be sold in a single market, although some markets may specialize in single types of bird. Chickens from large- and small-scale commercial sectors and scavenging poultry may mix in these markets. Traders and other intermediaries and service providers visit the markets and may easily move contaminated materials away from the market to poultry units of various sectors. Live birds may be bought for production and are an easy way to transfer infection between different parts of the domestic poultry and captive bird sector. LBM have played an important role in the spread of H5N1 HPAI (as well as other poultry disease, including other avian influenza viruses).

Intermediaries and service providers

In addition to the many types of domestic and captive birds, there are many different people who make their living through the poultry sector by providing services of one kind or another. These are referred to in this paper as intermediaries and service providers. They

include traders, suppliers of equipment, suppliers of medicines and vaccine, vaccinators, animal health workers (including veterinarians), suppliers of poultry, suppliers of feed, transporters and others. These people move from farm to farm and among different production systems either directly or through mixing points. For example, they may provide feed to both large- and small-scale producers, or they may buy poultry at markets to resell in villages. They have great potential for spreading disease either directly via live birds or indirectly via contaminated materials. Intermediaries also play a vital role in LBMs, forming direct and indirect links among different segments of the poultry and captive bird sector

Of particular concern are specialist suppliers of DOCs (separate from those supplied directly from a hatchery) and young birds reared to point of lay (POL) for egg producers. Traders in both DOC and POL birds may mix birds from different sources and distribute them to different locations. In some cases, these mixing nodes can be important for spreading infection and introducing disease from other countries, given the important international trade in hatching eggs and DOCs.

This brief description illustrates the highly complex nature of the domestic poultry and captive bird sector. Contact between and among different segments of the sector are common but not always well understood. Even within supposedly simple sectors such as large-scale commercial production, the networks for marketing and supplying services are often complex but may vary significantly between and within countries. Experience in countries where the disease has occurred seems to indicate that the more complex the domestic poultry and captive bird sector, the more difficult it is to eliminate infection.

In terms of biosecurity, most recommendations to date have been directed at the keepers of domestic poultry. Some recommendations have been produced and implemented for LBMs, but only in a limited number of countries. There has been limited targeting of messages and interventions for intermediaries and service providers although their role in

Structure of the domestic poultry and captive birdsector

- The sector is made up of many different types of domestic (including Sectors 1 to 4) and non-domestic captive poultry.
- As well as domestic poultry there are fighting cocks, show and breeding birds, birds of prey and prey species, decoy birds for hunting and captive exotic wild birds.
- The linkages between different production systems and types of bird are complex and vary from country to country.
- There are many people other than keepers of birds who form a part of the domestic and captive bird sector, including traders, LBM workers, animal health workers, feed sellers, and transporters.
- The more complex the production and marketing chain (i.e. the more steps and people involved) the more difficult it seems to be to control and eradicate H5N1 HPAI.
- All stages in the chain should be taken into account when biosecurity measures are being devised and recommended.

the spread of H5N1 HPAI is recognized. More emphasis must be placed on actively involving them in future because they form key links in the poultry production system. The role of fighting cocks, exotic birds, captive birds of prey and hunters also need to be considered.

APPLICABILITY OF COMMONLY RECOMMENDED BIOSECURITY MEASURES

There is no single standard set of measures that can be recommended. In each country, region or production system, the potential sources of infection should be assessed to determine what will have the greatest impact, and this should be done

before the disease is present - to identify potential routes of spread using an analysis of the production and marketing chain and risk assessment along this; and

when an outbreak occurs - to identify the probable actual routes of spread through outbreak investigation. It is important when an outbreak occurs to make every effort to determine the source of infection. This will not be possible in every case, but over a series of outbreaks, a pattern of common routes of spread will emerge.

Having identified the routes, a package of measures addressing biosecurity needs along these routes should be put together in collaboration with those who will have to apply them. These latter will also have to be supplied with the resources to be able to do so.

However, there are some basic measures which are desirable and should be used where possible. They are frequently recommended but are not often applied outside large-scale commercial production settings, and even then not always consistently. The following is not an exhaustive list – it highlights the most important measures and identifies reasons why they may not be adopted by some producers, intermediaries and service providers.

Physical barrier to the entry of people and objects

There is little doubt that this is the single most important measure that any poultry unit can take to decrease the risk of infection. A well-organized entrance with a barrier, used to exclude most people and objects, will drastically reduce the possibility that virus will enter via infected birds and contaminated materials. Without such a barrier it is difficult to ensure proper biosecurity.

One way in which this measure is being applied in some countries is by restructuring and/or redesigning poultry farms to make them physically more biosecure, and/or relocating them further apart from each other. These solutions are appropriate for large-scale commercial and some small-scale commercial farms in some countries but, by their very nature, will take some time to apply and therefore to have effect. Even then, their effectiveness will depend heavily on the overall layout of the area (poultry density, access roads, etc.), the design of the units and the measures applied at the farm gate to impose segregation, cleaning and disinfection.

Nor can this sort of change be used in all poultry sectors. Housing of scavenging poultry has frequently been recommended as a biosecurity measure for these birds, but this should be reassessed. There is little doubt that it is effective in decreasing disease spread, but it fundamentally changes the nature of the system which depends on unrestricted movement. Enclosing them limits their feed sources; they become completely dependent on feed brought to them. In effect, the system becomes similar to that of small-scale commercial poultry, and their maintenance requires similar resource levels. Also, in all systems, a physi-

cal barrier is only effective if movement of animals, personnel and equipment through the barrier is controlled. This is unlikely to be the case for scavenging poultry, whether housed or not.

Water and feed sources

Water provided for birds should either be from known safe sources (e.g. deep boreholes) or water safe for human use (e.g. a reliably chlorinated municipal supply). There should be no supplies from untreated sources or access to surface water that might be contaminated with the faeces or other materials (including carcasses) of poultry or wild birds. Where surface water must be used, it should be treated on site to deactivate any potential contamination by H5N1 HPAI. Achieving this is possible for some confined birds, although may be more difficult for small-scale commercial flocks in more remote areas, but is clearly not possible to achieve for scavenging poultry or free-ranging ducks.

Feed supplied to birds should be heat-treated to deactivate any HPAI virus and then transported and stored in a way that prevents contamination with bird droppings or other infected materials. This may require some investment in feed stores for commercial producers, but is feasible. However, there always remains the possibility that scavenging poultry and free-ranging ducks will come into contact with contaminated materials.

Poultry housing that is wild bird and rodent proof

All poultry housing should be designed and maintained to prevent access, particularly by wild birds but also by rodents. This is possible with purpose-built housing on large commercial farms, although not always achieved. It is often not possible for small-scale commercial farms where the buildings used may not be purpose-built or have been made from less secure materials. For scavenging poultry and free-ranging ducks, there will always be the possibility of contact with wild birds and rodents. This is particularly concerning near water bodies with large populations of water fowl. In these areas, the option of banning poultry keeping has been considered, but the practicality of achieving this is not clear.

Use of "all in, all out" (AIAO) systems in commercial units

For all commercial flocks, of whatever size, it is preferable to move to an *all in, all out* (AIAO) system (all birds must enter together and leave together). By sourcing batches of birds all at the same time, and preferably all from the same source, the risk of disease introduction is decreased. It should also be possible to source the birds from a known supplier who offers some guarantee of disease freedom. Perhaps more importantly, AIAO avoids the serious biosecurity risk posed by teams that move between farms catching and removing birds who could have had contact with infection elsewhere.

One of the major advantages of AIAO is that at some point in time the unit will be empty of birds, allowing buildings and equipment to be cleaned and the level of pathogen contamination reduced. At the very least, whole sheds of poultry – if not the whole site – should be cleared at the same time.

AIAO is easiest for large-scale commercial companies with access to credit or reserves to cope with the cash flow variations created by this practice. It is particularly easy for large companies with multiple sites. However, even large commercial single site egg producers

often have several houses containing flocks of different ages in order to produce a regular output of eggs.

AIAO may be very difficult for small-scale commercial single site producers. They usually rely on selling to the local market. For meat producers, it may be difficult to find a market for large batches of birds that have to be sold off. For egg producers, a gap in production could lead to a loss of customers. In this case, a change to an *"all in, gradual out"* cycle (all birds enter together but leave in separate batches over a period of time) may be considered but would only be safe where the staff removing the birds are those that normally work on the site.

Neither AIAO nor *all in, gradual out* are practical for scavenging poultry flocks which are of mixed age and often mixed species, and mix with other birds from other flocks on a daily basis.

Ban on bird keeping by poultry unit workers

A strict ban on the keeping at home of any birds (domestic poultry or pet birds) by workers at poultry farms is another vital step if biosecurity is to be effective. This may be possible in large poultry farms, which, where possible, should draw their staff from urban areas. It is not uncommon for large companies to provide workers with free or low cost eggs and meat as an incentive to not keep chickens at home. But it is not easy to enforce this ban when workers are drawn from rural populations, as they often are in developing countries. The risk can be mostly, but not completely, mitigated by strict segregation of footwear and clothing and basic hand washing as outlined below.

This recommendation is clearly not applicable to scavenging poultry.

Changing outer clothes and footwear

All people working on a poultry production site should be required to change (or cover) their outer clothing and footwear. So should all visitors (including the owner, veterinarians, advisers, traders, family, friends, etc.) This is particularly important for visitors who have had recent contact with other birds. Those visiting the site who do not normally have contact with other birds may be permitted to use disposable overshoes (although these must be strong enough not to tear while on the premises) rather than change footwear, but they should still be required to use outerwear or disposable overall provided by the owner of the poultry. It is never advisable to rely on washing footwear or on the use of footbaths or dips.

Where high value stock is involved (e.g. parent and grandparent stock), there should be sufficient financial incentive to require that staff shower on and off the site.

The use of separate clothing and footwear should be possible for small-scale commercial flocks, but it is unlikely to be feasible for scavenging poultry keepers for whom it may represent a significant investment. There is also the difficulty of defining the location of a biosecurity barrier, by extension the best location for changing clothing and footwear.

Mandatory rest period between visits

Temporal barriers are an important part of biosecurity. Where possible, poultry keepers should require that anyone visiting the farm should not have visited any other poultry keeping establishment within at least the last 24 hours. Even then, visitors should still be

required to go through all the other normal biosecurity procedures, such as changing footwear and wearing protective clothing.

This type of measure can be fairly easily introduced by large-scale commercial producers, but it is unlikely to be so easy for small-scale commercial producers and almost impossible for scavenging poultry keepers, if only because the intermediaries and service providers who work in these types of flocks are unlikely to be able to afford to limit their visits in this way.

It is still more important and effective to prevent as many people as possible entering the premises.

Quarantine for newly-introduced or returning birds

Although quarantine for new or returning birds introduced during a production cycle may be possible, and even if birds can be kept separate for the required period, there is still a need for strong biosecurity within the compound, including the separation of clothing, footwear and equipment (and preferably personnel) for the quarantine and non-quarantine areas, and a strict order of working and cleanliness. Without these, the chances are high that infection will spread to the rest of the flock.

Where the birds in quarantine are diagnosed as infected, it is likely that, following a risk assessment, veterinary authorities would cull the rest of the flock as "dangerous contacts"[4] . The owner would need to be able to demonstrate that strict segregation and biosecurity had been carried out within the premises to avoid this. Given these considerations, it is possible that quarantine may not be practical or effective at the household level for scavenging poultry and difficult for small-scale commercial producers.

Nonetheless, recommending quarantine may play an important role in reminding farmers about the risks associated with bringing poultry from outside.

Rear a single species

It is arguably preferable to rear only a single species and keep no other birds on the premises. This should be possible for both large- and small-scale commercial farms. However, many scavenging poultry keepers maintain more than one species and for a number of good reasons: the different species may fulfil different roles in diverse farming systems, the species mix may reduce the risk of losing an entire flock to disease, or there may be cultural reasons for keeping different species.

