# FAO Recommendations on the Prevention, Control and Eradication of Highly Pathogenic Avian Influenza (HPAI) in Asia (proposed with the support of the OIE)

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## EXECUTIVE SUMMARY

The on-going epidemic of Highly Pathogenic Avian Influenza (HPAI) in poultry in Asia is unprecedented in its geographical scope and rate of spread. HPAI viruses have continued to spread within the region, the report by Malaysia of infection with H5N1 HPAI in August 2004 bringing to 10 the total number of countries/regions that have been infected with an H5 HPAI. The epidemic has severely affected poultry production, with the death or destruction (culling) to date of at least 120 million birds, according to various government and media sources.

Estimates of the impact of HPAI in affected countries vary greatly, depending on the structure of the poultry sector, the speed of outbreak control and the method used to estimate the impact. World Bank estimates earlier this year suggested that the costs of the current outbreaks in Vietnam might have approached 1.8% of GDP. Estimates for Thailand suggest that the rate of growth of agricultural GDP may have halved during the outbreak year. The total cost of the 1997 outbreak in Hong Kong is said to have been hundreds of millions of dollars when the costs to international trade and tourism are included.

The impact of HPAI has been distributed within the entire poultry market chain, affecting producers, consumers and employees in the retail industry. Conversely, the impact on geographic regions has been uneven, with some local areas losing more than 50 per cent of their poultry. Various levels of assistance, in the form of compensation and credit, have been provided.

The epidemic also has an important public health dimension, with the death to date of at least 29 people, giving rise to serious concern about the potential for emergence of a pandemic strain of human influenza virus through reassortment of avian and, potentially, pig influenza viruses.

It is now clear that H5 HPAI viruses are endemic in parts of the region and that the existence of reservoirs of infection (in ducks and, potentially, wild birds and pigs) presents a serious challenge to eradication.

These factors highlight the necessity for countries infected with or threatened by HPAI viruses to implement appropriate measures for prevention and control. It is equally important that FAO and international organizations continue to collaborate with donors and affected countries in identifying and implementing strategies for recovery and rehabilitation of countries affected by HPAI.

This Position Paper presents the main scientific and technical issues and recommendations on prevention, control and eradication of HPAI, with a tabulated summary of FAO conclusions and recommendations in an annex to the Paper. They have been prepared with the contribution of several experts and government officials. The contribution of OIE experts and the recommendations of the OIE Terrestrial Code[1] are of particular importance. However, it is important to note that these Guidelines reflect the knowledge of HPAI in Asia today. As the disease epidemiology evolves and scientific knowledge and management tools become more comprehensive, management approaches may need to be modified. As such, these recommendations will be under continuous review.

[1] Terrestrial Animal Health Code 13th Edition OIE 2004

Control of H5N1 HPAI in Asia is a complex task, which can only be achieved by the cooperative effort of countries in the region. Surveillance for early diagnosis and reporting, particularly to the OIE, are key to success and must be optimized. FAO is working with international and regional organizations, such as OIE, WHO and ASEAN, and with individual countries to develop collaboration and to enhance HPAI diagnosis and surveillance in Asia via the formation of sub-regional Networks using harmonised methods and tools.

At a practical level, it is essential to reduce the amount of virus circulating in poultry and on farms. No single set of measures is appropriate to all countries and, consequently, multiple strategies are being used. These range from stamping out and eradication to control using vaccination. The measures chosen must be based upon good disease management principles and adapted according to the local situation. National authorities are responsible for deciding on and implementing strategies that are appropriate to the situation in the country, based on epidemiological (including farming and marketing systems), biological, economic, political and social factors.

It is also important to have a good understanding of the epidemiology and ecology of H5N1 viruses, especially the role played by potential reservoirs of infection or disseminating vectors, such as domestic waterfowl, live bird markets, wild birds and pigs. There are still many important epidemiological questions and FAO is working with international and regional organizations and research institutions to promote the conduct of required research.

Veterinary Authorities must consider several factors in choosing the most appropriate strategies for the control of HPAI. Endemically infected countries may adopt different strategies to those adopted by countries that are facing new and limited numbers of outbreaks or that are free of infection but at risk from infected neighbouring countries.

Control strategies must be based on knowledge of the major pathways of spread of the HPAI viruses, their persistence in the environment, susceptibility to inactivation, and the proven efficacy of vaccines to prevent infection and/or disease.

The main measures available to prevent, control and eradicate HPAI are:

- Effective disease surveillance for early detection and reporting of outbreaks
- Enhanced biosecurity of poultry farms and associated premises.
- Control of movement of birds and products that may contain virus, including controls at the interface of infected and uninfected areas.
- Changes to industry practices to reduce risk.
- Rapid, humane destruction of infected poultry and poultry at high risk of infection.
- Disposal of carcases and potentially infective material in a biosecure and environmentally acceptable manner.
- The proper use of vaccination.

All of these control measures reduce risk but none used in isolation is sufficient. All available measures must be considered as to feasibility and prospects of success of the approaches under consideration. In light of this assessment, which should be discussed by government with the private sector and other stakeholders, the best combination of measures may be determined.

When outbreaks of H5N1 or other HPAI viruses occur, immediate stamping out is the most appropriate and the first response of Veterinary Authorities and it is most likely to be sucessful when it is combined with movement controls, decontamination of infected premises and proper surveillance and monitoring.

FAO recommends the humane destruction of chickens by asphyxiation using carbon dioxide gas. Cervical dislocation using bovine castration forceps is preferable for domestic waterfowl. In addition to humane treatment, it is important to prevent inadvertant spread of virus and to avoid risks to human health and safety when killing birds.

Stamping out must be accompanied by movement control, proper disposal of carcases and other potentially infective material, and cleaning/disinfection of affected farms and associated premises. Stamping out may involve the destruction of poultry in a defined radius around the infected premises (recommendations of international organizations and individual countries vary from 1 km to more than 10 km) and/or of poultry in 'at risk' farms. If stamping out is used, farmers should be compensated in some form (direct or indirect) for loss of stock

Live bird markets can act as reservoirs of infection from which HPAI viruses can spread to farms. FAO recommends the temporary closure of live bird markets in areas affected by outbreaks of HPAI. It may also be necessary to introduce measures such as rest days and specific cleaning and disinfection to manage the risk of spread and maintenance of HPAI viruses via live bird markets.

Veterinary authorities should critically review industry practices (e.g. poultry production, transportation and marketing) in infected and "at risk" countries and compartments to assess how they might be modified to reduce risk. Systems that involve production, transport and marketing of different species of poultry together, particularly chickens with waterfowl, and systems that combine production of pigs and poultry on the same farm are not recommended.

Pigs that are reared on premises where poultry are found to be infected with HPAI should be subject to official veterinary inspection. Pigs with clinical disease suggestive of influenza should be destroyed and samples submitted for laboratory diagnosis. Otherwise, samples from normal pigs on these farms should be submitted to the laboratory for testing to rule out the possibility of sub-clinical infection with H5N1 HPAI. If active infection is confirmed in any of these pigs the herd should be destroyed

All decisions, whether simple in concept (e.g. requiring that poultry cages and other equipment are constructed with 'easy to clean' materials) or more complex, should be the subject of prior consultation with industry and other stakeholders.

Controls on the movement of birds/products between countries should be based on OIE recommendations, which provide the basis for safe international trade in the least trade restrictive manner. Veterinary authorities should consider the possibility of "leakage" across borders and control points when developing disease control and prevention strategies.

In countries/compartments that have reservoirs of HPAI viruses in wild birds or domestic waterfowl, control measures must focus on preventing these viruses from entering the domestic chicken population. FAO recommends against the destruction of wild birds or their habitat. Rather, farm biosecurity must be enhanced.

FAO has defined four poultry production systems according to the level of biosecurity and the marketing of birds and products. While it is feasible to tighten biosecurity on commercial poultry farms, this may be more difficult, or impossible, in the case of non-commercial enterprises, such as back-yard production systems, particularly where flocks forage outdoors. In tightening biosecurity, the possible spread of HPAI viruses via the activities and movement of personnel should not be overlooked. If there is active infection with HPAI in backyard poultry farms in neighbouring villages and/or evidence of infection in wild birds, Veterinary Authorities should consider establishing 'poultry-free zones' around commercial farms.

Consistent with the Recommendations of FAO/OIE/WHO conferences held in Bangkok and Rome, in February 2004, vaccination can be used as a tool to support eradication or to control disease due to HPAI and to reduce the viral load in the environment. In situations where it may not be feasible or desirable to proceed with massive culling and in situations of high viral challenge, targeted vaccination may be the most appropriate means of 'dampening down' an HPAI outbreak. In the situation where farm/village/backyard biosecurity cannot be improved and there is significant challenge from HPAI viruses, including infection in neighbouring villages, wild birds, domestic ducks or bordering countries, Veterinary Authorities should consider vaccination strategies to minimize propagation by this sector, to protect susceptible birds from infection and to manage human health risks.

Three broad vaccination strategies may be described:

i) vaccination in response to an outbreak – which may involve vaccination around an infected area (ring vaccination) or vaccination of only designated, high-risk poultry (which may include village chickens) in combination with destruction of infected poultry. The objective is to minimize virus amplification and transmission to eradicate infection as quickly as possible.

ii) vaccination in response to a defined 'trigger'
Early warning of a viral incursion may be provided via targeted surveillance of high-risk birds (e.g. unexpected mortalities in domestic waterfowl, wild birds or poultry in live bird markets). This may trigger the use of prophylactic vaccination to prevent cases of infection in domestic poultry (which may include village chickens).

iii) "baseline" vaccination
Pre-emptive "baseline" vaccination of all or part of a population of poultry may be used if the risk of infection is high and/or the consequences of infection are very serious. This approach might be considered to protect valued genetic material; to safely restock village chickens after stamping out; to safeguard zoological collections; or to protect long-lived chickens, such as commercial layer and breeder flocks, in areas subject to high viral challenge (e.g. due to infected waterfowl or insecure borders with infected countries)

When performing emergency vaccination, chickens of all ages must be vaccinated. Up to 2 weeks is required for the development of flock immunity to a sufficient level to protect the majority of the chickens.

Inactivated vaccines produced in accordance with OIE guidelines are currently available and approved by Veterinary Authorities in many countries, and FAO recommends their use. A live recombinant fowlpox with H5 AI gene insert has been used in a few countries but most other countries have not yet licenced this vaccine for unrestricted use and it is currently under review by the OIE.

Research must continue with the goal of developing and validating new vaccines that can be administered via food or water; that are effective in ducks and other poultry species; and that better facilitate the application of DIVA ('differentiating infected from vaccinated animal') strategies.

In all vaccination campaigns, FAO recommends the implementation of surveillance systems that measure the response to vaccination and are capable of detecting the presence of field virus in clinically normal vaccinated poultry. The latter objective may be satisfied using a DIVA strategy and/or the placement of identified sentinel (unvaccinated) chickens.