And, in practice, infection risk is not so much altered by the species kept as by how well biosecurity is otherwise implemented.

Compartmentalization and zoning

Recognizing the difficulty some countries face in eradicating animal diseases from their territory as a whole and maintain animal disease-free status, the OIE has introduced the concepts of zoning and compartmentalization for disease control and international trade.

[4] Birds that, while not showing signs of disease, have a known risk of having come into contact with virus, directly or indirectly. This should be assessed by a veterinarian

Within the framework of these concepts, countries may eradicate a disease from only part of their territory and resume trade from this part of the territory while the country as a whole is not yet free; they can do this by defining an animal subpopulation with a distinct health status ("free from a certain disease") within its boundaries. Compartmentalization is defined as "one or more establishments under a common biosecurity management system containing animals with a distinct health status" and is therefore based on a functional separation. Zoning applies to defining groups of animals with a distinct health status on the basis of geographical separation (i.e. in a zone with definable geographical boundaries).

Underlying these concepts lies the possibility of a clear epidemiological differentiation between the animals that belong to the zone or compartment and those that do not. The effective implementation of the concepts will be influenced by technical issues such as the epidemiology of H5N1 HPAI, structure and distribution of the animal population, country and infrastructure factors, the biosecurity measures which may be applicable, the health status of animals in adjacent areas and the necessary surveillance in and outside of the compartments or zones which is linked to the efficiency of the veterinary services. In the case of the poultry sector, it will generally be easier to implement biosecurity measures in areas where there is a high percentage of highly industrialized commercial poultry than in areas with a high percentage of smallholders or scavenging poultry.

The first basic principle in defining a zone or compartment is to establish a clear definition of the animal subpopulation belonging to the zone or compartment. The animals belonging to the subpopulation of a zone or compartment should always be recognizable and traceable.

The second important principle is to ensure the epidemiological separation of the subpopulation in the zone or compartment from other populations and potential sources of infection. A good biosecurity plan should always be provided for either zone or compartment.

In the case of zoning, the veterinary authorities will be primarily responsible for providing this biosecurity plan, whereas in the case of compartmentalization the biosecurity plan should be provided by the owners/managers of the establishments in the compartment and the plan should be approved and monitored by the veterinary authorities. The biosecurity plan must describe all factors relevant for the integrity of the zone or compartment and must show that the zone or compartment is epidemiologically closed. It must provide clear evidence that critical control points for introduction of a pathogen are well managed. Well-described standard operating procedures to implement, maintain and monitor the measures to manage the critical points properly should be provided.

Important elements of a biosecurity plan include quality assurance schemes, procedures for animal and human movement controls, poultry health measures (including vaccinations, medications and other veterinary care), control over vehicles, security of feed and water sources, and control of pests and wild bird populations, among others.

Geographically-based zoning could include birds in all types of husbandry system, LBMs and networks of intermediaries and service providers. But the difficulties of maintaining the integrity of a zone are clear and will require significant government resources.

Compartmentalization is a possible option for large industrialized companies that can control all inputs. Such companies are wish to either export poultry/poultry products or compete with imported products. Having high biosecurity status may lead to an advan-

tage in the market if consumers actively seek this level of assurance. However, even if a compartment is formed, there will need to be bilateral agreements between the veterinary authorities of the exporting and importing countries. It is important that this is taken into account at the time.

In developing countries, compartmentalization is today extremely difficult to put in place in many production systems. This may be the case even for many large-scale producers if they depend on inputs from third parties. Compartmentalization is not applicable to small-scale producers or scavenging poultry.

More details of zoning and compartmentalization can be found in the in the *Terrestrial Animal Health Code* published by the OIE.

Cleaning and disinfection (C&D)

These are taken together here because they tend to be recommended as a single phrase, without differentiation.

The equipment needed to properly clean vehicles such as cars and lorries is relatively expensive and requires a source of power. Its use is likely to be limited to large-scale commercial producers. On the other hand, cleaning footwear and other small objects requires equipment that is relatively simple and cheap (a bucket, brush, water and soap will often suffice).

The limits to relying on disinfectants have been discussed above. Their cost and availability make their use in scavenging poultry unlikely and perhaps problematic for small-scale producers. It is often recommended that they be used in wheel dips or footbaths, but there is good evidence that even this is not as effective as expected.

Cleaning of small objects with soap and water should be recommended for both small-scale producers and keepers of scavenging poultry but disinfection should only be recommended for small-scale producers and only as a second step following cleaning.

There are standard protocols for the cleaning then disinfection of hatcheries, poultry houses and LBMs when they are emptied of live animals. All these premises should have standard protocols for this and compliance should be recorded and monitored.

"Traffic light" system

Maintaining high levels of biosecurity over long periods is difficult; the greater the intensity of biosecurity measures, the more they impinge on the daily routine and the more resources (time and finances) required. Further, people respond differently to perceived threats.

One useful concept may be that of the "traffic light" system indicating changing biosecurity needs (and therefore practices) as the threat increases or decreases:

To work well, this system must be well understood beforehand (which requires significant work with stakeholders) and the advice on the biosecurity measures to implement at the various stages must be well prepared beforehand. In addition, there must be a good disease surveillance system and an established method of signalling when the threat level increases and to what level. This may be possible in the larger commercial systems with good chains of command, but is less likely to work for small-scale commercial and scavenging poultry because of the greater difficulty in rapidly transmitting the message about increased risk and the actions to take.

Colour	Level of threat	When applicable
Green	Low	Disease not present in the country or neighbouring countries – outside known risk period for introduction by migrating birds
Amber	Medium	Disease present in neighbouring countries but at low level and not close to border
Red	High	Disease present in neighbouring countries close to border or at high levels – poultry units close to known wild bird migration routes and/or resting sites during migration seasons

What does this brief analysis of commonly recommended measures indicate?

Many measures known to be effective from use in large-scale commercial poultry systems are much less applicable in small-scale commercial systems and even less so in scavenging poultry. Their applicability for use by intermediaries and service providers is uncertain; to date, none of these measures has been particularly aimed at these parts of the complex poultry production network. Nevertheless, the principles of biosecurity are applicable at all stages of the production and marketing chain, but require a different approach to formulating recommendations.

Applicability of commonly recommended biosecurity measures

- There many known effective biosecurity measures, but these have mostly been developed for large-scale commercial production systems.
- There is a need to ensure that large-scale commercial farms adopt these measures.
- Few of the commonly recommended measures are appropriate for small-scale commercial systems or for scavenging poultry.
- The commonly recommended biosecurity measures have not been specifically designed for intermediaries, non-domestic poultry, hunters, etc.

THE PRACTICAL DESIGN OF BIOSECURITY

If the common technical recommendations available in existing publications on biosecurity could be applied, they would lead to good levels of biosecurity being in place.

Why they are not being applied? The answer lies in better understanding of the practicalities of biosecurity and using this understanding to formulate work in the field.

Preventive biosecurity measures must be proportionate and practical if they are to be adopted and be sustainable; what is feasible in large industrialized integrated companies is not feasible for scavenging poultry.

Biosecurity programmes must be designed and established with the active participation of those who will implement them, in other words the stakeholders. They must also be tailored to what is needed and possible, not what is perfect – it is better to achieve a partial reduction in risk than to attempt something too complex which may not be applied and therefore have absolutely no impact.

One approach is to attempt to classify different potential interventions according to their attributes. Pagani and Kilany defined different measures according to their potential impact and ease of application in Egypt. In Turkey, a World Bank HPAI project takes into account the costs of different biosecurity measures when assessing their practical utility.

By combining these two approaches, and adding some other attributes, it is possible to describe each potential measure in a way that should indicate its applicability in different situations. The following attributes are suggested:

- Potential effectiveness in reducing risk
- Persistence of this effectiveness
- Speed of implementation
- Setup cost (including labour/effort)
- Recurrent cost (including labour/effort)
- Disruption of the production system
- Social and cultural acceptability

Table 1 shows some an evaluation of these attributes for various potential measures. Table 2 takes this information and looks at what might be applicable in different systems. Neither of these tables should be taken as definitive, but they illustrate the approach. By combining the information from Tables 1 and 2, it becomes possible to identify forms of intervention to be discussed with stakeholders in different production systems.

For example, restructuring/relocation has a high level of effectiveness in reducing the risk of HPAI on a long-term basis (i.e. with high persistence and little recurring cost), but will take a long time to implement and will probably incur a high initial (set-up) cost. Other measures, such as cleaning, can be implemented quickly at low cost, but involve some recurring cost and will be effective only for as long as effort is maintained.

It is clearly best to identify the measures which will have the highest level of effect, but this cannot be the only criterion used. Unless the persistence of a measure is high, it will only remain effective if it is repeated as often as is required and on a long term basis. High initial or recurrent costs will prevent uptake by most producers, intermediaries and service providers. However, even large-scale commercial producers would prefer to spend as little as possible on implementing biosecurity. A measure that carries a high level of disruption is very unlikely to be implemented unless it is enforced. Acceptability will also vary according to local social and cultural conditions. All these must be taken into account in each situation.

A key tool for identifying potential biosecurity problems and using this to identify control points and methods is a biosecurity audit. This is a standard tool in the poultry industry that uses HACCP (Hazard Assessment and Critical Control Point) methodology. This will identify problems and potential solutions as well as be a useful tool for monitoring compliance. Standard manuals are available but an audit can also be carried out using a simpler checklist approach in less complex situations, such as among small-scale producers, keepers of scavenging poultry, intermediaries and service providers and. Publications containing biosecurity audit methods are included in Annex 1.

Having identified potential solutions, the next step is to engage in dialogue with poultry keepers and other stakeholders to determine whether they are sensible, and can and should be applied. This may take some time. People normally do what they do for very

good reasons, which might include lack of resources to introduce change, competition for time between different activities, risk aversion or social and cultural practices that are part of normal life.

Convincing people of the benefits of change, and winning their commitment to maintain this change once it is in place require a number of key elements:

1) a sound risk assessment that clearly documents the need for change
2) incentives to change behaviour (e.g. access to premium markets)
3) stakeholder involvement in design and implementation
4) regulatory requirements or penalties for non-compliance
5) clear agreement about who should contribute finance and effort, and why

By and large, people will only apply measures according to perceived risk: the greater the risk (including the consequences) they perceive for themselves, the greater the disruption or cost/investment they may be willing to accept to prevent the disease occurring. However, some biosecurity measures may create such levels of inconvenience or disruption that they will only be properly applied in times of highly perceived threat. In such cases, the "traffic light" system outlined above may prove useful provided that it has been well-prepared and understood so that rapid response to changing conditions is possible.

What this implies is that biosecurity is not merely a technical issue. Livestock specialists must work with colleagues from other disciplines (socio-economics and communications in particular) in order to better understand the problems of and possibilities for implementing biosecurity.

The practical design of biosecurity

- Biosecurity measures must be practical and proportionate to the risk.
- Preventive biosecurity to decrease the risk of infection (bioexclusion) should be mostly emphasised in most locations although biocontainment remains important.
- Biosecurity measures should be designed with those who will be implementing them to ensure that they are sustainable and feasible.
- There is a need to develop biosecurity recommendations for all parts of the domestic poultry and captive bird sector, including intermediaries.

TABLE 1
Potential characteristics of selected biosecurity measures

	Impact on biosecurity			Costs		Non-cost barriers	
	Potential effect in reducing risk	Persistence of effect	Rapid implementation possible	Initial cost	Recurrent cost	Disruption of production system	Culturally acceptable
High pressure washer (110-130 bar)	+++	+	+	$$$	$$	- -	Y
Medium pressure washer (60-80 bar)	++	+	++	$$$	$$	- -	Y
Low pressure washer (knapsack sprayer, etc.)	+	+	+	$$	$$	- -	Y
Full fencing and closed entrance to farm area	+++	+++	+	$$$	$	-	Y
Strict control of entrance/exit	+++	+	++	$	$	- - -	Y/N
Cleaning footwear with soap and water	++	+	+++	¢	¢	- -	Y
Cleaning all equipment entering farm with soap and water	++	+	+++	¢	¢	- -	Y
All in, All out system	+++	+	+++	$$	$$	-	Y
Annex to poultry house for biosecurity procedures	+++	+++	++	$$	$	- -	Y
Shower with change of clothes and footwear	+++	+	+	$$	$$	- -	Y/N
Separate boots and overall to use on farm	+++	+	+++	$	$	-	Y
Separate boots and overalls to use in house	++	+	+++	$	$	-	Y
Permanent housing of poultry	++	++	+	$$	$$$	Y/N	Y/N
Banning the keeping of birds at homes of workers	+++	+++	+++	$	¢	- -	Y/N
Providing poultry products to workers as an incentive to not keep birds at home	+++	+++	+++	$$	$$$	-	Y
Exclusion of wild birds and rodents	+	+++	++	$$	¢	-	Y
Use of controlled ventilation	+	+++	+++	$$$	$$$	-	Y
Covered feed stores	++	+++	++	$$	¢	-	Y
Manure management (composting, spreading)	+					-	Y/N

Keys:

+ + +	Strong positive effect	-	Weak negative effect	$$$	High cost	¢	Minimal cost
+ +	Moderate positive effect	- -	Moderate negative effect	$$	Moderate cost	?	Unknown
+	Weak positive effect	- - -	Strong negative effect	$	Low cost		

TABLE 2
Potential for uptake of selected biosecurity measures in different systems

	Large-scale commercial	Small-scale commercial	Scavenging poultry	Hatcheries	Live-bird markets	Ducks/rice	Intermediaries and service providers
High pressure washer (110-130 bar)	Y	N	N	Y	Y	N	N
Medium pressure washer (60-80 bar)	Y	N	N	Y	Y	N	N
Low pressure washer (knapsack sprayer, etc.)	Y	Y	N	Y	Y	N	Y
Full fencing and closed entrance to farm area	Y	Y/N	N	Y	N	N	N
Strict control of entrance/exit	Y	Y/N	N	Y	Y/N	N	N
Cleaning footwear with soap and water	Y	Y	N	Y	Y	Y	Y
Cleaning all equipment entering farm with soap and water	Y	Y	Y	Y	Y	Y	Y
All in, All out system	Y	Y/N	N	N	N	N	N
Annex to poultry house for biosecurity procedures	Y	Y	N	Y	N	N	N
Shower with change of clothes and footwear	Y	N	N	Y	N	Y/N	N
Separate boots and overall to use on farm	Y	Y		Y	N	N	N
Separate boots and overalls to use in house	Y	Y	N	Y	N	N	N
Permanent housing of poultry	Y	Y	N	Y	N	N	N
Banning the keeping of birds at homes of workers	Y	Y/N	N	Y	N	N	N
Providing poultry products to workers as an incentive to not keep birds at home	Y	N	N	N	N	N	N
Exclusion of wild birds and rodents	Y	Y/N	N	Y	N	N	
Use of controlled ventilation	Y	Y/N	N	Y	N	N	
Covered feed stores	Y	Y	Y				
Manure management (composting, spreading)	Y	Y	N		N		

SOCIOECONOMIC ISSUES

The previous section identified four characteristics that need to be considered from a socio-economic perspective when designing and implementing biosecurity measures, namely: set-up cost; recurrent cost; disruption of the production system, and socio-cultural acceptability. It also identified the need to provide or demonstrate incentives to change behaviours, to involve stakeholders in devising implementation methods, to introduce regulations and penalties for non-compliance, and to determine who should pay for what.

Incorporating these socio-economic aspects into the design of a biosecurity programme offers a way to screen recommendations to ensure that they are likely to be implemented well enough and for long enough to achieve their aim.

Socio-economic issues can be examined through three fundamental questions. To illustrate the point, each of these will be examined in relation to a few actors in the production and marketing chain, drawing on information from studies in several countries over recent years. The same questions were applied in designing the recommendations for each stakeholder in Section 3 on *Specific issues and options*.

1. To whom are poultry important?

Different kinds of people keep or trade poultry, or provide inputs and services to poultry keepers. They do so for many reasons. A livelihoods analysis can be a useful way to understand the multiple motivations of people involved in the poultry sector because it explores the ways in which poultry fit into a livelihoods portfolio and contribute to physical assets, earnings, social networks, human health and the natural environment.

Keepers of small commercial flocks

These entrepreneurs are men and women, in rural and peri-urban areas, who have invested in poultry as a way to make a small income or as the first step to increasing their assets.

Many are men, but small-scale poultry businesses are also important for women. Small commercial poultry flocks require limited capital and very little land, and are a socially acceptable activity for women in most societies because they are particularly compatible with the demands of a family life or another job. Some flock owners are highly motivated, well-organized and among the leaders in their peer groups, while others are poorly informed and poor managers. Some are gamblers who will take advantage of favourable conditions to invest for a short time. If the poultry market has been distorted by protection, this particularly encourages skewed investment by distorting the relationship between input and output prices.

These "asset building" flocks are a feature of urbanizing societies or economies that are beginning to grow. They generally operate on very low margins and are vulnerable to market fluctuations or sudden changes in regulations.

Unfortunately they also present a particular problem for HPAI risk management. There is a general consensus that stricter biosecurity is needed for these flocks but it needs to be implemented in a way that helps the more entrepreneurial farmers to adopt new measures, using incremental steps rather than sudden changes and by providing information and training. It may be appropriate for governments to sponsor some investments in biosecurity for social reasons.

Keepers of scavenging and rooftop flocks

Very small poultry flocks are found everywhere from remote rural villages to city rooftops and are owned by enormous numbers of families, many of whom are very poor. Often they are owned and managed by women. Children also take care of birds and may own them and give them names; care of poultry is one of the ways to learn responsibility and independence. In villages and on city streets, they are found scavenging, in contact with other poultry, wild birds and people. Many city flocks, however, are kept enclosed on rooftops or in courtyards by owners who pay close attention to them.

Scavenging poultry production is important from a livelihoods perspective because even the smallest flocks fulfil multiple livelihood objectives: poultry provide meat, eggs, cash, manure, exchange and cultural capital. The particular and unique value of poultry for local livelihoods lies not in any one of these functions alone, but in their interchangeability, the low entry costs to scavenging poultry production for the poor and the central role of women.

Scavenging poultry production is also important from a national development perspective; poultry production has an important equity effect because income is more evenly distributed across the population than in other livestock sectors. Therefore, while it is difficult to impose biosecurity on these flocks, it is neither feasible nor desirable to limit scavenging poultry as a livelihood option for the poor unless the overall benefit to society can be clearly shown to outweigh the cost and compensatory measures are established for the losers.

Keepers of nomadic duck flocks

Nomadic duck herding, where ducks move from farm to farm, can only be done in particular ecological zones, usually those where paddy rice is grown. The flock owners are part of a tradition of several generations and have established contractual relationships with the owners of rice fields so that the ducks move through them after harvest eating crop residues, snails and insects. Sometimes ducks from more than one owner are herded together. This is a specialist enterprise done by relatively few people in limited areas, but important locally. Duck meat and eggs are prized by consumers and the birds make a positive contribution to the rice crops in which they are grazed through their manure and reducing pests.

Small traders

Small traders who specialize in buying and selling poultry (as opposed to those taking their own birds to market) are usually men, owners of bicycles or motorbikes on which they travel many miles in a day. Some are highly specialist in the birds they trade. Like any trader, they provide news and information as well as a service.

2. What might people be willing to do to improve biosecurity?

People will be willing to take some actions to protect their birds or those of other people. By understanding their motivation, recommendations can be made that are not only technically correct according to a risk assessment but also realistic in terms of the way that people behave.

A livelihoods analysis will be useful here because it explores the way that people man-

age their assets and the coping strategies that they use to deal with risk and disasters.

It makes sense to tackle biosecurity through incremental steps, where the biggest risks are tackled first and provide an incentive to continue, and each additional step provides further benefits.

Keepers of small commercial flocks

These producers show widely varying responses to risk and regulation. The first response of many of those who suspect HPAI in their flock is to sell their birds quickly. Those who have invested in poultry to cash in quickly on a market opportunity will not necessarily be motivated to upgrade their production systems; they are more likely to evade regulations as long as possible and then switch to another business. Others who are more entrepreneurial will be willing to invest money and time in biosecurity, to the extent that they can. Experience in Viet Nam suggests that when biosecurity regulations are raised, some producers will upgrade and become more profitable than before, while many others will go or stay out of business.

Keepers of scavenging and rooftop flocks

Owners of scavenging flocks will be limited in what they can do for biosecurity, regardless of their motivation. There is some evidence that they may be willing to apply stronger measures in an emergency (e.g. segregating their birds for several days when an outbreak occurs in the village, until it dies out) than are normally possible. Owners of rooftop flocks may be segregating them routinely

Small traders

Like small commercial producers, traders vary quite widely in their behaviour. For example, import and export restrictions provide incentives for some people to specialize in illegal cross-border trade in poultry. Some traders appear to specialize in suspected sick birds bought at very low prices while others avoid birds that appear to be sick. Small traders appear not to be well informed about risks and generally do not apply hygiene measures, even in countries where HPAI is endemic.

3. How much can people afford to spend on biosecurity, who should pay for what, and what balance of incentives and penalties may be needed?

People seldom change their behaviour without a combination of "pull" and "push" factors. Information and awareness campaigns are important to support the uptake of biosecurity measures, but without economic or social incentives they will not be enough to motivate a change in production behaviour.

It has already been suggested that recommendations must be affordable in terms of both set-up and recurrent costs. Poultry keeping does not offer high margins per bird, and any extra investment needs to be matched by a financial return.

An economic evaluation of biosecurity would use either a cost effectiveness analysis or a cost-benefit analysis. Cost effectiveness analysis would mean defining an "acceptable" level of risk or biosecurity (which would be dependent on the stakeholder) and finding the cheapest way of achieving it. Cost-benefit analysis would compare benefits (in terms of

profitability) from applying biosecurity measures with costs of implementing. There is very little hard evidence to suggest what either of these would look like for small commercial flocks, scavenging flocks or even LBMs. On the cost side, there is already some information available and estimates could be made quite easily. However, very little has been documented about effectiveness or benefits for these systems. The most achievable goal at the moment is a cost efficiency analysis that looks for the least-cost way of implementing a recommended set of biosecurity measures on a small scale.

Even with an obvious economic incentive, there will still be a need for regulation so that the behaviour of the most irresponsible people does not damage the safety of the rest.

An argument can be made that public funds should contribute to biosecurity investments in scavenging poultry production and upgrading of markets because of the contribution towards a public good (reduced pandemic risk)[5].

Keepers of small commercial flocks

Small flock owners operate on tight margins and will not want to make much financial outlay in biosecurity unless i) they can see that an investment will lead to an overall improvement in profitability, and ii) they have cash available.

Improved profitability may not be related to reduced HPAI incidence, because the risk to any individual flock is low, but to a generally reduced level of disease incidence and perhaps to improved market access.

It is important to consider not only the total benefit and cost of an investment but also the cash flow implications. Small flock owners may also be at a disadvantage if required not to bring birds back from a market, because buyers can strike hard bargains at the end of the day.

There may be motivation to invest if the flock owner is contracted to a larger company that requires it, and may perhaps provide assistance with the set-up. But very strict regulations on biosecurity may also motivate large companies to stop working with contract farmers and raise birds only in their own flock because the cost of monitoring quality in the contract farmer's flock becomes too high.

Some ideas for incentive structures that encourage the adoption of biosecurity measures include: (i) linking eligibility for compensation to minimum standards of biosecurity; (ii) providing tax rebates for biosecurity measures (in Indonesia, for example, some small commercial producers pay tax); and (iii) piloting public-private risk insurance schemes that link participation with minimum standards of biosecurity. All will have a cost in monitoring/certification and require a suitable certifying body. None has yet been evaluated in the conditions of HPAI-endemic countries.