Vaccination should not be considered as a permanent measure. The need for vaccination should be reviewed regularly and an exit strategy developed, even if vaccination is not likely to be halted for several years.

In the case of countries that export poultry products, the most favourable status is country freedom from avian influenza. Countries that become infected usually lose their export markets and should take steps to regain their former trading status as quickly as possible. The OIE Terrestrial Animal Health Code (hereafter referred to as the OIE Terrestrial Code) chapter on Avian Influenza provides more specific guidance on the requirements to be satisfied by countries experiencing an outbreak of notifiable avian influenza[2]. In the event of new outbreaks, the first approach will be to stamp out infection. It is important to mention that the use of vaccine does not imply automatic loss of export markets[3], subject to full compliance with OIE recommendations, particularly those concerning the strict application of active surveillance to provide the necessary assurances that notifiable AI viruses are not circulating in any country/zone/compartment[4] from which export is proposed or occurring.

Official Veterinary Services are key players in the definition and implementation of control strategies and their extent and efficiency have a major bearing on the capacity of countries to deal with HPAI. There must be a strong chain of command and scientific capabilities and infrastructure related to disease diagnosis, surveillance, data analysis, reporting, and disease control must be continually reinforced and augmented. The Official Veterinary Services must work closely with partners in industry, the private sector, the veterinary profession and other stakeholders, particularly when implementing disease control measures that will have a major impact on producers and consumers of poultry products.

The initial alert to a possible disease outbreak normally originates from veterinarians or animal health workers in the field. It is important to develop sustainable information networks at the grassroots level and to implement systems that provide for the clear and timely transmission of disease intelligence from the field to headquarters i.e. 'bottom-up'. It is also

[2] In the OIE Terrestrial Code Article 2.7.12.5 notifiable avian influenza is defined as an infection of poultry caused by any influenza A virus of the H5 or H7 subtypes or by any AI virus with an intravenous pathogenicity index (IVPI) greater than 1.2 (or as an alternative at least 75% mortality) as described elsewhere in the Code.

[3] The OIE Terrestrial Code Articles 2.7.12.1 to 2.7.12.4 are enforceable. Countries are considered free or infected based on the absence or presence of infection, irrespective of whether vaccination has been carried out. Articles 2.7.12.5 to 2.7.12.29 are under study, awaiting additional information on surveillance and the risk posed by various commodities, and should not therefore be considered as finalised recommendations to be applied by Member Countries at this time.

[4] The term compartment is defined and the application of compartmentalization discussed in the OIE Terrestrial Code, Chapter 1.1.1 Article 1 and Chapter 1.3.5 Articles 1, 2 and 3.

important to facilitate the flow of information 'top-down', so that decisions and requirements made by headquarters are clearly and quickly transmitted to those who must implement them in the field.

Official Veterinary Services must prepare and exercise contingency plans and operating procedures for managing outbreaks of transboundary animal diseases, including, specifically, HPAI. Plans must be updated regularly in response to developments in scientific knowledge and the recommendations of international organizations.

Economic, political and social issues have a significant impact on the choice and implementation of disease prevention, control and eradication strategies. Analysis of the costs and benefits of different approaches supports informed choice of control strategies, because it can provide guidance on whether a proposed strategy is economically viable, the potential source of finance, the risks of non compliance with regulations and the best means to provide exit strategies for producers and processors who cannot afford to comply with more stringent measures. It is important that such an analysis take account of indirect as well as direct impacts on a wide range of stakeholders.

Veterinary Authorities must take into account the recommendations of WHO and national public health organizations when implementing strategies for the prevention, control and eradication of HPAI infection.

All virus isolates should be made available to OIE/FAO and WHO reference laboratories for antigenic and genetic analyses to provide for early detection of new strains and antigenic variants.

In conclusion, the current HPAI epidemic in Asia is a crisis of global importance and it will continue to demand the attention of international and regional organizations, donor countries, and countries in the region for some time to come. The establishment of endemic infection with H5N1 HPAI viruses in some parts of the region, and the apparent development of reservoirs of infection (in ducks and, potentially, wild birds and pigs) means that the eradication of these viruses needs a sustained long term management response. This will require major investments to strengthen Veterinary Services, in particular their capacities for surveillance and early warning, detection, reporting and response and for the rehabilitation and restructuring of the poultry sector.

It is not possible to prescribe an approach that will suit each country and it has to be clearly stated that it is the government's responsibility to define its national strategy, according to the biological, epidemiological, economic, political and social factors that pertain to their situation. Veterinary Authorities should consider the principles described in this paper for possible application to the situation and should implement the suite of measures that is most appropriate to the local conditions.

There is considerable scope for research to better understand the epidemiology of HPAI in Asia, particularly the role and significance of reservoirs of infection for disease eradication, for the management of public health risks and for the development of better vaccines.

FAO will continue to collaborate with international and regional organizations, countries, the private sector, the veterinary profession and the research community to improve capacities for

prevention, control and eradication of HPAI and to support recovery and rehabilitation in the region.

## FOREWORD

This report contains the recommendations of the Food and Agriculture Organization of the United Nations (FAO) in support of the efforts to control highly pathogenic avian influenza (HPAI) in several Asian countries. It is based on peer reviewed papers on the current knowledge of influenza viruses in general and avian influenza (AI) viruses in particular; on reports of consultants that have worked with countries affected by the currently circulating HPAI viruses under FAO's national and regional technical cooperation programme (TCP); on the results of expert meetings between government officials and experts in disease management, laboratory diagnosis, epidemiological and economic assessments; and on several comprehensive studies of the poultry sector in Asia.

FAO wishes to acknowledge the important contribution of the World Organisation for Animal Health (Office International des Épizooties (OIE) Headquarters officials and that the experts of the OIE Reference Laboratories and Collaborating Centres.

This document expresses views that are supported by the OIE. It makes frequent reference to recommendations of OIE and those of the World Health Organisation (WHO). Both OIE and WHO are key partners of FAO in the effort to prevent further disease spread and to protect the human population. The combined efforts of these international organizations are aimed at the control and eradication of HPAI by decreasing and eventually eliminating the viral load in the environment, assuring the use of proper standards and procedures for diagnostic testing, application of high quality vaccine products, and protection against occupational hazards in the implementation of programs.

Recommendations of FAO/OIE/WHO conferences held in Bangkok and Rome, in February 2004 are still relevant and applicable. The document[5] "Guiding Principles for HPAI Surveillance and Diagnostic Networks in Asia" (conclusions of the FAO Expert Meeting, 21-23 July 2004, Bangkok) should be read in conjunction with this report, as it presents minimum requirements for diagnosis and surveillance, which, along with improved biosecurity, are key elements in prevention, control and eradication.

The FAO recommendations present a minimum approach for consideration by national authorities. Each government is responsible for defining a national strategy according to the biological, epidemiological, economic, political and social factors relevant to the country. These recommendations represent 'best practice' and it is recognized that some countries may need external assistance to implement such practice. Eradication of the currently circulating H5N1 virus is the ultimate goal of all efforts. Improved capacity for early detection and rapid response is equally important, so that countries are better placed to deal with future epidemics of HPAI or other transboundary animal diseases.

FAO recognizes that several important studies remain to be completed, particularly in regard to the understanding of the molecular basis for viral virulence, to knowledge of the ecology of the infection in its avian and mammalian hosts, including pigs, and experience with the poultry production and marketing systems used in Asia and how these systems influence disease spread..

[5] The "Guiding Principles" may be viewed at http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/Guiding%20principles.pdf

As the epidemiology of AI viruses in Asia evolves and scientific knowledge and management tools become more comprehensive, it may be necessary to modify approaches to the prevention and control of HPAI. Surveillance must be strengthened and data analysis augmented with molecular epidemiology studies, to ensure that changes in disease epidemiology and local conditions are reflected by appropriate adjustments to veterinary control strategies. As such, these recommendations will be under continuous review.

FAO is very grateful to all the people who contributed to this report.

Animal Health Service
Animal Production and Health Division
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## 1. INTRODUCTION

Avian influenza (AI) is a serious disease in poultry, resulting in severe mortality in chickens and major disruption to production and trade. In recent years, the potential for AI to cause human disease and death and the emergence of a major pandemic has increased official concerns about these viruses.

AI is caused by a range of influenza Type A viruses, including high and low pathogenicity strains. In Asia, H5N1 HPAI viruses are currently the most significant and first emerged in the Peoples Republic of China (PRC) in 1996. Infection with these viruses has continued to occur since then, with outbreaks reported from Hong Kong in 1997, 2001, 2002 and 2003.

Highly pathogenic avian influenza (HPAI) in most cases due to viruses of the H5N1 strain is known to have been present in several Asian countries, including Cambodia, Indonesia, Japan, Republic of Korea, Lao PDR, PRC, Taiwan Province of China (H5N2), Thailand and Viet Nam, since 2003.

In June-July 2004, PRC, Thailand and Viet Nam reported cases in poultry.

In August 2004 Malaysia reported its first case of H5N1 HPAI in poultry, PRC reported isolations of H5N1 viruses from pigs that had been sampled in 2001 and 2003, and Viet Nam reported 3 fatal human cases of infection with H5N1 HPAI.

In September Malaysia reported several outbreaks of H5N1 HPAI near the border with Thailand and Indonesia, Cambodia, Thailand and Viet Nam reported new cases of infection in various poultry species. Thailand also reported additional human mortalities due to H5N1 infection.

Since 2004, there has been an increased awareness of the potential for H5N1 infection of pigs. The significance of this finding for disease management and public health is currently under investigation. FAO recommends acceleration and intensification of these investigations.

In regions/countries where HPAI occurs, the overall objective, even if a long term one, should be eradication of the virus and recovery of the poultry sector. However, the strategy to be employed can only be decided once the epidemiology of the disease and the ecology of the virus are fully understood. Of particular importance are the role of potential reservoirs of infection and the structure and modes of operation of the poultry industry in the affected area. At present, many important questions relating to the epidemiology of H5N1 HPAI remain unanswered, such as whether there is a permanent reservoir of highly pathogenic viruses in wild birds and the role played by domestic waterfowl and pigs in the maintenance and spread of these viruses. Better assessment of the economic and social impacts of HPAI and of possible approaches to restructuring of the producing sectors are also needed. FAO recommends acceleration and intensification of these investigations.

Multiple strategies are being used to control H5N1 HPAI viruses in Asia, ranging from stamping out[6] and eradication[7] to control using vaccination.

[6] Stamping out – the destruction of poultry on infected farms or farms in close proximity to infected farms so as to control the spread and possibly eliminate a pathogen.

This paper examines the various control strategies that have been and could be implemented for these viruses. It has been prepared with the input of several experts and government officials. The contribution of OIE experts and the recommendations of the OIE Terrestrial Code (see footnote 1) are of particular importance. It reviews the factors that should be taken into account in planning and implementing control strategies (including biological, epidemiological, economical, political and social issues, farming systems, and public health implications) and explains how countries, parts of countries (regions/zones) or compartments can adopt a strategy appropriate to their individual situation. No single set of measures is appropriate to all countries, parts of countries (regions/zones) or compartments. Rather, each government is responsible for defining a national strategy according to the biological, epidemiological, economic, political and social factors relevant to the country. Nonetheless, many of the measures discussed herein are key elements in any control programme.