Keepers of scavenging and rooftop flocks

A feature of scavenging poultry flocks is that their owners spend almost nothing on them – they produce an output that is very small but many times larger than their input. As soon

[5] The benefit of reducing pandemic risk is available to everyone; however, private individuals and organizations will not be directly remunerated for their contribution towards producing it and they may be reluctant to bear the entire cost.

as investment is considered, the question then arises whether or not to upgrade the flock to a small commercial unit. Measures that can be taken using time and local materials rather than cash might be adopted.

If increased productivity could be demonstrated, this could become the incentive to apply biosecurity. Protection of people from disease could also be a motivating factor. Approaches agreed by the community may work better than regulations imposed from outside.

Small traders

Biosecurity measures for a small trader will probably not require much investment. Behaviour change (e.g. not entering premises where birds are reared, washing equipment and motorcycle/bicycle/cages before leaving a market) may be much more important.

Good hygiene among traders can be promoted by the farmers with whom they trade, regulations and provision of washing facilities at the markets they visit, and possibly by certification of traders linked to hygiene standards.

Market owners

The costs of upgrading a market might reasonably be shared between the private poultry production sector (because good biosecurity will not only reduce the risk of HPAI but also raise productivity and profit from poultry) and the public sector (because HPAI presents a public danger whose management has to be supported by the public sector). There is some evidence to suggest that investment in improving market hygiene can provide good returns.

Socioeconomic issues

- Incorporating socioeconomic analysis into biosecurity planning helps in identifying the social and cultural acceptability of proposed measures, the level of cost people can afford to pay, and the regulations, incentives and penalties that may be appropriate for inducing behaviour change.
- Three sets of questions need to be asked for each actor in the production and marketing chain when designing a biosecurity plan:
  1. To whom are poultry important
  2. What might/will people be prepared to do to improve biosecurity?
  3. How much can people afford to spend on biosecurity, who should pay for what and what balance between incentives and penalties that may be needed?
- Economic assessment of biosecurity measures may be based on cost-effectiveness or cost benefit analysis. Livelihoods analysis is useful for understanding the importance of poultry and motivations of people.

COMMUNICATION ISSUES

Communication is the process of mediating exchange among all parties to an activity or issue in order to identify the attitudes, perceptions and needs of each, and on that basis formulate explanations, recommendations and messages about policies and activities that best address the collective interest. Communication is also a tool of advocacy, promoting the importance of biosecurity for livestock and livelihoods in key sectors, especially policy-making circles and farming communities.

Communication is therefore essential for the "buy-in" of all parties to these policies and activities, and their subsequent adoption and effective implementation.

Communication is also a way of creating an "environment" or "culture" which supports activities designed to satisfy this collective interest.

In the context of biosecurity and HPAI planning (as understood in this paper), communication brings together the various stakeholders – poultry keepers, owners and handlers, technical specialists and policy-makers – and facilitates the sharing of information and opinions on an equal footing among them. It specifically aims to ensure that policies are not imposed in a top-down fashion by offering the channels through which those who will be affected by and expected to implement the policies in question can voice their concerns and needs and have them taken into consideration.

Communication related to biosecurity for the prevention and control of HPAI has two major interrelated, yet distinct, objectives:

- help motivate poultry keepers, producers, transporters and traders to adopt appropriate biosecurity measures, and
- help ensure that these measures are widely adopted as rapidly as possible.

Communication in itself cannot replace the provision of services or overcome structural barriers such as lack of economic means. What communication can do is influence the provision and uptake of those services, or support the cause of making a case for subsidies and economic aid for promoting biosecurity.

Take the question of improving biosecurity in an LBM, for example, where it is imperative that an adequate supply of clean water be available. Communication cannot replace the need for clean water, but effective promotion among market authorities could ensure the provision of clean water and good communication could positively influence its use for cleaning premises, cages, vehicles, and so on among the poultry traders and transporters who frequent the market.

Another issue at the heart of the communication challenge is that, by and large, communication campaigns for the prevention and control of avian influenza in recent years have largely focused on human health (i.e. reducing human exposure to the HPAI virus) and less on animal health (i.e. preventing animal-to-animal transmission and onward spread).

Encouraging early reporting by farmers of suspect events involving poultry (such as unusual die-offs) or persuading them to take up preventive biosecurity measures (such as segregation of poultry or regular and thorough cleaning of cages and implements) has proved to be difficult and complex.

A third aspect of the communication challenge is related to awareness, perception and behaviour change. Data from studies of communication campaigns in a number of affected countries have revealed a clear trend – awareness of HPAI among at-risk populations is

quite high, perception of risk is quite low, and changes in actual practices and behaviours are very much less than ideal.

In Egypt[6] in 2007, following an intensive communication campaign using mass media and inter-personal communication, a research team interviewed over 4,000 individuals from urban and rural communities in 12 governorates.

Among others, the team found that:

- over 90 percent of the respondents knew the signs of HPAI in poultry and that HPAI is transmissible to humans, but just over 25 percent had sufficient knowledge of protective practices[7]
- 25 percent said that they would throw dead birds into the garbage, but half said they would do nothing; 15 percent said they would throw sick/infected birds into the garbage, and 53 percent said they would do nothing
- if they saw signs of HPAI in their poultry, 52 percent said they would put the birds in a plastic bag and throw the bag into the garbage; 38 percent said they would throw the dead birds away, but slaughter and freeze the rest, while only 6 percent said they would notify the authorities
- the respondents generally felt that catching avian influenza could be very serious, that avian influenza was a serious problem in Egypt, and that government action was strong enough to prevent disease; but they also believed that the possibility of catching avian influenza oneself was very low

Survey data from several other countries reveal similar trends of high awareness, and low perception of risk and changes in behaviours/practices.

In the public health sphere, it has been well documented that despite large-scale communication campaigns, high levels of awareness do not necessarily translate into changes in behaviours and practices. The key to changing behaviours/practices lies in the level of perception of risk.

In 2007, an FAO participatory anthropological study looked at the beliefs and practices of smallholder rural farmers in Cambodia[8] to try to shed light on the reasons for the gap between awareness and practices despite HPAI communication campaigns. The team found that:

- there were two parallel, simultaneously operating models for explaining and managing poultry sickness in people's minds – the *"naturalistic"* model and the *"contagion/contamination"* model. The difference between the two is very important. *The naturalistic model entails a treatment model of response* – people turn to traditional household remedies and seek professional cures for their poultry in order to keep them from dying. On the other hand, the contagion model lends itself to a prevention model of response – examples include farmers rushing to sell healthy poultry when it looks like sickness is spreading in flocks or buyers checking the vents of poultry before purchasing them and taking them to market. Although the specific behaviours

[6] Avian Influenza Survey: Knowledge, Attitudes and Practices of the Egyptian Public, 2007, UNICEF.

[7] Calculated on the basis of knowing at least two out of five recommended practices.

[8] Bridging the Gap between HPAI Awareness and Practice in Cambodia: Recommendations from an Anthropological Participatory Assessment, 2007, FAO.

in these examples are not ideal, the underlying prevention model of response should be encouraged among scavenging poultry keepers when it comes to HPAI. Communication strategies should draw on these two distinct existing explanatory models and encourage the shift from the "naturalistic" to the "contagion/contamination" model.

- *awareness and understanding* of priority messages (including those related to biosecurity) were high but how *practicable* they were seen to be depended on socio-economic circumstances; this suggests a missing dimension – awareness of *why* the behaviour being promoted *makes sense* to the receiver of the message.
- for some households, poultry are an asset, for others they are a *source of income*.
- the concept of *risk* is not widely perceived among rural farmers, many of whom tend to believe that HPAI will not happen to them for a wide variety of reasons.
- the primary concern for the average rural poultry farmer is the *wellbeing and prosperity* of the family.

What these and other studies illustrate is the need for communication strategies to build on the way people perceive their own situation and the environment in which they act. Communication cannot be merely prescriptive, laying down rules on behaviours to practice and behaviours to avoid. Strategies must take into account the complex interplay between risk perception, response, behavioural intent and message design.

Different people have different ways of seeing, interpreting and responding to the same situation and to the same response measures. For some, the threat of their birds being infected with HPAI is high, for others it is low; for some the biosecurity measures proposed will be effective, for others they will be ineffective. These different ways of looking at the same issue cut across each other and render it difficult to come up with a one-off communication strategy – communication has to be tailored to best meet the needs and realities of different "target" groups.

However, beyond recognizing that the potential motivation of poultry keepers, producers, transporters and traders to adopt appropriate biosecurity measures is firmly rooted in the perception of risk, it is important to consider ways of facilitating rapid and wide-scale adoption of appropriate measures through tailored communication campaigns.

One of the problems is that for the vast majority of scavenging and small-scale poultry keepers and producers, the concept of and need for *biosecurity* and its associated practices may be a relatively new and almost "alien" notion[9]. For this reason, the eventual adoption of biosecurity measures by such communities can be seen as the adoption of something new, of "innovation"[10].

If this is so, then the role of communication is to facilitate and promote the spread of the "innovation" – in this case the biosecurity measures that are required for HPAI prevention and control – throughout poultry-keeping communities over time.

Whether or not the innovation will be adopted depends on three factors:

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[9] The opposite is more likely to be true for those in the larger scale, industrial/commercial poultry production enterprises.

[10] This section draws on Diffusion of Innovation theory which, despite criticism, has evolved over the decades and has strongly influenced communication approaches and strategies.

- the "adopters"- those who take up the innovation (bearing in mind that some people pick up and implement new ideas quickly, others less so, and still others very slowly if at all);
- how the innovation is perceived (which will determine its rate of adoption - i.e. the relative speed with which it is adopted by members of a social system, and usually measured as the number of members of a system adopting an innovation in a certain period of time).
- the stages of adoption of the innovation (from awareness, through interest in, and testing and adoption of the innovation).

it is important to understand and identify the different categories of "adopters" and their role in the diffusion of new ideas and practices, and analysis of "stages of adoption" is useful for gaining insights into the progress being made in the adoption of an innovation.

However, it is the characteristics of an innovation – or more accurately, individuals' perceptions of these characteristics – that are key to the adoption process:

- ***Relative advantage*** (the degree to which an innovation is perceived as better than the idea it is designed to supersede).

The degree of relative advantage may be measured in economic terms, but social prestige, convenience and satisfaction are also important. Most importantly, it does not matter so much if an innovation has a great deal of objective advantage, but it does matter whether an individual perceives the innovation as advantageous.

- ***Compatibility*** (the degree to which an innovation is perceived as being consistent with existing values, past experiences and needs of potential adopters).

An idea that is incompatible with the values and norms of a social system will not be adopted rapidly.

- ***Complexity*** (the degree to which an innovation is perceived as difficult to understand and use).

New ideas that are simple to understand are more rapidly adopted.

- ***Testability*** (the degree to which an innovation may be experimented with on a limited basis).

Generally speaking, new ideas that can be tried out in an incremental manner, in order to reduce uncertainty, will be adopted more quickly than innovations that do not lend themselves to such experimentation by the potential adopters.

- ***Visibility*** (the degree to which the results of an innovation are visible to others).

The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Observability also generates peer discussions around the new idea, which facilitates uptake.

Overall, innovations that are perceived as having greater relative advantage, compatibility, testability and observability, and are less complex will be adopted more rapidly than others.

In terms of biosecurity, it is clear that few of the biosecurity measures recommended for HPAI prevention and control lend themselves easily to rapid adoption, particularly among scavenging and small commercial poultry producers, and perhaps also in many LBMs.

However, this diagnosis helps clarify the direction to take in choosing the content of communication materials and strategies most appropriate for facilitating adoption of biose-

curity "innovations". Again, it is dialogue with the target groups/communities that offers the best way forward in understanding these issues for planning communication support campaigns.

The most critical stage of the diffusion process is reaching a "critical mass", when the number of individuals who have adopted the innovation is sufficient to make the whole diffusion/adoption process self-sustaining.

Communication (or "outreach") activities should concentrate on achieving this critical mass by focusing on the "early adopters" –often opinion leaders in their communities – who are instrumental in bringing the diffusion process to this stage, poised for subsequent adoption on a larger scale throughout the social system.

Finally, while communication can play a key role in developing and improving biosecurity levels and standards provided it takes individuals and communities as its starting point, it should also be seen as an instrument of advocacy, stimulating policy-makers and media to rally round the importance of biosecurity. Only if this occurs will it be possible to create the "enabling" or "support" environment within which individuals and communities can play their role.

Communication issues

- The role of communication is to facilitate and promote the spread of "innovation" (biosecurity) by building on the way people perceive their own situation and the environment in which they act.
- Communication cannot be merely prescriptive, laying down rules on behaviours to practise and behaviours to avoid, but should take into account the complex interplay between risk perception, response, behavioural intent and message design.
- Effective communication must help overcome the widespread perception that poultry sickness and death are natural, a perception that leads to lack of reporting sick and dead birds, lack of hygiene when handling poultry, and the consumption of sick and dead poultry.
- Awareness of why the biosecurity practices being promoted make sense to those expected to implement them is key to behaviour change and must form part of any communication strategy.
- Communication is as an instrument of advocacy, stimulating policy-makers and media to rally round the importance of biosecurity, helping to create the "enabling" or "support" environment within which individuals and communities can play their role.

Section 3
Specific issues and options

This section looks at some of the major issues present in various sectors of the poultry production and marketing chain and identifies a number of possible solutions (options).

LARGE-SCALE COMMERCIAL PRODUCERS (SECTORS 1 AND 2)

Issues

A high level of biosecurity to prevent infection at these units is vitally important because of the risk that large amounts of virus could be released given the size and density of their poultry flocks, particularly if the owners were tempted to sell off many birds suddenly via LBMs if a flock was thought to be infected.

The large size of the enterprises and their access to funds and technical advice means that theoretically biosecurity levels can be high and maintained. In addition, good biosecurity levels can help increase profit margins in an increasingly competitive international market. This is particularly true for integrated companies.

However, field experience has shown that even quite large flocks, particularly laying hens but also including valuable parent and grandparent flocks, may have inadequate biosecurity (often a failure of control at the entrance to the premises) and where they are free of disease this is more because of a lack of challenge (i.e. an absence of disease in the locality).

There is a growing trend towards free-range systems in the large commercial sector, both for laying hens and broilers. This presents a much greater challenge to effective biosecurity because it is almost impossible to prevent contact with wild birds and environmental contamination.

Options

There are well-established protocols for large-scale commercial establishments. Most have been written for developed countries with temperate climates and need adaptation for less developed and/or warmer climates. However, the similarities between the systems are greater than the differences and adaptation should not prove to be difficult. Standards and methods already available require implementation, and how this can be achieved will vary from country to country.

In many countries, there are associations for both large-scale commercial poultry meat producers and egg producers, with the former usually stronger and with a longer history of interaction with government and regulatory affairs. It is important that governments strengthen or establish close links with both types of association, which can act as strong conduits for persuading their members of the need for biosecurity, and for transmitting biosecurity messages. Both types of association should be included in national biosecurity

programmes. They will probably be willing and able to adopt a system of biosecurity audits using their own staff.

Not all producers are members of such associations, but there are usually relatively few large-scale commercial farms in any given country (compared to the number of villages with scavenging poultry) and their size means that they are generally well known. Where they do not already exist, governments should establish lists of these units with addresses and contact details as well as locations in order to ensure that all can be included in any biosecurity programme.

Action on biosecurity is likely to be best achieved by a combination of private initiatives and some government regulation. Governments should encourage the private sector and use regulation to inject some impetus. A first and mandatory step for the private sector should be implementation of risk assessments and biosecurity audits to identify potential risks, evaluate how well biosecurity measures are being applied and design the corrective measures needed to achieve adequate biosecurity.

All commercial farms, regardless of their size, should have a farm biosecurity and disease prevention plan, which details how the farm will address the risks of infection with H5N1 HPAI and other pathogens. This plan should examine the various risk pathways for the farm and then devise appropriate measures to deal with these including the barriers that will be established and the measures applied to inputs and outputs to ensure that they risk they pose is minimized. This should cover operational procedures as well the physical facilities required to achieve the required goal.

For example, if entry of vehicles onto the farm is recognized as a key risk factor for the introduction of H5N1 HPAI, there are a number of ways this can be tackled. The farmer could continue to allow vehicles to enter the farm but insist on through cleaning and disinfection at the farm gate; he/she could designate a 'semi-dirty' area in the farm where vehicles can park, with this area being cleaned and disinfected after the vehicles leave; he/she could modify management procedures so that vehicles do not enter the farm; or he/she could ensure through a certification system that vehicles coming directly to the farm have already been cleaned and disinfected. The relative cost of these measures and extent to which they can be expected to reduce the risk of infection (which is a very subjective measure) should be considered carefully, including the sustainability of the measures and the capacity to conduct audits on their implementation.

The challenge is to persuade the producers that the costs of heightened biosecurity are justified in comparison with the risks. One strong argument is that in AIAO systems, biosecurity leads to a reduction in other diseases that affect productivity (e.g. infectious bronchitis, infectious laryngo-tracheitis, Newcastle disease, and low pathogenic avian influenza).

Anecdotal evidence suggests that even in companies with seemingly good biosecurity, tightening procedures gives a return on investment, suggesting that further improvements are possible and will be beneficial to profitability. Hard evidence for this should be sought and publicized. If this is done, biosecurity can be promoted as an investment rather than a cost.

In many countries, consumers and supermarket chains are increasingly demanding some degree of quality assurance for poultry products for various reasons (including salmonellosis, campylobacteriosis, residues and welfare) and industries have adopted codes of

practice either voluntarily or with government involvement. Biosecurity standards could be made a part of these codes through registration with and licensing by government veterinary services, with failure to comply leading to a loss of access to markets.

A cost-sharing (between government and producers) or privately funded approach to compensation as already advocated by the World Bank would provide an incentive to improve biosecurity to reduce the risks of losses.

However, both the need for registration and compensation tied to biosecurity may be used by large companies (which frequently have close contacts with policy-makers) to impose similar restrictions on small-scale commercial producers, which could lead to these producers finding it difficult to continue trading. A second approach is through a system of voluntary standards and quality control which consumers can recognize and which gains and retains market share while allowing a premium on prices. This type of system has been used in Thailand and Turkey, among others.

In countries with the highest standards of production and where access to export markets or consumer confidence in the face of disease are important, governments and producers should consider compartmentalization to establish populations of poultry of an assured health status protected by high levels of biosecurity agreed and regulated by government veterinary authorities.

Key issues and options

- There are strong incentives for large-scale commercial producers to adopt biosecurity measures; where necessary, governments can strengthen these incentives through regulation requiring that a given level of biosecurity be achieved in order to have access to markets.
- Detailed methodologies for biosecurity at large-scale commercial farms are available; governments (perhaps in conjunction with producer associations where they exist) should work with producers to adapt these methodologies for the national context.
- Governments should develop and maintain a database of large-scale commercial producers.
- Governments and the poultry industry should work together to establish a system of compartmentalization where this is justified.

SMALL-SCALE COMMERCIAL PRODUCERS (SECTOR 3)

Issues

These producers are probably at as great a risk, or higher, than the large-scale commercial producers because of a high number of contacts with intermediaries and service providers combined with a lack of good physical barriers to infection. Birds are mostly destined for markets so the potential for spread is high. Many of these farms are in peri-urban areas where they may pose a higher threat to other poultry and people because of higher popu-

lation densities. Indeed, this sector may pose a high threat to scavenging poultry rather than the reverse because small-scale commercial flocks are often located in villages and put scavenging poultry at risk.

The large numbers of these producers and their ability to move in and out of production at short notice makes registration and certification of birds produced much more difficult than for large-scale commercial producers. At the same time, their relatively small scale of activity means that financial resources are likely to be low and biosecurity measures must take this into account if they are to be applied over the long term.

Options

This is such a varied segment that no detailed list of solutions can be proposed. It will be necessary to undertake participatory work with producers locally to determine what measures can be introduced and maintained with the resources available to them, to produce and disseminate extension messages, and to monitor and report on uptake and impact of these messages

Biosecurity audits and risk assessments for this sector should be introduced to demonstrate to producers the potential risks of infection. Critical to adoption will be the producer's perception of risk and benefit. The emphasis will need to be on least-cost measures that are easy to apply.

Biosecurity measures should focus first on segregation. Perhaps the most practical change in these producers would be the building of a small enclosure, or annex, outside the entrance to the poultry house which could be kept locked and at which a biosecurity point could be established where outer clothing could be put on and footwear changed. If this annex cannot be built outside, it could be built inside the house.

Where possible, the part of the yard containing the poultry shed should also be closed to visitors and vehicles. A fence capable of keeping free-roaming scavenging poultry away from the poultry shed would be another useful measure.

The ability to implement an AIAO management system should be assessed. Where it is possible, the impact of this and the application of basic segregation, although requiring a moderate level of investment, will improve protection against HPAI and show gains in improved productivity due to lower levels of endemic diseases. However, there may be a limited capacity to apply this measure.

Key issues and options

- Participatory field work is required to establish which biosecurity measures are feasible and sustainable, to produce and disseminate extension messages, and to monitor and report on uptake and impact of these messages.
- Biosecurity should emphasize the creation of physical barriers against infection and to control access; this may require some public funding.
- Cleaning of inanimate objects should be the second step.

As well as segregation, emphasis should be placed on thorough cleaning with soap and water of all inanimate objects from outside the farm that may come into contact with the poultry. Where disinfectant can be readily obtained, its use should be promoted.

In many countries, the small-scale sector is affected by strong competition from large commercial companies, which makes it even harder for them to bear extra costs. A degree of financial help may be required to make initial investments, but this will only work if there is an ongoing commitment from and ability of the producers to apply the measures.

HATCHERIES

Issues

Hatcheries distribute many live birds as DOCs. When they hatch, these chicks are not infected with avian influenza but may become infected between hatching and distribution if the virus is being brought to the hatchery through contaminated products or maintained if other birds are present. The numbers of chicks produced and the variety of locations to which they are distributed, often through intermediaries, potentially make hatcheries a very powerful source of infection.

In addition, the egg trays (or flats) used to transport eggs to hatcheries are high-risk material. Disposable cardboard trays should only be used once but this is not always the case. Plastic egg trays are designed to protect eggs but their structure makes cleaning and subsequent disinfection very difficult. This is equally true of the trolleys on which the flats are usually stacked.

If hatcheries are forced to close, the impact for the production and marketing chain could be very severe, because they are essential for the functioning of the commercial poultry industry, particularly the broiler chicken sector. The high costs hatcheries will face if they become infected could be a strong incentive for ensuring a high level of biosecurity.

Options

Hatcheries are relatively small in number and most have known locations that cannot be easily changed. They have an interest in being known as suppliers of good quality chicks and therefore it may be possible to introduce a degree of regulation that includes an agreed set of biosecurity measures. All commercial hatcheries above a certain size in terms of weekly production capacity should be registered and licensed, with licensing dependent on the adoption of strict biosecurity procedures.

Modern hatcheries should conform to the highest possible levels of biosecurity as described in manuals for large-scale commercial producers.

Where hatcheries are smaller and more traditional, good biosecurity is still essential.

Some essential procedures are:

- No birds of any species should be kept at the hatchery for any purpose (unless they are the sole source of the eggs being hatched).
- Only hatchery staff should enter the hatchery.
- All staff entering the hatchery must change outer clothes and footwear.
- Wherever possible, there should be a one-way flow through the hatchery, and the

points at which eggs enter and leave the hatchery should be separated to minimize the possibility of cross-contamination.