## 2 FACTORS TO CONSIDER IN DETERMINING THE APPROPRIATE STRATEGY FOR CONTROL

The strategies chosen by veterinary authorities to control HPAI in compartments, countries or regions are determined by a number of factors, to be considered in light of the particular situation of the country, region or compartment.

In the OIE Terrestrial Code (see footnote 4), a compartment is defined as ‘one or more establishments under a common biosecurity management system containing an animal subpopulation with a distinct health status with respect to a specific disease or specific diseases for which required surveillance, control and biodiversity (sic) measures have been applied for the purpose of international trade.’ The requirements necessary to establish and maintain the distinct health status of a zone or compartment must be appropriate to the disease, based on its epidemiology, environmental factors, control measures and surveillance.

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The OIE Terrestrial Code defines a ***Stamping-out policy*** as carrying out under the authority of the Veterinary Administration, on confirmation of a disease, the killing of the animals which are affected and those suspected of being affected in the herd and, where appropriate, those in other herds which have been exposed to infection by direct animal to animal contact, or by indirect contact of a kind likely to cause the transmission of the causal pathogen. All susceptible animals, vaccinated or unvaccinated, on an infected premises should be killed and their carcasses destroyed by burning or burial, or by any other method which will eliminate the spread of infection through the carcasses or products of the animals killed.

This policy should be accompanied by the cleansing and disinfection procedures defined in the OIE Terrestrial Code.

The term ***modified stamping-out policy*** should be used in communications to the OIE whenever the above animal health measures are not implemented in full and details of the modifications should be given.

[7] The OIE Terrestrial Code defines ‘eradication’ as the elimination of a pathogenic agent from a country or zone.

## 2.1 The level of infection

Countries and compartments in Asia range from being free from these viruses to being endemically infected. Endemically infected places include those with reservoirs of infection that either cannot be eliminated (e.g. infected wild waterfowl) or can only be eliminated by changing the farming system significantly. Farming systems such as outdoor production of ducks on ponds present a high likelihood of establishing and maintaining reservoirs of infection.

Vaccination is more appropriately used in countries or compartments with endemic infection than those where the virus does not occur. However, the likelihood of infection occurring (e.g. the threat from neighbouring countries/compartments that are infected) must also be taken into account.

## 2.2 The presence of wildlife reservoirs

Surveys of wild birds worldwide have demonstrated the presence of AI viruses of all known H and N subtypes in apparently normal free-ranging avian species, including species that follow global patterns of seasonal migration. In a three-year Canadian study, Hinshaw et. al. (1980) isolated influenza viruses from 26% of waterfowl tested, with 60% of birds excreting virus in their first year.

Until recently, HPAI viruses had been isolated rarely from wild birds. Such reporting is limited to an outbreak of disease associated with a H5N3 HPAI virus in South Africa in 1961, which resulted in the death of some 1300 wild common terns, and single isolations of HPAI viruses H7N1 in finch (Germany), H7N7 in a gull (Germany), H7N3 in a Peregrine Falcon, and a single isolate of an H7N1 virus in Italy.

In contrast, the recent outbreaks of H5N1 HPAI in Asia have resulted in clinical disease and death in a wide range of non-domesticated avian species in the wild and in zoological collections.

Infected dead wild birds (excluding those in zoological collections) include crows, a peregrine falcon, a Little Egret, Grey herons, a Black-headed gull, a sparrow, open-billed storks and a pigeon. However, these have been individual cases without the massive die-offs as seen in terns in South Africa in 1961.

Samples collected from clinically normal birds in the wild have not yet yielded any H5N1 viruses.

Experimentally, many avian species can be infected with H5N1 viruses and and in some cases these birds develop disease. Susceptibility varies with species and with the strain of virus. Infection with H5N1 HPAI does not necessarily cause clinical disease. However, Sturm-Ramirez et al. (2004) reported that, in late 2002, outbreaks of H5N1 HPAI virus caused deaths in wild migratory birds and resident waterfowl, including ducks, in two Hong Kong parks. These authors also showed that H5N1 isolates from 1997 and 2001 were not consistently transmitted efficiently among ducks and did not cause significant disease. Some experimentally infected mallards excreted virus for at least 5 days post infection without showing signs of clinical disease.

Epidemiological studies suggest that, in some cases, wild birds are likely to have played a role in the transmission of H5N1 viruses to domestic poultry. This is based largely on circumstantial evidence and the low probability of other sources of infection.

Based on the detection of H5N1 viruses in wild birds, the capacity of some species to carry these viruses, albeit for a short period and the epidemiological evidence, wild birds should be considered one of the potential reservoirs of infection. However the extent of infection in this reservoir and the range of species involved are not known.

Identification of H5N1 in wild birds has caused some veterinary authorities to contemplate taking action to reduce the population of wild birds in areas adjacent to commercial poultry farms. Efforts to destroy wild birds or their habitat are likely to result in dispersal of the population and to have little effect on risk or the course of HPAI infection in commercial poultry. Rather, authorities should take action to limit the exposure of farmed chickens and other poultry to wild birds by improving the biosecurity of farming enterprises. Where exposure cannot be limited, e.g. production sector 3 and 4, (see explanation below) and there is evidence of a high level of HPAI in wild birds, vaccination against H5N1 should be considered.

2.3 Farming and marketing systems

Farm management and marketing systems influence the probability of poultry being challenged (and becoming infected) with H5N1 HPAI.

Based on farm biosecurity and the system used to market products, FAO has broadly defined the following production sectors:

*Sector 1*: Industrial integrated system with high level biosecurity and birds/products marketed commercially (e.g. farms that are part of an integrated broiler production enterprise with clearly defined and implemented standard operating procedures for biosecurity).

*Sector 2*: Commercial poultry production system with moderate to high biosecurity and birds/products usually marketed commercially (e.g. farms with birds kept indoors continuously; strictly preventing contact with other poultry or wildlife).

*Sector 3*: Commercial poultry production system with low to minimal biosecurity and birds/products usually entering live bird markets (e.g. a caged layer farm with birds in open sheds; a farm with poultry spending time outside the shed; a farm producing chickens and waterfowl).

*Sector 4*: Village or backyard production with minimal biosecurity and birds/products consumed locally.

The probability of infection is higher in production sectors 3 and 4 than in sectors 1 and 2. However, if the virus does enter farms in sectors 1 and 2, infection may have a greater impact due to the concentration of susceptible poultry in these farms.

Live poultry markets are important sites for multiplication of AI viruses. HPAI viruses have been isolated from live bird markets with, and without, evidence of clinical disease. Infection

can spread from these markets to farms via the movement of contaminated people, poultry, cages and transport equipment.

Egg marketing practices can also lead to the spread of AI viruses. Contaminated egg flats that are recycled without disinfection can also spread the virus.

The epidemiological implications of pigs as hosts of HPAI viruses remain to be fully investigated. However, it has been suggested that farms that include poultry (especially ducks) and pigs appear to present a greater likelihood of pigs becoming infected with AI viruses and for reassortment events to occur in the pig.

### 2.4 Likelihood of infection or re-infection in countries or compartments

Countries or compartments bordering infected places often adopt different measures for control and prevention of HPAI than those without infected contiguous neighbours. Island nations that are free of infection will focus on the control of legal and illegal entry of poultry and poultry products via ports, because the likelihood of geographical spread is less than for countries that are contiguous with infected countries. The presence of infection in wildlife reservoirs, which are not affected by border controls, increases the risk of infection spreading from one country/compartment to another.

### 2.5 Involvement in international trade (also see section 5.7)

For countries or compartments that are involved in international trade in poultry or poultry products, infection with HPAI may result in severe economic losses due to closure of export markets. These countries and compartments have a strong financial interest to eliminate the virus as quickly as possible and regain their export markets. Surveillance during and after the outbreak is important to demonstrate that the infection has been eradicated and virus is no longer circulating in the country or compartment of interest.

Countries with significant export markets usually restrict the use of vaccine to regions or compartments that are not directly involved in export. In fact, the use of vaccine does not imply the automatic loss of export markets (see footnote 3). Strict application of the compartmentalisation concept (see footnote 4) and the DIVA (Differentiating Infected from Vaccinated Animals) strategy may enable earlier resumption of export, based on acceptance by the importing country of surveillance results confirming that there is no field virus circulating in vaccinated flocks.

As discussed in the OIE Terrestrial Code, Chapter 1.3.5, when an exporting country has defined a zone or compartment, based on implementation of the measures stipulated in the Code, an importing country should recognise the existence of this zone or compartment and accept the application of the appropriate measures with regard to the importation, or transit through its territory, of commodities from the zone or compartment. Importing countries may require evidence of the application of measures for control, compartmentalisation etc, based on reports of surveillance for viral activity in vaccinated and unvaccinated compartments.

### 2.6 Animal Health Infrastructure

The Animal Health Infrastructure comprises the Official Veterinary Services, which have the mandate to deal with transboundary animal diseases via central and field services, the

diagnostic laboratory infrastructure and the broader stakeholder group, including industry, private sector veterinarians, district/village animal health workers and smallholders).

Official Veterinary Services are key players in this process. There must be a strong chain of command and scientific capabilities and infrastructure related to disease diagnosis, surveillance, data analysis, reporting, and disease control must be continually reinforced and augmented. The Official Veterinary Services must work closely with partners in industry, the private sector, the veterinary profession and other stakeholders, particularly when implementing disease control measures that will have a major impact on producers and consumers of poultry products.

As stated elsewhere, surveillance is important to HPAI preparedness and management. HPAI must be reportable, meaning that veterinarians, laboratories and farmers have a legal responsibility to report cases or suspected cases of disease.

In Asia the involvement of non-veterinary animal health workers is particularly important to baseline surveillance for disease outbreaks in livestock and poultry, because official and private sector veterinarians are not always able to deliver veterinary services directly to producers throughout the country. As in other parts of the world, producers, including smallhoders, can also make a significant contribution to surveillance. Veterinary authorities must implement disease awareness programmes that clearly explain the reasons for reporting disease and the consequences for those reporting. The content and presentation of this message must be appropriately structured for diverse audiences, including veterinarians, farmers, animal health workers and the general public.

### 2.7 Economic, Political and Social issues

Economic, political and social issues have a significant impact on the choice and implementation of disease prevention, control and eradication strategies. Analysis of the costs and benefits of different approaches supports informed choice of control strategies, because it can provide guidance on whether a proposed strategy is economically viable, the potential source of finance, the risks of non compliance with regulations and the best means to provide exit strategies for producers and processors who cannot afford to comply with more stringent measures. It is important that such an analysis take account of indirect as well as direct impacts on a wide range of stakeholders.