In terms of materials, if disposable (cardboard) egg trays are used, one-time use must be enforced because they cannot be cleaned and disinfected. Cleaning of non-disposable egg trays/flats and trolleys requires the use of an industrial machine or high pressure washers. In both cases, careful post-cleaning checking is required. Ideally, egg flats and trolleys should be marked for a single farm and only return to that farm from the hatchery, or perhaps be associated with a particular egg collection run to minimize cross-over between farms.

Key issues and options

- Day-old-chicks (DOCs) are not infected at hatching but may be infected after hatching if biosecurity at the hatchery is poor.
- Hatcheries are an essential part of the production and marketing chain; their continued operation
  is vital to commercial production, particularly of broiler chickens.
- All hatcheries above a certain size should be registered and licensed.
- Strict biosecurity is required because of the potential for wide dissemination of infection from a single hatchery.

KEEPERS OF SCAVENGING POULTRY (SECTOR 4)

Issues

At least initially, the majority of outbreaks were in village poultry. However, this sector covers the majority of flocks in most countries and when the proportion of flocks of particular types is calculated, it emerges that scavenging poultry may have had a lower risk of infection than commercial poultry, in particular small-scale commercial poultry. These findings have led to dramatically different perceptions of the role of scavenging poultry in H5N1 HPAI.

Some, often the large commercial producers, have seen scavenging poultry as more of a problem than a benefit; they argue that the majority of outbreaks and human deaths have come from this sector. Others point to the socio-economic importance of scavenging poultry and emphasize the lower risk compared with the commercial sector. However, there is no question that scavenging poultry can and do become infected and can maintain the disease without the involvement of other types of producers (e.g. in Turkey). It is therefore essential that action be taken to decrease the risk of infection in these birds, while ensuring that the measures are proportionate to the actual risk.

There are several obstacles to biosecurity in this sector:

1. It has been in the nature of scavenging poultry-keeping that the high mortality events which could be reduced by the introduction of biosecurity measures have always been accepted as a normal part of keeping poultry – ironically, this is one of the principal reasons that holds keepers back from investing in their birds.
2. The relatively low risk of a given poultry keeper's flock becoming infected, even dur-

ing an outbreak in the country, probably limits any incentive to introduce biosecurity. Studies in affected countries in Southeast Asia indicate that even during quite intense outbreaks, the risk of an individual household being infected is relatively low (under 1 in 1,000). This level of risk is unlikely to be seen as high enough to justify anything more than very simple, easily applied and virtually cost-free measures. In the absence of human deaths, or even when they have been present, scavenging poultry keepers often do not see a great need for biosecurity. In fact, Newcastle disease, another endemic poultry disease, has been as important in terms of killing poultry as HPAI and yet it has been rare that preventive vaccination has been reliably and sustainably used or biosecurity implemented or increased against this disease.

3. Many poultry keepers say they do not believe what is said about HPAI, seeing it as a pretext used by governments to carry out widespread culling of their poultry; this culling itself may have been the original source of this belief and it certainly reinforces it.
4. Most messages on biosecurity for scavenging poultry keepers have been aimed at the individual keeper. However, given that all scavenging poultry within a community, irrespective of their owner, interact with other flocks and may form a single epidemiological unit from a risk point of view, biosecurity messages should also call for action involving the entire community.

Biosecurity measures for scavenging poultry can never be as strong as they can be for commercial poultry for so long as they retain the characteristics that make them part of the low input, low output, high efficiency system that explains why they are kept. But, this is no reason to ban them, try to house them all, or cull them in large numbers over a wide area when infection occurs. Governments and the commercial poultry industry have to accept the presence of the scavenging poultry system because of its socio-economic, nutritional, cultural and religious importance to the people that keep the birds. It is also probable that they have a lower risk of exposure to infection and that the consequences of infection may be less in terms of onward spread than for commercial producers because of smaller flock sizes and fewer links to intermediaries, service providers and LBMs.

A key factor in biosecurity is to establish the boundary of the unit around which the biosecurity barrier, real or virtual, should be created. This boundary should enclose the epidemiological unit in which health status is assumed to be the same. For commercial farms, it is mostly easy to define such units; this is not the case for scavenging poultry. By their nature they roam, so the owners of a flock do not control all of the risk that their birds face, although the epidemiological unit is the group of flocks that are in contact with each other and so could potentially be exposed to infection through the actions of any one contacting another. This epidemiological unit is most likely to be all the poultry in a village, but could be smaller than this (e.g. where a village is made up of two or more self-contained areas) or could be much larger (e.g. all the poultry in a city or large town).

Options

Working with scavenging poultry keepers will require much of effort to achieve an impact. They are numerous and geographically widely spread. Strong institutional infrastructure will be required to achieve significant coverage and dissemination of messages. Scavenging poultry keepers may best be engaged through a participatory epidemiology approach

in which better understanding of the risks, risk pathways and protection measures can be reached. Risk assessments should be carried out for villages and peri-urban areas in the same way as for commercial farms. An audit of biosecurity risks and discussion of possible measures should be carried out to establish plans that are realistic and sustainable.

This approach will need to be mediated by someone with a good understanding of the approach. Government officials are frequently not well versed in working in this way and may not been seen as reliable sources of information in some places. It may be preferable to work through NGOs and ensure that village leaders (secular and/or religious) and trusted professionals (e.g. teachers, health workers) are part of the process, as well as the intermediaries and service providers who normally work with scavenging poultry. Doing things this way may lead to village-wide agreement on, for example, measures aimed at biosecurity management of traders coming in and out of the village, disposal of carcasses, and so on.

Any measure introduced must be locally sustainable (i.e. with no need for repeated inputs from outside agencies) and represent the minimum possible financial burden, in terms of both costs and time. Even then, progress may not be rapid, but when villagers see that something is workable and useful, its adoption often spreads within and between villages with little effort.

There are simple measures that can be recommended, although there is still a need to review the possibilities of these with the keepers in a participatory process. The measures include: avoid contact between village poultry and any commercial flocks and intermediaries and service providers; keep poultry away from surface water; do not bring live birds from markets; and clean or change shoes before and after visiting markets.

Key issues and options

- Scavenging poultry have been the most frequently affected by H5N1 HPAI, and have been a major source of human illness – however, the risk of an individual flock being infected is no greater than for commercial flocks.
- Keepers of scavenging poultry cannot introduce effective biosecurity measures alone; community-led initiatives are needed.
- Any new measure must be locally sustainable (i.e. without repeated inputs from outside agencies) and with minimum possible burden, in terms of costs, time and initial and ongoing requirements.
- Housing scavenging poultry fundamentally changes the production system.
- Sustainable use of disinfectants is unlikely, but biosecurity will need to rely on cleaning.
- Field work is needed to formulate recommendations that keepers of scavenging poultry will implement, taking into account their perception of risk and ability to invest resources in biosecurity; this is a challenge and should not be underestimated.

It is important to convince scavenging poultry keepers that buying replacement birds at an LBM is dangerous. This is as true for other diseases as it is for HPAI. Buying birds directly from a known source, such as a neighbouring village where the disease history is better known and the risk of undisclosed infection at the time of purchase is less, is a much safer practice.

Persuading people of the need to act will be easier where the threat of disease is seen as high. The possibility of using a "traffic light" system with varying levels of alert and biosecurity requirements was described above but the question of perceived risk requires more in-depth investigation.

DOMESTIC DUCK KEEPERS

Issues

The problem of undetected infection in ducks has been mentioned above. This applies as much to ducks that are permanently confined as to free-ranging ducks.

In Asia, many ducks are kept in flocks that are allowed to scavenge in post-harvest rice fields and may be moved long distances during harvest seasons, following harvesting patterns. Contact with faeces from wild birds is impossible to prevent. The fact that the flocks move represents a high risk that they could become infected from both wild birds and domestic poultry and spread the disease to other areas. The ability of ducks to remain asymptomatic for long periods of time means that this is a major way of maintaining and spreading the infection. Applying effective biosecurity measures in this system is problematic.

The "obvious" answer is to ban free-ranging duck-keeping, or to make it socially difficult to continue. But they form an integral part of the "rice/duck" system and the consequences of banning them might be worse than the possible gains.

Options

Where ducks are permanently confined, the same biosecurity measures as required for other domestic poultry flocks of similar sizes and management levels should reduce the risk of infection to a low level. However, given the potential for ducks to be infected with H5N1 HPAI and shed virus without showing clinical signs, biocontainment is as important as bioexclusion.

Key issues and options

- Where ducks are permanently confined, duck keepers must implement the same bioexclusion measures as other poultry keepers. They will also need to practise routine biocontainment because of the possibility of undetected infection.
- Effective biosecurity for free-ranging duck flocks that are part of the duck/rice system is probably not possible; any biosecurity measures should be supplemented by licensing, movement control and vaccination.

For free-ranging duck flocks, registration of flocks, vaccination (perhaps paid for by the owner) on a regular basis with a requirement to test and certify the ducks and licensing their movements (including to markets and slaughterhouses) based on this would decrease the risk associated with these flocks. In Thailand, initial restrictions on movement were followed by the provision of resources to house and feed duck flocks. That has been successful, although it may have led to some producers giving up keeping ducks in this system. In Viet Nam, vaccination and some movement control have been used, but the results have not been as good, possibly linked to a lower than planned uptake of vaccination. The identification of practical solutions depends on country-by-country or case-by-case evaluation.

LIVE-BIRD MARKETS

Issues

Many LBMs are never empty of birds which arrive and leave daily in a two-way stream, allowing virus to persist and accumulate over time, turning the markets into heavily contaminated sites. Operating LBM in a way that minimizes the risk of becoming infected is possible but requires a sophisticated veterinary system and highly motivated staff.

For all markets, there is a need for cleaning (and where possible disinfection) of materials that leave the market and may come into contact with poultry. The safe disposal of offal and other waste is also important. While many of the birds are destined for slaughter (and so pose less threat of onward spread), a significant number of birds are often bought either for production or to be eaten some time later at home, where other poultry may be present. The traders who move between producers and markets also represent a high risk of spreading infection via contaminated materials.

There is a range of obvious improvements that can be introduced, but all carry a cost, either direct or indirect, and some may fundamentally change the way market traders conduct their business. Because of this, some changes carry the risk of creating a parallel, hidden, unregulated marketing system which should be avoided at all costs.

Options

It is important that all stakeholders (market operators, stall holders, local authorities, veterinary services, traders, etc.) be involved in the development of a biosecurity plan for any LBM. There is a strong linkage between LBM and intermediaries and service providers, particularly poultry traders who buy poultry from producers to be sold in LBM.

The aim should be to create low risk trading at known licensed locations in a way that is affordable for the market authorities and traders. It is far preferable to adapt and regulate LBMs than to ban them on anything other than a temporary basis during an emergency. It should be possible to develop standard packages of improvements, but it will be important that these are applied in as uniform a manner as possible in order not to create different transaction costs in different locations and so push trade towards less biosecure markets. Redevelopment of markets may be an area where state support may be needed for the initial investment. It may be possible to recoup some or all of the cost through a cost-sharing approach involving the private sector, market operators and government.

Care should be taken that enforcement does not create a set of parallel unofficial mar-

kets, so the approach will need to be one of emphasizing the benefits to the traders using the markets (increased consumer confidence, lower losses due to disease, etc.) coupled with strong enforcement measures on illegal marketing.

In some countries, consumer attitudes may shift significantly towards an acceptance of chilled or fresh poultry, therefore allowing a shift away from LBM to centralized slaughtering. This would allow the replacement of the selling of live birds to consumers and a move from retail to wholesale markets.