### 2.8 Public health issues

H5N1 HPAI is a zoonotic disease. Humans may be infected via close contact with infected birds and by working in an environment that is heavily contaminated with HPAI viruses (e.g. people working in the slaughter of infected poultry or clean-up of infected premises). Infection has not been transmitted via handling or consumption of poultry products (meat and eggs). H5N1 virus (several different strains) has been shown in meat and eggs in experimentally inoculated chickens and ducks, but neither handling nor consuming products was associated with human infections in Hong Kong in 1997. Although there is no evidence of sustained transmission of this virus between people, public health authorities have expressed concerns that an H5N1 and other HPAI viruses might acquire the ability to transmit more readily from human to human, potentially leading to emergence of a human influenza pandemic.

As a result, WHO has recommended that urgent measures be implemented to reduce and eliminate the cycling of influenza viruses in poultry.

WHO and relevant national human health authorities should be consulted on strategies that are implemented by veterinary authorities to protect public health in responding to HPAI.

## 3. ECONOMIC, POLITICAL AND SOCIAL ISSUES

Estimates of the impact of HPAI in affected countries vary greatly, depending on the structure of the poultry sector, the speed of outbreak control and the method used to estimate the impact. In the USA, two previous outbreaks of avian influenza are estimated to have cost respectively US$65 and US$140 million for disease control and loss of poultry. World Bank estimates earlier this year suggested that the costs of the current outbreaks in Vietnam might amount to between 0.3% and 1.8% of GDP depending on the length of the outbreak, the severity of culling of poultry and the spillover effect on tourism. Estimates for Thailand suggest that the rate of growth of agricultural GDP may have halved during the outbreak year. The total cost of the 1997 outbreak in Hong Kong is said to have been hundreds of millions of dollars when the costs to international trade and tourism are included.

The impact of HPAI has been distributed within the entire poultry market chain, affecting producers, consumers and employees in the retail industry. Conversely, the impact on geographic regions has been uneven, with some local areas losing more than 50% of their poultry. Various levels of assistance, in the form of compensation and credit, have been provided.

This section is divided into two parts. In the first we consider economic appraisal, focussing on elements of a control strategy that can be included within an economic evaluation. In the second part we cover human issues that are important when planning a control strategy but harder to value.

### 3.1 Reasons for economic appraisal

Economic appraisal carried out during the design of an HPAI strategy provides guidance on the cost of proposed control measures to different stakeholders compared to the benefits that they may expect to see from an effectively implemented control programme.

From a policy perspective, an appraisal can suggest:

**Whether a proposed strategy is viable in economic terms.**
Do the expected benefits exceed the expected costs?

**From what sources it might be financed.**
Those who benefit most might reasonably be expected to contribute most. However, the method of contribution (e.g. payment at point of service, direct or indirect taxation) needs to be designed to make financing efficient.

**Potential risks of non compliance.**
Those who do not expect to benefit or find it hard to pay for new biosecurity measures may be less inclined to comply with regulations.

**Equity issues and the need for exit strategies.**
If a proposed strategy is expected to reduce market access for some players, it may be necessary to provide them with assistance to move to alternative sources of livelihood

The challenges in producing an accurate and meaningful economic analysis are summarised in the following sections.

## 3.2 Estimating benefits of control strategies

Benefits are created when a change in system creates increased output value, reduced costs or a combination of the two. The benefits of an effective HPAI control strategy are those provided by a considerably reduced risk of disease outbreaks.

**a) Increased income and food security**.
HPAI outbreaks cause loss of birds through mortality and culling. They also disrupt markets, affecting demand for poultry products and prices, and they may destabilise employment and income for those in commercial poultry production, processing or retailing. In extreme cases, they impact negatively on the tourist industry.

For rural small holders, poultry farming generates important income from the sale of birds and eggs. Chickens can provide immediate cash when crops fail, or a family member needs medication. Losing the whole flock greatly reduces the family's flexibility to face risks. Small commercial producers may have invested much to create a more business oriented poultry enterprise. If they lose the whole flock, they have lost a major investment and may have incurred debts. It may be very difficult for them begin production again.

When humans die from disease, there may be an associated long term income loss for their families. Human life has a productive as well as a social value.

If, by removing the risk of disease, poultry markets and associated industries can return to their former state, the benefit of a control strategy is equivalent to the losses avoided by preventing future outbreaks. There are data and models that allow this calculation to be made for some countries. Losses to the Vietnamese poultry industry, and direct and indirect effects on the Thai economy from the outbreaks in early 2004 have been estimated.

If, however, the management practices required to improve biosecurity results in a change in the type or level of production in a country or for a particular sector of the poultry industry, then we cannot assume that the value generated from the industry will return to an "as before" state. It may be the same, less or more, and this needs careful estimation.

Scenario 1: a country with a large proportion of sector 3 and 4 producers, operating in market chains that supply domestic consumers, and a small number of sector 1 producers that focus on export and are effectively separate from other sectors. In this scenario, the concept of compartmentalisation (see footnote 4) may offer benefits. This approach could enable the sector 1 producers to regain their small export market, and gradually restock other sectors. Over time, income from poultry could return to pre-outbreak levels. Estimation of benefits in such a situation could be fairly straightforward.

Scenario 2: a country with a large industrial sector made up of exporters in highly integrated and self contained market chains that include contract farmers. Some large but less integrated commercial producers focus on the domestic urban market and trade or otherwise interact with smaller commercial producers. If the country implements policies to increase biosecurity in commercial producers, contract farms may vanish from the integrated system because of the high cost of certifying their biosecurity. Some commercial producers might become larger and more industralised and reinstate or even increase their markets and value of production. Small commercial producers, however, could be left in a highly precarious state. Some might leave the industry, with a loss to their own livelihood and those of their employees and the people in their associated market chains. Estimation of economic impacts in such a situation is much more complex because it requires predictions of changes to the structure of the poultry sector.

**b) Reduced costs of dealing with disease outbreaks**.

These include: outbreak investigation costs; destruction and disposal of birds; cleaning and disinfection, possibly including environmental mitigation; movement controls, treatment, verification of rules; vaccination; costs of maintaining birds while farms are in quarantine.

Even with a well designed HPAI prevention strategy, outbreaks may still occur, with associated combat costs, but over time they will reduce in number. Costs of combat for each outbreak may also be lower with a well designed outbreak contingency plan that controls disease spread quickly. Any reduction in outbreak combat costs from the HPAI control strategy creates a benefit.

**c) Reduced costs of dealing with human disease cases.**

The presence of disease incurs direct costs in treating human cases, segregating them, protecting animal health and public health workers and carrying out surveillance in at-risk areas. Reducing the number or scale of outbreaks or even a pandemic, which is estimated to lead to millions of deaths within less than 2 years, will create a benefit by removing these costs.

**Challenges in estimating benefits**

Estimates of benefits should take into account:

- The extent of the change proposed by a control strategy – will it require sector restructuring, or only small management changes by different actors in the market chain? To what extent can indirect as well as direct effects be expected?
- The different stakeholders who will be affected, who will gain the most and the least.
- The seasonality of production and disease. Production may have a higher value in one month than another because of seasonal pricing, but also because small farmers depend more on livestock income or consumption in seasons where crops are not productive.
- The uncertainty in predicting outcomes or attributing them to the AI control strategy. Even the simplest analysis requires an estimate of the number of new outbreaks that might occur in the absence of control or with particular types of control strategy. It is equally difficult to predict shifts in world trade for poultry that will affect the value of export markets, with or without AI. The number of human cases to date has been relatively small, but health authorities fear the emergence of a pandemic virus causing millions of deaths and billions of people affected by the infection.

### 3.3 Estimating costs of control strategies

Estimates must take into account:

- The total cost of a policy. This is the cost of the extra resources used to implement it plus the total loss in output value that it creates.
- The costs incurred by each major stakeholder. Some of these will be actual costs (new resources used) and some will be transfer costs. For example, compensation. This does not represent a real cost – no resources are used up – but finances are transferred from the government to farmers to the reduced the impact of their loss.

**Direct costs**

Direct cost resulting from using new resources (human, capital, equipment, consumables) to implement the control strategy.

i) Investment needed to achieve and maintain a heightened state of biosecurity.

Depending on the stakeholder and the circumstances, these costs may include: strengthening of veterinary services infrastructure and capacity; improved or new farm buildings and infrastructure, equipment, staff and training; improved facilities at markets; in extreme cases, complete relocation of farms or markets. Rebuilding an industry sector after a major disease outbreak is a major challenge for governments and industry due to the major cost implications and the significant dislocation to markets that can result from necessary or unavoidable industry restructuring. In the case of a major disease outbreak, governments may invoke disaster relief mechanisms that are supported by international organizations and aid donors.

ii) Recurrent costs of preventing outbreaks.

These may include: surveillance and diagnosis costs; movement control; administrative costs of enforcing regulations; on-farm biosecurity measures; on-farm traceability measures; in some cases vaccination

Governments and producers would normally aim to keep these costs as low as possible while still maintaining adequate standards. Disaster relief may assist with investment costs but it is rarely provided for longer term recurrent costs.

**Indirect costs**

These are the costs resulting from reduced levels or values of production because of temporary or permanent changes to management systems or markets. It is important not to forget indirect costs. In practice, when calculations are made with computer models, the indirect costs are usually accounted for in the estimation of benefits.

**Transfer costs**

Transfer costs are costs transferred from one stakeholder to another. They are not included in the total cost of an HPAI strategy because they do not represent an additional use of resources, only the transfer of loss from one stakeholder to another. However, they are important in estimating the impact of an HPAI control strategy on individual stakeholders. Examples include compensation and subsidies. Compensation is of particular interest in the context of HPAI, or any other major infectious disease.

Arguments for providing compensation are either:

- To encourage compliance with culling regulations. Farmers are more likely to comply with regulations if they know that they will recover the cost of culled birds from the government. Without compensation, they may decide to sell birds on suspicion of sickness.
- To avert a livelihoods crisis. Farmers whose birds are culled or die during an epidemic may suffer heavy financial losses and be unable to finance the cost of restocking.

When estimating the cost of compensation, a decision needs to be made about whether to compensate only for the market value of the birds or to include also the value of lost production. It is rare in any country or for any disease that farmers receive full compensation for losses including "down time" in the production system. More commonly they receive the market value of the lost animal or bird, or a proportion of its value. An alternative to compensation is to provide credit at minimal or no interest.

**Challenges in estimating costs**

Estimates of costs should take into account

- The impact of cash flow as well as total cost.
- The balance between investment, recurrent and emergency elements, and the sources of funding for each.
- The administration of funding, particularly emergency and transfer funds. This adds to the total cost, but equally importantly, if it is not well designed, it reduces the possibility of implementing the strategy as designed and therefore the chances of success of the strategy.
- Differential impact on each major stakeholder. For example, under some circumstances the impact of a quarantine can be very different for producers (who bear extra feed costs ) or traders (who may benefit from reduced prices when the quarantine ends)

## 3.4 Political and social consequences

Independent of economic consequences, outbreaks of HPAI have significant political and social consequences, particularly if outbreaks continue to occur despite government efforts to control the situation. These are hard or impossible to quantify within an economic evaluation but nevertheless important.

Public confidence can be seriously compromised – particularly when cases of infection occur in people and have serious or fatal consequences. Fear of contracting disease is very hard to value, but important for those who work with poultry or meat or consume poultry meat.

Large exporting industries may put pressure on governments to limit smallholder production, with the goal of improving general biosecurity and facilitating disease eradication. However, governments must also take into account the significant contribution of village and backyard poultry production to the supply of dietary protein and food security.

HPAI in Asia has had a major impact on smallholders and villagers, whose capacity to raise poultry for food or exchange has been seriously compromised. The destruction of millions of healthy birds may raise public concern about the adverse environmental effects of carcass disposal and animal welfare. In some parts of the world, mass destruction of animals or birds is increasingly unacceptable from a societal or religious viewpoint, particularly if safe and effective vaccines can be used to control disease. Destruction of birds without using their products may lead to public doubt regarding safety of these products. These problems are

exacerbated by media images focussing on mass slaughter of poultry and sensational reporting of outbreaks.

HPAI can also have a negative impact on social and cultural activities, such as raising and exhibiting songbirds, racing pigeons and fighting cocks. Religious activities can also be affected, such as the capture and liberation of wild birds as a religious observance. These activities generate a risk pathway both for disease transmission within avian populations and for human exposure to avian influenza virus. Governments, wishing to limit the risk of spread and to avoid human exposure, may take steps to ban social gatherings and trade in these birds, limiting valued social, cultural or religious activities.

Finally, HPAI may have an adverse impact on biodiversity due to the effect of the disease, and control strategies, on scarce genetic resources. Vaccination is a recognized method of salvaging valued genetic material (e.g. grandparent poultry bloodlines). However, the potential consequences of reducing the pool of indigenous poultry breeds also needs to be recognized. In the situation where the genetic pool is threatened by disease, and disease control activities, the use of vaccination to preserve rare non-commercial genotypes should be considered.

## 4. DISEASE CONTROL

### 4.1 General Principles

Control of HPAI is achieved by reducing the amount of virus circulating in poultry and on farms. Measures such as stamping out, cleaning, disinfection and vaccination are implemented to reduce the amount of virus present. Additional measures, such as movement controls, enhanced biosecurity and, as appropriate, vaccination are implemented to create barriers between uninfected poultry and foci of infection.

Surveillance and monitoring are key to the prevention and control of HPAI. Early detection of incursions of virus by targeted surveillance gives veterinary authorities early warning of a potential problem, providing for the proactive introduction of risk management measures such as enhanced biosecurity. To this end, FAO recommends a general strengthening of animal disease surveillance and more emphasis on timely reporting to the OIE and other International (FAO) and Regional Organizations.

A precondition for effective disease surveillance and control is a competent, properly resourced and well-trained Official Veterinary Service. Facilities must be available to provide rapid and accurate diagnosis of disease and detection of infection. In some countries, resources from international organizations and donor countries support important elements of the required infrastructure. FAO, OIE and WHO will continue to work with countries in the region to enhance veterinary infrastructure and the capacity to prevent and control HPAI.

It is important to invest resources in the development and improvement of systems for active disease surveillance and timely reporting to the OIE. This enables early warning of incursions to the Official Veterinary Services in the affected and neighbouring countries, greatly improving the prospect of successful eradication.

***Regional cooperation***

The spread of H5N1 HPAI across national boundaries demonstrates that it must be managed as a transboundary animal disease (TAD), with the cooperation of countries in the region — ideally through the formation of regional epidemiological and laboratory networks. This does not mean that all countries must adopt identical control and response strategies. However, regional coordination, communication and harmonization of approaches to surveillance, diagnosis and control will enhance understanding and facilitate control of the disease.

With the cooperation of countries in the Region, FAO is implementing sub-Regional Technical Cooperation Programmes (TCPs) that provide for HPAI Diagnostic and Surveillance Networks in Southeast Asia, East Asia and South Asia. These Networks are built upon the concept that countries within a sub-region adopt minimum, standardized requirements for diagnosis and surveillance of HPAI as set out in the document "Guiding Principles for Diagnosis and Surveillance of Highly Pathogenic Avian Influenza" (conclusions of the FAO Expert Meeting, 21-23 July 2004, Bangkok) (see footnote 5). The short-term objective is to improve data collection and analysis at the national level and the medium-long term goal is to improve information sharing and analysis at the sub-Regional and Regional level.

In the longer term, it is anticipated that appropriate Regional bodies, such as the Association of Southeast Asian Nations (ASEAN) and the South Asian Association for Regional Cooperation (SAARC), will assume responsibility for the HPAI Networks in the respective regions of Asia.

### 4.2. Emergency response to (and contingency planning for) virus incursions

Fighting a disease epidemic or combating any other animal health emergency is in many respects like fighting a fire and requires a similarly disciplined approach. While the Official Veterinary Services are critical to the process, other agencies of government, such as those responsible for finance, international borders, environmental controls, public health and emergency services, must be closely involved and coordination of these various agencies is critical to successful disease management.

Official Veterinary Services must be able to make rapid decisions, based on analysis of the best information that can be made available from all sources and to convert those decisions into clear orders that can be conveyed to those who must carry them out. Veterinary managers must know that directions have been implemented, and the results. A well-defined chain of command and clear flow of information are particularly important for disease control operations.

Information should flow from the bottom up (it is often the case that the alert to a possible disease outbreak originates in the field) and from the top down. Efficient mechanisms for the transmission of information from the field and laboratory to the national veterinary services headquarters and for feedback of information from headquarters are essential. Information should be shared, as appropriate, with all participants in the disease control programme, including community animal health workers, district/provincial/national and regional governments and the private sector.

Emergency preparedness planning aims to develop capacities for early warning and early response to disease epidemics and other animal health emergencies. This requires preparation,

in advance, of both generic and disease-specific contingency plans and operating procedures; testing (exercising) such plans; training staff; the development of field and laboratory capabilities at national, provincial and local levels; the development of mechanisms to involve other necessary government and private sector services and farming communities in an emergency response; development of the capacity to apply all the necessary resources to counter the disease or other animal health emergency in the most efficient way (including equipment, personnel and finances); and advance establishment of the administrative and legal structures needed to deal with an emergency.

Contingency plans should cover:

- Chain of command, lines of communication and management
- Instructions on methods of humane destruction
- Instructions on methods of carcase disposal
- Instruction on methods of cleaning and disinfection
- Instructions on quarantine measures to be applied on affected farms and associated premises (including vermin and wild bird control)
- Sources, stockpiles and distribution systems for supplies (e.g. vehicles, material for stunning and destruction of poultry, personal protective equipment)
- Disease investigation procedures, including traceback and trace-forward of animals and other products at risk of contamination
- Specific responsibilities of relevant departments and staff (names/addresses)

There should also be arrangements for regular review of the plan, to take into account developments in epidemiology and advances in scientific knowledge on the disease.

FAO recommends that the Veterinary Services conduct animal disease simulations to give staff essential practical experience in emergency response.

FAO has produced a *Manual on the Preparation of National Animal Disease Emergency Preparedness Plans* as a resource for animal health authorities in preparing generic and disease-specific plans. In addition, FAO's EMPRES Global Animal Disease Information System (EMPRES-*i*) is being developed to support national veterinary epidemiologists and facilitate regional and global information sharing and collaboration on the progressive control and eradication of major TADs. EMPRES-*i* includes information on global disease distribution, current threats, response to emergencies, and training and resource material for veterinary epidemiologists. EMPRES-*i* comprises five modules (currently under development):

- animal disease information systems;
- disease recognition;
- disease mapping;
- disease alerts and responses to emergency situations; and
- tools for veterinary epidemiologists.

FAO's EMPRES has developed a multi-media program called 'Good Emergency Management Practice' (GEMP)[8] to promote the concept of a Code of Practice in dealing with

[8] GEMP may be viewed at http://www.fao.org/ag/AGA/AGAH/EMPRES/e_gemp.htm

animal health emergencies. GEMP is defined as 'the sum total of organised procedures, structures and resource management that leads to early detection of disease or infection in an animal population, prediction of the likely spread, prompt limitation, targeted control and elimination with subsequent re-establishment of verifiable freedom from infection in accordance with the OIE Terrestrial Code.

### 4.3 Understanding the viruses

Control strategies for AI must be based on knowledge of the major pathways of spread of the viruses. H5N1 HPAI virus is mainly excreted via the faeces and respiratory excretion of infected poultry. Most commonly, transmission is via direct contact between birds, or through contact with the virus on fomites (clothing, shoes, equipment, etc.), or more rarely through air borne particles.

Chickens infected with H5N1 HPAI die rapidly and only excrete virus in the short period between infection and death, which is usually less than 48 hours. By contrast, ducks infected with H5N1 HPAI can excrete virus for seven days or more. Although ducks may die as a result of infection with some of these viruses, others remain clinically normal. The behaviour in other poultry species of H5N1 HPAI viruses that are currently circulating is still being investigated.

Pigs can be infected with both avian and human influenza A viruses. Human influenza H3N2 viruses have been detected in pigs in Asia, Europe and Africa and H5N1 HPAI was reported in surveys of pigs sampled in China in 2001 and 2003. Pigs have cell surface receptors for both human and avian viruses and they appear to host a broader range of nucleoprotein genes in reassortant viruses than either man or birds. Genetic reassortment of influenza viruses occurs frequently in pigs, which are frequently described as a potential 'mixing vessel' for genetic reassortment of human and avian influenza viruses. In addition to being a possible source of reassortant influenza viruses, pigs could also be involved in the direct transfer of AI viruses and in the re-emergence of influenza viruses that have caused epidemics in previous years. Influenza viruses of the H3N2 subtype persist in pigs many years after their antigenic counterparts caused 'Hong Kong' flu in the human population.

The significance of pigs to the control and eradication of H5N1 HPAI in Asia remains unclear. PRC has reported positive serology and, in a few cases, isolated H5N1 AI virus from pigs. Although disease in pigs attributable to infection with H5N1 HPAI has been suspected, it has not been proven to date. No direct links to the spread of H5N1 HPAI in poultry nor to human cases of infection have been demonstrated. Research is urgently needed to clarify the significance of H5N1 HPAI infection in pigs.

The persistence of HPAI viruses outside the host is a significant factor in determining the best way to control this disease.

Faecal material from infected poultry is a major means of disseminating HPAI viruses. Avian influenza virus can be present at concentrations as high as $10^{8.7}$ mean egg infectious doses of virus per gram of faeces. Clothing and equipment contaminated with faeces are an important means of spread and special care must be taken to prevent contaminated equipment or people wearing contaminated clothing and footwear from entering farms.