Some interventions have been shown to be effective at decreasing the infection burden in LBMs. As a response to the outbreak of H5N1 in poultry and humans in 1997, changes were introduced in the management of LBMs in Hong Kong SAR. These consisted of banning certain species (quail, ducks and geese) from live sale, introducing a single day per month when markets were completely emptied and cleaned, and sourcing poultry only from known vaccinated flocks. The addition of a second day of closure led to a further (albeit statistically non-significant fall) in infection levels. None of these measures has completely prevented the virus from being present and circulating in the markets, but there has been a significant decrease.

Other interventions that merit consideration include changing the types of cage used so that they are fully cleanable (plastic or metal as opposed to wooden or other permeable materials) and regularly cleaned[11], using separate areas for different species, and demarcating cleaning points for vehicles and footwear both entering and leaving the market (particularly leaving).

Many LBMs lack basic infrastructure such as solid washable flooring, waste disposal systems, drainage, and reliable running water supplies. These sorts of minimum standards should be put in place.

Key issues and options

- Live-bird markets (LBMs) have been major contributors to H5N1 outbreaks, both as key mixing points and sources of disease spread; they have also been sources of human disease.
- Biocontainment of infection is vital at these sites.
- Biosecurity measures such as introducing rest days, limiting the species which can be sold at a market and the use of cleanable cages have been shown to have an impact on reducing the persistence of infection in LBMs.
- LBMs can play a positive role in the control of H5N1 HPAI by acting as places where information can be disseminated and gathered, and active surveillance for disease/virus can be carried out.
- Closing LBMs should be undertaken with care because it could create informal and unknown markets, worsening the disease situation.

[11] In some situations (e.g. in Nigeria), there may also be the possibility of using disposable transport cages made of local materials that are collected and burnt after a single use.

If disease is detected in a market, the sale of poultry at the market must be banned immediately until the source of infection is found and cleared. However, this must only be used as a short-term emergency response and clearly communicated as such from the start to prevent the setting up of covert markets. The focus should be on ensuring that traders, poultry producers and others who have contact with poultry leave the markets with clean footwear, vehicles and equipment.

LBM also offer a unique focal point for the dissemination of information to a wide range of actors in the production and marketing chain (especially poultry keepers and traders), and they are excellent places in which to collect disease intelligence. LBMs serve as key active monitoring points for early disease and/or virus detection in the area served by the market. They can act as trigger points for implementation of the highest possible level of biosecurity in the area served by the market and for intensive measures to detect disease in the same area.

INTERMEDIARIES AND SERVICE PROVIDERS

Issues

Because intermediaries and service providers can and do play a key role in the spread of disease, they need to follow biosecurity procedures. As importantly, they may be able to act as sources of advice and support for best practices because they are often more trusted than government officials. However, to date, insufficient attention has been paid to this group in either role.

Most intermediaries only keep poultry for short periods of time and therefore if a bird becomes infected while in their care it is sold before the full scale of the problem emerges. Therefore the direct incentive derived from implementation of biosecurity measures that is recognized by farmers is much weaker for intermediaries. However, all players in the sector are affected when major restrictions are applied to the trade in the event of a new outbreak.

Large-scale commercial farmers have the financial strength to refuse to trade with intermediaries and service providers if they do not satisfy their requirements. Small-scale producers, scavenging poultry keepers in particular, may be in a much weaker position to individually enforce biosecurity and may not be able to run the risk of losing services or markets by refusing to use intermediaries and service providers who may have an effective local monopoly. To some extent, they are at the mercy of the biosecurity levels practised by their intermediaries and service providers and of the intermediaries and service providers used by other poultry keepers in the same village.

Options

Working with intermediaries and service providers will require a participatory approach similar to that outlined for the keepers of scavenging poultry.

Intermediaries and service providers for small-scale commercial and scavenging poultry keepers have strong links with and are dependent on their local producers; this could provide a collective incentive to adopt biosecurity practices to protect their own business and that of their clients. It is important that intermediaries and service providers, particularly

Key issues and options

- Intermediaries and service providers have an interest in maintaining their own businesses and those with whom they work.
- They create links between different segments of the domestic poultry and captive bird sector, and constitute a key disease spread risk; they must implement adequate biosecurity measures.
- Intermediaries have contacts with many producers and are often trusted sources of information; they can therefore act as disseminators of biosecurity messages and advocates for biosecurity plans.
- There is a need to development appropriate and sustainable biosecurity measures to be applied by intermediaries, and to monitor their uptake and impact.
- Regulation of intermediaries may be appropriate and should be considered but may have negative consequences if not undertaken carefully.

those that go from site to site, be trained in and use appropriate biosecurity measures themselves. It is equally important that they be given the knowledge to advocate for and spread the use of basic biosecurity to poultry keepers.

Veterinarians and other animal health workers are an especially high risk group because they are asked to look at sick animals and so represent perhaps the highest risk of transmitting the disease to other households or commercial producers; they certainly have the greatest responsibility to ensure that they do not by observing strict and visible biosecurity measures. Specific messages for this group are justified and can be linked to technical information about the disease that they will need in order to be able to detect and report to the authorities.

Like all other intermediaries and service providers, transporters who specialize in moving poultry and poultry products have to be included in any biosecurity chain. Transporters should follow protocols for segregation (not entering farm premises unless necessary), cleaning and disinfection and they should follow the instructions of commercial farm operators.

Since slaughterhouse produce by-products such as feathers, internal organs and effluents that may be contaminated, slaughterhouse workers must ensure that these are treated in such as way as to deactivate the virus; for example, feathers can be heat treated, internal organs can be cooked or rendered and effluents can be mixed with disinfectants. Together with feed mills, slaughterhouses are also locations in which cleaning and disinfection of vehicles and equipment can take place to prevent and limit spread.

There may also be a need to introduce regulation of some intermediaries and service providers. Licensing of poultry traders might be possible in some situations, although it will be impractical in many others because of enforcement issues. In addition, it could run the risk of driving such traders underground.

POULTRY FANCIERS, KEEPERS OF FIGHTING COCKS, EXOTIC BIRDS AND BIRDS OF PREY

Issues

Compared with domestic poultry, these are all high value birds. For all these birds, compensation levels are unlikely to be set high enough to cover the cost of eventual replacement, and there is no easy source of replacement should they be lost or culled as part of an infected unit. This creates two contradictory pressures: one an incentive to invest in biosecurity, the other an incentive to attempt to evade control measures such as culling.

These birds are all moved from location to location as part of their function which makes biosecurity more difficult than for enclosed farmed birds. The high value of these birds also makes smuggling them over long distances an attractive proposition[12].

Options

Given the relatively low numbers of these birds (compared with overall numbers of poultry), there may be a strong rationale to vaccinate fighting cocks, birds of prey, pet birds and those in zoological collections. However, wherever possible, this should be combined with appropriate biosecurity measures. For birds of prey, the need for this has been recognized and designs for units that incorporate this are available. Again, the high value of these birds means that the financial costs of the measures are acceptable.

The trade in captured wild birds is large and difficult to regulate, and birds may become infected at any point from before capture to sale in markets. They should be regarded as an integral part of the domestic poultry and captive bird production and marketing chains and included in biosecurity measures for the sector. Ideally, they should never be sold in the same markets as live poultry. Veterinary authorities should act to ensure that this practice, where it exists, is phased out and replaced with separate systems and strong enforcement of this separation.

There are regions where poultry, particularly cockerels, are used for ritual and religious purposes by healers and priests. They should also be included in biosecurity measures, particularly with respect to the safe disposal of all body parts.

Key issues and options

- These bird keepers must be involved in any biosecurity programme.
- The trade in captured wild birds is large and difficult to regulate, and birds may become infected at any point from before capture to sale in markets. They should not be sold in the same markets as live domestic poultry.

[12] Domestic poultry are often moved across borders illegally but normally only across relatively porous land borders into neighbouring countries either because of price differentials or as a part of social human movements; they are rarely moved over long distances because of the high costs involved relative value of the birds.

HUNTERS

Issues

In many countries, wild birds have been implicated as the source of infection for domestic poultry with H5N1 HPAI but a direct link has rarely been established. However, hunting wild birds is practised worldwide and after preparation for eating, their remains (feathers, internal organs, meat scraps, etc.) could be a source of virus spread. These remains are commonly disposed of on the ground within the compound where they are eaten by dogs and cats, but also picked at by poultry. The internal organs of infected birds are known to carry high loads of virus and this may be a potent source of transfer of infection from wild birds to domestic poultry.

Options

Further field work is needed to identify how common this route of introducing infection from wild birds actually is.

Significant numbers of extension messages have been prepared, aimed at the hunting community and designed to protect humans from infection via hunted wild birds. To these messages should be added others on ways to protect domestic poultry.

It is also important that in addition to messages directed at hunters (mostly men), the same messages should be directed at their families and partners, who usually clean and prepare hunted birds for eating and therefore often have control over what is done with the remains of the bird.

Key issues and options

- Hunted wild birds have recently been found to have played a role in introducing virus into domestic poultry; this finding requires further examination through detailed outbreak investigation.
- Public awareness messages should be produced both for hunters and their women folk about this risk and how to avoid it.
- Awareness messages should focus on advising hunters that the remains (feathers and internal organs) of hunted wild birds should be disposed of by burning or burying; they should not be disposed of in the environment where they could act as sources of infection for domestic poultry.

Conclusions

H5N1 HPAI is a disease that is potentially highly susceptible to the application of biosecurity measures because it is highly dependent on the actions of people for its spread. Emphasis should be placed on biosecurity which has a proactive preventive impact and will enable producers to protect their flocks themselves.

Biosecurity is made up of three components: segregation, cleaning and disinfection. Segregation is the most important phase of biosecurity, even for large commercial units, because it removes the possibility of infection entering a unit. Cleaning will remove most contamination, with disinfection as the final stage to deactivate any remaining virus.

The attributes of different biosecurity measures must be analysed to try and understand which may be appropriate and have the greatest impact for which production system. Recommendations must be practical and sustainable from the point of view of the producers, intermediaries and service providers.

Some options for biosecurity are discussed and proposed in this document for each of the key parts of the poultry and captive bird sector. Veterinary, production system, socio-economics and communication expertise is required if practical and sustainable improvements in biosecurity are to be brought about in many of these, including small-scale commercial producers, scavenging poultry keepers, LBM, intermediaries and service providers.

In all of these it will be key to work with the stakeholders in a participatory process because success depends on making sure that those who will have to implement biosecurity accept the need and see the benefits of doing so. In particular, biosecurity for scavenging poultry is likely to require a community-based approach rather than recommendations for individual producers. It will be equally important to monitor uptake and impact of the measures.

It is proposed that action to achieve this can start with a programme of field-based work that is sufficiently funded to be able to cover countries, particularly from West Africa to Southeast Asia and with sufficient duration to see reliable results.