In general, AI viruses are not particularly hardy. Short-term exposure to ultraviolet radiation, desiccation and common detergents and disinfectants readily inactivate them. However, the virucidal effect is greatly lessened when viruses are protected in organic matter, such as faeces.

Cooler temperatures enhance the persistence of AI viruses. AI viruses can persist and retain infectivity in faeces for at least 35 days at 4$^{o}$C but for only about 4 days at 25$^{o}$C. In water they can persist and retain infectivity for more than 30 days at 0$^{o}$C and for up to 4 days at 22$^{o}$C.

Wild birds are a reservoir for low pathogenic AI (LPAI) viruses and can play a key role in the introduction of LPAI viruses in domestic poultry. Once introduced into domestic poultry, LPAI viruses can be maintained in the agricultural sector with minimal or no involvement of wild birds. In some circumstances, the circulation of H5 and H7 LPAI viruses in gallinaceous poultry has resulted in the emergence of HPAI viruses that have typically infected only domestic poultry. In other circumstances, infection with H5N1 HPAI in wild birds may result from 'spill over'of virus from infected poultry. According to the available published literature, the infection and production of disease in wild birds by the current H5N1 viruses is unusual for HPAI viruses.

The origin of the H5N1 viruses currently in Asia is unknown. All isolates of H5N1 viruses to date are highly pathogenic, including those from geese in 1996 and those isolated more recently from domestic ducks and wild birds. In the current Asian situation, H5N1 viruses infecting farmed poultry are highly pathogenic and will have a profound effect on populations of susceptible chickens without any delay. In contrast, a delay in expression of disease would normally occur if an LPAI virus enters a flock and subsequently mutates to an HP virus.

Most chickens die quickly after being infected with the currently circulating H5N1 HPAI viruses. Consequently, serological screening may be of limited value in detecting H5N1 infection. Where infection has progressed very rapidly through a flock (particularly with broiler chickens raised on the floor) it would be necessary to test every available bird to provide an acceptable level of confidence as to the test results and it is possible that birds left alive will not be seropositive.

In any case, FAO recommends against the destruction of wild birds to control HPAI. This is unlikely to have any positive practical effect on disease control and is likely to have adverse effect on the biodiversity of Asian fauna. Instead, FAO recommends that measures be taken to separate wild birds from farmed poultry. In the case of production sectors 1 and 2, this objective is feasible but it is much more difficult for sectors 3 and 4. Veterinary authorities should consider targeted surveillance and vaccination of these sectors where this is a high likelihood of exposure to H5N1 HPAI e.g. in infected wild bird populations. FAO highly recommends further research into the epidemiology of HPAI in wild birds and the significance this has for disease control and eradication (see below).

## 4.4 Measures for prevention, control and eradication of HPAI

The main measures available to prevent, control and eradicate HPAI are:

- Effective disease surveillance for early detection and reporting of outbreaks
- Enhanced biosecurity of poultry farms and associated premises.

- Control of movement of birds and products that may contain virus, including controls at the interface of infected and uninfected areas.
- Changes to industry practices to reduce risk.
- Rapid, humane destruction of infected poultry and poultry at high risk of infection.
- Disposal of carcases and potentially infective material in a biosecure and environmentally acceptable manner.
- The proper use of vaccination.

None of these risk reduction measures, implemented alone, will be sufficient to prevent, control or eradicate HPAI. Rather, they must be implemented in combination and supported by surveillance to ensure early detection and rapid response to viral incursions. Public education and awareness campaigns are also important to help in controlling the disease and to safeguard public health.

Each of these measures is considered in more detail in the following sections.

### *4.4.1 Enhanced biosecurity at poultry farms and associated premises.*

Biosecurity comprises two elements — biocontainment and bioexclusion. Bio-containment (i.e. the prevention of spread of virus from infected premises) is considered below in sections 4.4.4 and 4.4.5. Bio-exclusion refers to measures to exclude infectious agents from uninfected premises.

Good biosecurity depends on the formation of a barrier between farms and the outside environment. This sounds simple but can be difficult to implement successfully in practice. Many items and people routinely enter poultry farms, including replacement birds, feed, water, farm workers, veterinarians, poultry buyers and catchers, and vaccination crews. It is difficult to entirely exclude free ranging animals (e.g. vermin, pet animals, wild birds) from farms but steps should be taken to prevent their entry into poultry sheds.

The exclusion of wild birds from farms merits particular mention because of the potential for wild birds (especially waterfowl) to harbour AI viruses. Wild birds may come into contact with farmed poultry directly (especially if the farmed birds are free-ranging) or indirectly (via contamination of feed and water). The latter pathway is especially important for farmed ducks reared on ponds and for farmed chickens whose drinking water is obtained from ponds. Influenza viruses target the gastrointestinal tract of waterfowl and ducks can shed virus for as long as 30 days. Influenza viruses can persist and retain infectivity in water (more than 30 days at $0^{o}$C and up to 4 days at $22^{o}$C). Wild waterfowl should be excluded from ponds or, if this cannot be done, drinking water for poultry that is obtained from these sources should be treated, e.g. with ultraviolet radiation or chlorination.

The main goal of a biosecurity programme is to manage the risk posed by people and items that cross the barriers erected to protect the farm. This is achieved through careful planning and design of farms, use of movement restrictions, appropriate disinfection and use of protective clothing. All commercial poultry farms should develop and implement a formal biosecurity plan as appropriate to the farm. It is helpful to document the biosecurity plan and specify those responsible for its maintenance.

The usefulness of biosecurity plans depends on compliance by farmers and farm workers, who must have a basic understanding of the purpose of the measures. Breaches of biosecurity

can occur no matter how stringently the measures are implemented. The risk of biosecurity breaches is higher the more people and items routinely enter the farm.

The effectiveness of biosecurity in precluding virus entry also depends on the quantity of virus circulating in the vicinity. Obviously, the more virus that is present, the greater the likelihood that breaches of biosecurity will result in entry of the virus. Where the challenge is sufficiently high that biosecurity can not prevent the entry of virus, the use of vaccination should be considered.

By definition, production sectors 3 and 4 are not biosecure. Although attempts should be made to improve biosecurity in these sectors, it is not feasible to prevent the entry of AI where there is a continuing source of infection in commercial poultry, domestic ducks of subsistence farming or possibly wild birds. In situations of high viral challenge, targeted vaccination may be the most appropriate means of 'dampening down' an HPAI outbreak. The decision to use vaccine must be considered in light of other issues as discussed elsewhere.

More detailed information on biosecurity is available from the references at the end of this paper.

### *4.4.2. Control of movement of birds and products that may contain virus, including controls at the interface of infected and uninfected areas.*

#### *4.4.2.1 Controlling movement of items from infected zones in an outbreak*

Controls on movement of people, poultry and objects from the infected place and the area surrounding the infected place should be implemented in response to an HPAI outbreak. These measures should be described in the disease contingency plan.

The nature of controls implemented depends on the disease situation in the country or compartment. It is necessary to balance the risk of viral spread with the social and economic effects of the response measures. Movement restrictions will differ depending on whether a control or an eradication campaign is implemented. Movement controls will normally be less stringent in situations where infection is endemic and vaccination is practised.

Veterinary authorities must control the movement from infected premises and within control zones of products that could spread infection. This includes specification of what items can be moved; under what conditions they can move and treatments that must be applied. Movements out of infected areas must be similarly controlled.

Marketing systems are disrupted when outbreaks of HPAI occur. Live bird markets in the area around the infected premises and those linked to the infected premises through bird movements should be closed. If there is reason to suspect that infected birds have been in the market, the facilities should be depopulated, thoroughly cleaned and disinfected. Cloacal swabs from live birds in the market and/or faecal samples from cages should be submitted for laboratory testing to enable confirmation of the AI situation.

#### *4.4.2.2 Border controls*

Controls on the international movement of birds and products should be based on OIE recommendations, which provide the basis for safe international trade in the least trade

restrictive manner. Measures may be modified in the light of specific risk assessments and agreements between trading partners.

In an outbreak of HPAI, it is often the case that countries ban the import of poultry and poultry products until they consider that it is safe to resume trade, based on the infected country or countries meeting relevant OIE recommendations.

As with all control measures, border controls reduce but do not eliminate risk. Smuggling cannot be entirely prevented and, in some cases, enhanced quarantine measures may create an environment in which smuggling is highly profitable, especially if shortages of products occur. In such cases anti-smuggling activities must be enhanced.

Borders may be more, or less, secure, for a range of reasons— geographical, economic, social and political. Veterinary authorities must consider the possibility of "leakage" across borders when developing disease control and prevention strategies.

Wild birds do not recognise international borders. If infected wild bird populations are present, veterinary authorities should implement measures to prevent these birds from infecting domestic poultry, as discussed in Section 5.4.3.

### *4.4.3 Changes to industry practices to reduce risk*

It is possible to reduce the risk of an HPAI outbreak and to improve control over a disease situation by changing industry practices (e.g. poultry production, transportation and marketing) that facilitate viral spread. Veterinary authorities should critically review practices within infected and "at risk" compartments and countries to assess how these practices might be modified to reduce risk.

In conducting this assessment it is important to take into account the cost and social consequences of proposed changes and weigh these against the expected benefits.

Industry practices that have been modified or should be considered for modification in Asia include:

i) Marketing systems

Live bird markets play an important role in the poultry industry in Asia. These markets allow consumers to purchase fresh meat, which many prefer to refrigerated or frozen produce. However, live poultry markets can contribute significantly to the spread and maintenance of avian influenza viruses especially if the markets operate continuously without rest days (i.e. days on which no live poultry are housed in the market). Live bird markets present a risk of recirculation of poultry pathogens and a potential avenue of exposure of human beings to live birds. Some practices present particular health risks, such as the holding of poultry overnight and the return of unsold birds to farms. Market stocking rates and hygiene also influence the likelihood of spread of avian influenza. Lower stocking rates and a more stringent approach to hygiene will generally reduce the risk of survival and spread of AI viruses and other pathogens.

In 2001, the Government of Hong Kong introduced requirements for retail poultry markets to have compulsory rest days on which all poultry were sold or slaughtered and the stalls

cleaned, disinfected and rested for 24 hours before poultry were reintroduced. This measure has been shown to be effective in reducing the circulation of influenza viruses in markets.

In 2004, the Government of Macau introduced rules prohibiting stallholders from keeping live poultry overnight in markets. Hong Kong and Macau also require vaccination for all poultry sold in market stalls.

FAO recommends the adoption of requirements for live bird markets similar to those introduced in Hong Kong and Macau, with the goal of breaking the chain of transmission of avian influenza and other poultry pathogens.

Some countries require farmers to obtain a permit before moving birds to market. This provides an opportunity for checking of poultry for evidence of infection and disease prior to sale. Although it may not always be feasible for veterinary authorities to check the health of all poultry moving within a large-scale marketing system, some spot checks could be carried out, particularly in response to local changes in HPAI status.

Some countries have proposed to eliminate or severely restrict the sale of birds in live markets and move to centralised slaughtering. Such a change would have considerable social and economic consequences and broad consultation with stakeholders, including consumers, should be undertaken before considering such strategies.

ii) Segregation of species

Domestic waterfowl are known carriers of avian influenza viruses and the practice of farming multiple species presents a risk of transmission between waterfowl reservoirs of infection and terrestrial poultry. After the 1997 AI outbreak the Government of Hong Kong prohibited raising, transporting and marketing of ducks and geese with other poultry. Similar measures were also implemented for quail after scientific studies suggested these birds were carrying and excreting AI viruses, including H9N2 viruses with a constellation of internal genes virtually identical to that of the 1997 Hong Kong H5N1 virus.

FAO recommends that the practice of raising, transporting and marketing waterfowl and quail with other poultry be limited or prohibited.

Commercial farms, backyard production systems and markets that hold pigs and domestic poultry in proximity increase the likelihood that AI viruses will enter pig populations, presenting a risk of reassortment with pigs influenza viruses and the emergence of new influenza viruses. FAO recommends against the rearing, transport and marketing of pigs and domestic poultry in proximity. Pigs that are reared on premises where poultry are found to be infected with HPAI should be subject to official veterinary inspection. Pigs with clinical disease suggestive of influenza should be destroyed and samples (blood, tracheal swabs, lung) submitted for laboratory diagnosis. Otherwise, samples from normal pigs (blood and nasal swabs) should be submitted to the laboratory for testing to rule out the possibility of sub-clinical infection with H5N1 HPAI. If active infection is confirmed in any of these pigs the herd should be destroyed to prevent the spread of the virus between pigs, to ensure the pigs do not re-infect poultry when the farm is restocked and to minimise the risk of viral reassortment.

iii) Farming systems and practices

The broad grouping of farms into four sectors, depending largely on the degree of biosecurity practised, is described in Section 2. Infection is less likely to occur in sector 1 farms, providing that biosecurity is maintained, but the consequences of such infection may be great, due to the large number and high density of naïve poultry in the farm. Conversely, production systems in the other three sectors represent a continuum of pathways and risks for the entry of HPAI. Commercial farming practices that present greater likelihood of the entry of infection include pond-based rearing systems and systems where poultry forage outdoors and are kept in sheds at night. Village production effectively has no biosecurity and the likelihood that infection will actually occur depends on the challenge (prevalence of HPAI in surrounding farms and wild birds) and the existence of risk mitigating factors, such as vaccination.

If there is active infection with HPAI in Sector 3 and 4 poultry farms and/or evidence of a high prevalence of infection in wild birds, the Official Veterinary Services should consider establishing 'poultry-free zones', within which Sector 3 and 4 production systems are prohibited, around commercial farms. Alternatively, vaccination programmes could target backyard/village chickens to minimize disease propagation by this sector.

Many farmers in Asia keep multiple batches of poultry of different ages to spread their income and to avoid the financial risks associated with having all birds entering the market on the same date. However, partial sale of birds from commercial farms presents a greater biosecurity risk than the sale of the entire batch of birds (all-in, all-out production). This is primarily because birds remaining in the farm have been exposed to catchers or other workers, who customarily move from farm to farm and can readily spread infection if HPAI is in the area. Multi-age poultry farms present a higher risk than single age farms, mainly because they are not managed on an 'all-in, all-out' basis.

FAO recommends that, where possible, commercial farms operate on an 'all-in, all-out' basis and that catchers and other workers coming into direct contact with poultry practise strict biosecurity (e.g. change or clean and disinfect protective clothing, equipment and footwear) before entering and at the time of leaving farms.

Authorities may license or register commercial farms to generate information on farm location and ownership and the number and type of poultry kept. Licence conditions can be used to help ensure the adoption of specific biosecurity measures such as bird proofing. However, this has resource implications for the licensing organization and legal authority is required to enforce such measures.

Poultry cages, farm structures and equipment should, where possible, be constructed of materials that can be easily cleaned and disinfected. In this regard, steel and plastic are preferable to wood and bamboo.

iv) Transport

Cages used for carriage of birds from farms to markets should be constructed of material that can be easily cleaned and disinfected. The use of plastic or metal cages is therefore preferred to wooden cages. During transport, measures should be implemented to reduce the risk of faecal contamination of the area around markets when cages and poultry are off-loaded.

Facilities for cleaning and disinfection of transport cages before they are taken back to farms should be in place along with an official system for monitoring its effectiveness.

Materials used to transport table eggs, fertile eggs and day old chicks also pose a risk. It is recommended to use materials that can be cleaned and disinfected or disposable materials for this purpose.

### *4.4.4 Destruction of infected and at-risk poultry (stamping out)*

Destruction of infected and at-risk poultry (stamping out) has long been the accepted method of control for HPAI in the face of a disease outbreak.

Success rates for this method are high when it is implemented rapidly, prior to secondary spread and combined with rigorous movement controls, proper decontamination of infected farms and careful monitoring and surveillance to establish the extent of infection.

Under a stamping out policy, poultry on infected premises are destroyed. Some countries consider that all poultry in a zone of specified radius (which may vary from 1 to more than 10 km) around infected premises should be destroyed. Others direct attention to "dangerous contact premises" and only destroy birds on these farms when there is evidence that the disease has spread. Such farms are closely monitored for evidence of infection.

FAO recommends that policy on the culling of "at risk" poultry as part of a stamping out policy be risk based, taking into account the likelihood that the birds are infected. It can be difficult to accurately establish the extent of infection. If in doubt, a conservative decision should be made. Attention must be paid to local spread in densely populated poultry areas and to direct and indirect contacts in integrated poultry farms. If there is a high risk of reinfection of farms following restocking (e.g. due to the existence of reservoirs of infection in wildlife), the benefit of culling non-infected poultry is questionable. Equally, there is little reason to cull clinically normal, properly vaccinated poultry in a zone around an infected farm.

Infected poultry should be culled as quickly as possible and preferably within 24 hours of detecting infection. Delayed culling of poultry on infected premises results in production of large quantities of virus that increases the likelihood of spread.

When diagnosis can be presumptively based on clinical, pathological and/or epidemiological evidence, FAO recommends that culling not be delayed while awaiting laboratory confirmation of infection with HPAI. However, samples should always be taken before or at the time of culling to enable retrospective analysis of the infection status of the flocks destroyed.

In all premises suspected and confirmed as infected with HPAI, Veterinary Authorities should carry out a full investigation to establish the source of infection.

This involves detailed observation on the farm and its surroundings as well as interviews with the farm and workers to determine normal farm management practices. One of the critical objectives is to establish the time/date the disease was first detected and to trace the movements of people, poultry, feed and equipment onto and from the farm before and after the first signs of disease. This should cover movements in the period 14-21 days before the outbreak and all movements off the farm after the disease was first detected. Premises with poultry that may have been exposed to the virus via direct or indirect contact with confirmed

infected premises should be investigated for signs of disease and, if warranted, put in quarantine.

Veterinary Authorities should take steps to obtain the necessary legal authority to destroy infected poultry and, if required, those on surrounding farms. They should be able to obtain, at short notice, the services of teams of workers trained in the humane destruction of poultry. These workers must have proper training and knowledge of health and safety risks associated with HPAI and be appropriately prepared.

In the event of a widespread outbreak of HPAI, to which a rapid response is required, trained personnel are likely to be in short supply and priorities need to be determined for the response action to be undertaken. This should be addressed, to the extent possible, in contingency plans.

FAO recommends that countries take steps to ensure that workers contacting potentially infected poultry wear appropriate personal protective equipment (PPE) in accordance with WHO recommendations, (see references) and receive training in the correct fitting of this equipment. Under hot, humid conditions, practical problems may be encountered in fulfilling these requirements.

FAO recommends compliance with WHO advice on the vaccination of workers on infected farms with current human influenza virus vaccines before anticipated exposure to AI viruses in any response to HPAI, to minimise the potential risk of acquiring concurrent infection with avian and human influenza viruses. Two weeks are required to develop protective immunity. In practice, it is rarely possible to access a large number of immune workers at the beginning of the emergency.

Antiviral therapy is available and could be supplied to people working on known infected premises. Veterinary Authorities should conform with recommendations of WHO and relevant national health organizations with respect to public health considerations in responding to HPAI.

#### *4.4.4.1 Methods used for the destruction of poultry*

Various methods are used for destruction of poultry on farms. The method used should be humane and should not cause spread of disease. Importantly, it should not endanger workers. The methods to be used should be incorporated into contingency plans.

It may be difficult to prevent completely the spread of infection during destruction of poultry (and subsequent disposal of waste materials). Increased human movement and required cleaning, disinfection and disposal activities inevitably result in the release of dust and dander, which can potentially spread AI viruses to nearby farms. Appropriate risk reduction strategies include rigorous cleaning and disinfection of clothes, equipment and transport vehicles, and good personal hygiene on the part of workers, veterinarians and government officials. Litter and feed supplies, if contaminated, may be sprayed with water to minimise the generation of dust. If possible, disposal of waste materials on farm is preferred (also see below).

Asphyxiation using carbon dioxide is the method of choice for destruction of chickens and is most effective where birds are reared on the floor. Sheds must be properly sealed and gassing

continued until there is no movement of birds in the shed. Other gases have been used but present a greater risk to operators.

For houses with open wire mesh walls or where birds are kept in cages, the birds must be removed from the shed or cages before destruction. This may involve placing poultry in large containers or skips, smaller garbage bins or even strong plastic bags into which carbon dioxide is added. The containers must be free from leaks. Difficulties can be experienced with freezing of gas regulators when high flow rates of carbon dioxide are required.

Poultry placed in these containers must be handled humanely and live birds must not be piled on top of each other before death occurs.

Asphyxiation by carbon dioxide is not as effective in ducks and geese as in chickens. Physical methods such as cervical dislocation using cattle castration forceps are preferable for the humane destruction of waterfowl.

Sites where destruction is taking place must be secure to prevent unauthorised entry or exit of people and vehicles. A single entrance/exit is recommended and techniques should be employed to ensure all vehicles, items and personnel moving off the premises have been decontaminated. Veterinary authorities should have the legal authority to control movements on and off infected premises and premises that are subject of quarantine or other disease control measures.

Destruction of infected poultry should be performed on site. The slaughter of uninfected poultry (e.g. on “at-risk” premises) may be arranged through controlled processing at approved slaughterhouses. This should only be done if the birds are shown to be free from infection (e.g. by pre-movement testing). The slaughterhouse should be within the zone that is the subject of surveillance and/or disease control measures.

Before the destruction of poultry for disease control, samples should be submitted for laboratory testing and all investigations that rely on the presence of live birds should be completed (e.g. the precise location of dead or sick birds, the pattern of disease spread on the farm).

Accurate records of the age and type of birds killed and, as appropriate, records of valuation, should be kept to facilitate payment of compensation in situations where this may be required. These requirements apply to all farms on which poultry are being destroyed.