Annex 1
Reports

Country	Title	Authors	Date	Prepared for
General	Trends, issues and options in applying long term biosecurity measures on production systems and sector structure	Olaf THIEME	Jun 2007	FAO
Australia	Increasing awareness of avian influenza issues among small-flock poultry owners (Qualitative Research Report)	Blue Moon Consultancy	Mar 2007	Government of Australia
Bangladesh	A study on live-bird markets in Dhaka city and mixed (chicken and ducks) live-bird markets in peri-urban areas away from big cities	Bangladesh Centre for Communications Programmes (BCCP)	Dec 2007	FAO
Benin	Première évaluation de la structure et de l'importance du secteur avicole commercial et familial en Afrique de l'Ouest: Cas du Benin	Urbain FANOU	Apr 2006	FAO
Cambodia	Rural livelihoods and biosecurity of smallholder poultry producers and poultry value chain in Cambodia	Suon SENG, CEDAC	Jul 2007	FAO
Cambodia	The structure and importance of the commercial and village based poultry systems in Cambodia	VSF/ECTAD/AGAP	2005	FAO
Cambodia	Review of the poultry production and assessment of the socio-economic impact of the highly pathogenic avian influenza epidemic in Cambodia	Vétérinaires Sans Frontières-France	2005	FAO
Cambodia	Bridging the gap between HPAI "awareness" and practice in Cambodia	Benjamin HICKLER	Aug 2007	FAO
Cambodia	Evaluating poultry handling behavior among backyard poultry owners, their families and poultry market merchants: A cross-sectional survey of four geographic areas (a Knowledge, Attitudes and Practice survey)	Epidemiology Unit, Institut Pasteur du Cambodge, Phnom Penh, Cambodia	2007	UNICEF
Cameroon	Première evaluation du secteur avicole au Cameroun: Structure et importance du secteur avicole commercial et familial pour une meilleure compréhension de l'enjeu de l'influenza aviaire	Emil TELEU NGANDEU, Alexandre NGATCHOU	May 2006	FAO
Cameroon, Togo	Biosécurité dans les élevages avicoles à petite échelle: Analyse et conditions d'amélioration au Cameroun et au Togo	Charles E. BEBAY	Dec 2006	FAO
Cote d'Ivoire	Revue du secteur avicole: Côte d'Ivoire	Saliou KONE	Jun 2008 (draft)	FAO

Country	Title	Authors	Date	Prepared for
Cote d'Ivoire	Activités mises en œuvre pour l'amélioration de la biosécurité et la connaissance de la filière avicole dans le cadre de la lutte contre l'IAHP en Cote d'Ivoire	Cecile SQUARZONI	May 2008	FAO
Egypt	The structure and importance of the commercial and village based poultry in Egypt	Farid A. HOSNY	Nov 2006	FAO
Egypt	Interventions for improving biosecurity of small-scale poultry producers in Egypt	Paolo PAGANI, Walid Hamdy KILANI	Feb 2007	FAO
Egypt	Highly pathogenic avian influenza: A rapid assessment of the socio-economic impact on vulnerable households in Egypt	Ellen GEERLINGS	Jul 2007	FAO
Egypt	Avian influenza household survey: Knowledge, attitudes and practices of the Egyptian public	Fatma EL-ZANATY Noha EL-GHAZALY, El Zanaty and Associates	Jul 2007	UNICEF
Ethiopia	The structure, marketing and importance of the commercial and village poultry sector: an analysis of the poultry sector in Ethiopia	Solomon DEMEKE	2007	FAO
Ethiopia	Poultry biosecurity study in Ethiopia	Abebe WOSSENE	Apr 2006	FAO
Ethiopia	Review of the new features of the Ethiopian poultry sector: Biosecurity implications	Paolo PAGANI, Abede WOSSENE	Mar 2008	FAO
Ghana	The structure and importance of the commercial and village based poultry in Ghana	K.G. ANING	Aug 2006	FAO
India	The structure and importance of the commercial and village based poultry systems in India	Kornel DAS	Jun 2008	FAO
Indonesia	HPAI biosecurity for sector 3 chicken farmers in Bali: Final report, March 31 – June 6, 2008	The Indonesia International Rural & Agriculture Development Foundation (INI RADEF)	Jun 2008	FAO
Indonesia	Poultry market chain study in North Sumatra (OSRO/RAS/602/JPN)	Unit Bantuan Kemanusiaan Sahiva Usu	Nov 2007	FAO
Indonesia	The Bali poultry market chain	DENPASAR	2007	FAO
Indonesia	A review of free-ranging duck farming systems in Indonesia and assessment of their implication in the spreading of the highly pathogenic strain of avian influenza	Centre for Indonesian veterinary Analytical Studies (CIVAS)	2006	FAO
Indonesia	Study on livelihoods impacts of poultry ban in Jakarta 2007, Chapter V: CMP-HPAI impact on livelihood and associated gender issuese	ICASEPS	2008	FAO
Jordan	The structure and importance of the commercial and village based poultry systems in Jordan	Ibrahim ABU-ITELEH et al.	Mar 2007	FAO

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Kenya	The structure, marketing and importance of the commercial and village poultry sector: An analysis of the poultry sector in Kenya	Philip NYAGA	Jul 2007	FAO
Kenya	Biosecurity review and improved poultry husbandry systems for sectors 3 and 4 to prevent HPAI infection	Philip NYAGA	Sep 2007	FAO
KSA	The structure and importance of the commercial and village based poultry systems in the Kingdom of Saudi Arabia	Mohamed SHUAIB	Dec 2007	FAO
Laos	The impact of HPAI on the livelihoods of poultry producers in Laos: Implications for policy	Serge DOUSSAN-TOUSSE, Bea KEOVONGCHITH, Clémence PABION	Aug 2007	FAO
Laos	Involving communities in the surveillance and control of HPAI in Lao PDR - the role of village veterinary workers (impact of project implementation)	Dr. R. MONDRY	Apr 2008	FAO
Laos	Rapid review of the UNICEF-supported AI communications strategy	Serge DOUSSANTOUSSE & team	Mar 2007	UNICEF
Mali	Première évaluation de la structure et de l'importance du secteur avicole commercial et familial en Afrique de l'Ouest: Rapport du Mali	Adama TRAORE	Apr 2006	FAO
Morocco	The structure and importance of the commercial and village based poultry systems in the Kingdom of Saudi Arabia)	Ahmed BARKOK	Sep 2007	FAO
Mozambique	The epidemiology of poultry diseases, structure and importance of commercial and village based poultry industry in Mozambique	Filomena DOS ANJOS	Apr 2007	FAO
Myanmar	Knowledge – Attitudes – Practices (KAP) study on poultry-rearing and other practices pertaining to avian influenza	MMRD Research Services	Jun 2006	FAO/WHO/ UNICEF
Nigeria	The structure and importance of the commercial and village based poultry in Nigeria	D.F. ADENE ; A.E. OGUNTADE	Oct 2006	FAO
Nigeria	Active highly pathogenic avian influenza (HPAI) disease surveillance study in Nigeria		Mar 2008	FAO
SE Asia	Impact of avian influenza outbreaks in the poultry sectors of five Southeast Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam): Outbreak costs, responses and potential long-term control	Jonathan RUSHTON, Rommy VISCARRA, Emmanuelle GUERNE BLEICH and Anni MCLEOD		FAO
SE Asia	Flock size and HPAI risk in Cambodia, Thailand and Viet Nam	J. OTTE, D. PFEIFFER, R. SOARES MAGALHAES, S. BURGOS and D. ROLAND HOLST	2008	PPLPI/FAO
Senegal	Première évaluation de la structure et de l'importance du secteur avicole commercial et familial en Afrique de l'Ouest: Rapport du Sénégal	El Hadji TRAORE	2006	FAO

Country	Title	Authors	Date	Prepared for
Syria	The structure and importance of the commercial and village based poultry systems in Syria	Ahmad SUBUH	Feb 2007	FAO
Tanzania	The structure, marketing and importance of the commercial and village poultry sector: an analysis of the poultry sector in Tanzania	Halifa MSAMI	2007	FAO
Tanzania	Review of biosecurity in poultry production sectors 3 and 4 to prevent HPAI	Halifa MSAMI	2007	FAO
Togo	Première évaluation de la structure et de l'importance du secteur avicole commercial et familial en Afrique de l'Ouest: Rapport du Togo	Yawo Biova BADJE	2006	FAO
Tunisia	Revue du secteur avicole: Tunisie	Dr Riadh KARMA	Jun 2008	FAO
Turkey	Turkey: Poultry keeping systems, AI and biosecurity	Nedret DURUTAN and Cuneyt OKAN	2007	WB
Uganda	The structure and importance of the commercial and village based poultry in Uganda	Denis K. BYARUGABA	Sep 2007	FAO
Viet Nam	Review of free-range duck farming systems in Northern Viet Nam and assessment of their implication in the spreading of the highly pathogenic (H5N1) strain of avian influenza (HPAI)	VSF-CICDA	Mar 2006	FAO
Viet Nam	The economic impact of highly pathogenic avian influenza – Related biosecurity policies in the Vietnamese poultry sector	Agrifood Consulting International	Feb 2007	FAO
Viet Nam	Poultry sector restructuring in Viet Nam: Evaluation mission	Olaf THIEME, Phan VAN LUC, Carl Erik SCHOU LARSEN, Jan HINRICHS, Dea SCHIØDT SEEBERG, Le Thi MONG PHUONG, Brian BRANDENBURG, Pierre GERBER, Bui XUAN An, Nguyen Trung Thang		FAO/WB
Viet Nam	HPAI control measures and household incomes in Viet Nam	Joachim OTTE, David ROLAND-HOLST, Dirk PFEIFFER		PPLPI/FAO
Viet Nam	Temporal and spatial patterns of HPAI in Viet Nam	D.U. PFEIFFER, P.Q. MINH, V. MARTIN, M. EPPRECHT, and J. OTTE	2007	PPLPI/FAO

Country	Title	Authors	Date	Prepared for
Viet Nam	Duck farming systems and avian influenza in the Mekong delta of Viet Nam	Bui Xuan MEN	2007?	
Viet Nam	Improvement in biosecurity in semi-commercial chicken and duck farms in Nam Dinh and Phu Tho provinces in Viet Nam	Peter VAN BEEK	Feb 2007	FAO
Viet Nam	Improvement in biosecurity in semi-commercial poultry farms iin Viet Nam: Report of Mission 2	Peter VAN BEEK	Apr 2007	FAO
Viet Nam	Biosecurity checklist for sector 2 and 3 farms	Peter VAN BEEK	Apr 2007	FAO
Yemen	The structure and importance of the commercial and village based poultry systems in the Republic of Yemen	Jamil AL-MAMARI	Mar 2008	FAO

Annex 2
Manuals

Country	Title	Authors	Date	Prepared for
Australia	Code of practice for biosecurity in the egg industry	Tom GRIMES & Clive JENKINS	2001	Australian Egg Industry Association
New Zealand	Broiler growing biosecurity manual	Poultry Industry of New Zealand	Aug 2007	Poultry Industry of New Zealand
Canada	BC Poultry Biosecurity Reference Guide	BC Poultry Association Biosecurity Committee	Feb 2007	BC Poultry Association
Canada	BC Poultry Biosecurity Audit Procedural Manual	BC Poultry Association Biosecurity Committee	Mar 2007	BC Poultry Association
Canada	Illustrated biosecurity guide forRoutine entry and exit from livestock premises	CFIA	Aug 2002	CFIA
Viet Nam	Prevention and control of avian flu in small-scale poultry: A guide for veterinary paraprofessionals in Viet Nam	VSF-CICDA	Oct 2005	FAO / Govt of Vietnam
UK	Code of practice for the prevention and control of Salmonella in commercial egg laying flocks	DEFRA	2007	Defra
UK	Biosecurity and preventing disease – Peace of mind, a healthier flock and a more viable business	DEFRA	2005	Defra
UK	Biosecurity guidance to prevent the spread of animal diseases: biosecurity guidance on entering or leaving places where farm animals (including poultry) are kept or have been kept	DEFRA	Jul 2003	Defra
Latin America & Caribbean	Guide for the prevention and control of avian flu in small-scale poultry	FAO	2006	FAO
International	General guidelines for the application of compartmentalization (draft)	OIE	2008	OIE
International	Improvement of management and biosecurity practices in smallholder poultry producers	Ann DETMER & Anders PERMIN	Feb 2007	FAO
International	Stop the spread	WHO/OIE/FAO		WHO/OIE/FAO

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Highly pathogenic avian influenza, like any disease spread primarily through human activities, is susceptible to biosecurity control measures along the production and marketing chain. It is this that makes biosecurity such an important tool for the control and eradication of H5N1 HPAI. And, because it is human-mediated, the focus must be on changing the behaviours of people in such a way that the risk of disease transmission is decreased.

There is no technical barrier to biosecurity in theory, but its successful application requires understanding of the structure and problems of the poultry sector. *Biosecurity for Highly Pathogenic Avian Influenza: Issues and options* aims to set biosecurity in the context of the field situation and to propose options for its improvement.

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