### *4.4.5 Disposal of carcases and potentially infective material in a biosecure and environmentally acceptable manner*

Decontaminating infected farms and removing or disinfecting potentially infectious material are critical to effective disease control. The methods used must prevent spread of infection, have minimal impact on the local environment and must be acceptable to environmental protection agencies.

The main methods used for disposal of carcases and other materials are burial, burning and composting.

#### *4.4.5.1 Removal of carcasses*

It is preferable to dispose of carcases on farm, providing that there is a suitable site for burial or composting. It is important to avoid contamination of water supplies, for reasons of animal, public and environmental health. Relocation of carcases to another site creates an additional risk to farms along the route between the infected farm and the site of disposal. For biosecure transport, carcases must be placed in leak proof containers or sealed in plastic bags. Vehicles carrying carcases must be leak proof.

The rate of depopulation of farms must be monitored to avoid a build up of carcasses, which will occur if flocks are destroyed more quickly than carcases can be removed. This may present problems, especially when depopulating multiple farms and using off-site burial. Under these circumstances, it usually takes less time to kill birds than it does to remove the carcases. Carcases are easier to handle before decomposition has set in. Composting of carcases in combination with faeces and litter is another acceptable means of disposal.

#### *4.4.5.2 Removal of faeces and litter*

Faeces and litter are most readily dealt with by burial or composting. The material should be piled up in a secluded part of the farm, the surface disinfected and the stack covered with plastic or other suitable material.

#### *4.4.5.3 Cleaning and disinfection*

Cleaning and disinfection of infected places and equipment are a crucial part of control strategies for avian influenza. This should start with an initial dry cleaning (scraping and carting away faeces, litter, feed and other organic material) followed by preliminary disinfection (e.g. by spraying an appropriate liquid disinfectant). This should be followed by more thorough cleaning and a second round of disinfection. Items that cannot be properly disinfected should be destroyed.

Influenza viruses can survive for some time in organic material, so thorough cleaning with detergents is an important step in decontamination. All organic matter must be removed from poultry houses. Effective cleaning results in no visible feathers or faeces remaining in the shed.

Many disinfectants are effective against AI viruses, including detergents, hypochlorites, alkalis, glutaraldehyde, and Virkon®. The chemical chosen depends largely on the nature of the material being disinfected. Vehicles should not be disinfected with corrosive chemicals. Care needs to be taken when using disinfectants to balance the need to destroy the virus with the adverse environmental effects associated with excess use.

Outdoor areas used by poultry can be difficult to disinfect, especially if these include vegetated areas or earth. Poultry should be excluded from these areas for a minimum of 42 days to allow natural ultraviolet radiation to destroy any residual virus. The period of exclusion should be longer in cold weather. Spraying of disinfectants on vegetated outdoor areas or soil is of limited value due to the inactivation of these chemicals by organic material. Removal of surface soil is not normally recommended unless it is heavily contaminated with faeces.

Ponds are also difficult to disinfect and potential adverse environmental effects must be taken into account in implementing treatment measures. In the absence of other action, screening ponds to prevent bird access for a minimum period of six months would reduce the levels of infective HPAI virus considerably but may not guarantee freedom from virus, especially during cooler parts of the year.

If using ponds or dams to supply drinking water for farmed poultry, the water should be treated before use. Treatment with ultraviolet radiation or chlorination reduces the likelihood of viral contamination.

Farms that have been cleaned and disinfected should be the subject of an official inspection before restocking is permitted. Restocking should not occur less than 21 days following completion of cleaning and disinfection after destocking.

## 5 THE USE OF VACCINATION.

### 5.1 General

Despite the control measures that have been applied in East and Southeast Asia, continuing reports of outbreaks in Indonesia, Thailand and Vietnam and, most recently, in Malaysia, show that H5N1 HPAI has not been eradicated from the region. There is evidence that infection has been established in some parts of the region for some years and that the H5N1 HPAI viruses have become endemic in some countries. In response to this situation, some countries have commenced vaccination and others are considering the role that vaccines could play in their control programmes. Experience with use of vaccines in Hong Kong indicates that they can be used successfully to help eliminate H5N1 HPAI virus. Vaccination has also been used successfully in other regions to control AI viruses, including in the United States and in Italy, demonstrating that strategic use of vaccine in conjunction with other control measures can be effective in controlling or eliminating AI viruses. Most examples from Europe and North America relate to using vaccination to help control LPAI viruses.

A number of efficacious vaccines are commercially available. Based on field and laboratory evidence, these vaccines provide excellent protection against clinical disease in chickens, reducing mortalities and the effect of the disease on production. Properly used high quality vaccines confer good resistance to infection, so that the vast majority of vaccinated birds exposed to field virus do not become infected. For the few vaccinated birds that might become infected, shedding of virus is markedly reduced (both in the duration of excretion and the quantity of virus). Vaccination reduces the total amount of virus contaminating the environment and acting as a source of infection to poultry and humans. However, the vaccine must be of high quality and have sufficient antigenic mass for the birds to develop a protective immune response.

In addition to these technical considerations, governments must also consider the export issue as well as other non-technical factors in arriving at a decision to include vaccination as part of their control strategy. These include the social effects of widespread destruction of poultry on smallholder livelihood and the economic consequences of failure to control the disease (see Section 3).

## 5.2 Conclusions from international and regional meetings relating to vaccination

A number of international and regional meetings have already been held on the subject of emergency control of HPAI in Asia. Of these, the conclusions of the joint FAO/OIE/WHO meeting held in Rome in February 2004 are relevant and worth repeating. The conclusions of these meetings relevant to vaccination are:

- Stamping-out is the preferred option for an outbreak of HPAI and should be used in all flocks exhibiting clinical disease. It has been highly effective in controlling confined outbreaks of HPAI where there is limited and low risk of reintroduction.
- Recognizing that it may not be either desirable or feasible to proceed with massive culling in some situations, vaccination is considered a suitable option. The rationale behind this is that vaccination reduces susceptibility to infection and decreases shedding (both in duration and titre) and is therefore an appropriate tool to reduce the incidence of new cases and viral load in the environment and this is expected to contribute to other measures to reduce the potential for spread to humans.
- The use of vaccination must be seen as a tool to maximize biosecurity, be coupled to surveillance to detect promptly any change in properties (antigenic change) of virus circulating and must be carried out with appropriate products manufactured and quality controlled to ensure compliance with international standards referred to in the OIE *Manual of Standards for Diagnostic Tests and Vaccines*.
- Vaccination can be used either as a tool to support eradication or as a tool to control the disease and reduce the viral load in the environment. Controlling the disease through vaccination may be a prelude to eradication. The appropriate management of a vaccination campaign under the control of the veterinary administration is compatible with international trade, if it is in compliance with the OIE Terrestrial Code. Stamping-out and vaccination are not mutually exclusive and the mix or sequence of measures may differ between production systems and stages of a control programme. Vaccination should be used in a strategic manner with careful consideration of target groups and areas based on the outcome decided by the national authorities.
- The DIVA ‘differentiation of infected from vaccinated animal ’ approach is recommended either through the use of an appropriate diagnostic test or the use of sentinel birds. Today, only inactivated heterologous or homologous vaccines are candidates for emergency use.

## 5.3 Vaccines in use today

Most vaccines used to date for AI have been inactivated whole AI virus antigen in an oil-based emulsion adjuvant produced according to OIE recommendations. A live recombinant fowlpox with H5 AI gene insert has been used in a few countries but most other countries have not yet licenced this vaccine for unrestricted use and it is currently under review by the OIE.

The inactivated AI viruses used in vaccines possess an homologous H determinant (i.e. H5) to provide protection against the current H5N1 HPAI viruses. They possess either an homologous (i.e. N1) or heterologous (e.g. N2) neuraminidase (N) determinant. Vaccines containing either homologous or heterologous N determinants provide protection against current field strains of H5N1 virus. However, the use of heterologous N subtype vaccines provides an opportunity to use serological surveillance and a strategy to detect the circulation of field virus through the detection of antibodies to the N subtype of the field virus. This is

referred to as the DIVA approach. Inactivated heterologous vaccines have been used successfully and have led to the eradication of LPAI in Italy in such a DIVA strategy. Heterologous N subtype viruses may be detected using an Immunofluorescent Antibody Assay or a Neuraminidase Inhibition Assay (see "Guiding Principles for Diagnosis and Surveillance of Highly Pathogenic Avian Influenza" -conclusions of the FAO Expert Meeting, 21-23 July 2004, Bangkok).

The circulation of LPAI viruses, such as H9N2 and H6N1, both of which are known to occur in parts of Asia, may interfere with the use of DIVA strategies.

Recombinant vaccines based on a 'live' fowlpox virus delivery system expressing H5 antigen have been developed and are commercially available. One such vaccine is currently being used to control LPAI H5N2 in Mexico. This vaccine has been licensed for use in Mexico and for emergency use—under control of the U.S. Department of Agriculture and State Veterinarian—in the United States.

There is both field and experimental evidence that fowlpox virus-vectored vaccine can provide significant protection against AI. The response to vaccination using fowlpox virus-vectored vaccine may be impeded in older poultry that have had prior exposure to infection with fowlpox virus or vaccines against fowlpox. The fowlpox virus-vectored vaccine is of unknown efficacy in ducks and other avian species as the vector is not known to replicate in species other than chickens. The fowlpox recombinant can be used to vaccinate day-old chicks, via wing web stab, in the hatchery. This is the most biosecure part of the integrated production chain and there is a lower labour cost for vaccination.

A DIVA strategy can also be used with recombinant live vectored vaccines because these vaccines do not induce the production of antibodies against the nucleoprotein antigen that is common to all AI viruses. Therefore only field-infected birds will exhibit antibodies in the agar gel precipitation test or enzyme linked immunosorbent assay (ELISA) to detect group A (nucleoprotein) antibodies. Both vaccinated and infected birds will have HI antibodies against the specific H subtype.

As explained in section 5.7, use of the DIVA strategy may mitigate the impact of export market closures. If the infected country can demonstrate the absence of field virus in vaccinated flocks, importing countries may be prepared to reestablish conditions for import.

FAO recommends that the Veterinary Authorities implement arrangements for monitoring the immune status of vaccinated flocks. For this purpose, it is important to use the specific antigen that is the source of the HA antigen in the vaccine. Properly vaccinated birds will exhibit relatively high titres in the appropriate HI test. Use of the 'incorrect' antigen for the HI test may result in negative test results even though the chickens have attained a protective level of antibody.

Both conventional inactivated and recombinant vaccines must be administered by injection, which gives rise to practical and cost-related limitations to their use. Further scientific research and the development of vaccines that can be administered via feed or water (as well as vaccines for use in avian species other than chickens) is urgently required.

Several novel vaccines have been developed or are currently under development for AI. Each of these vaccines potentially offers specific advantages over conventional vaccines and some of these may prove to be useful adjuncts to the control of HPAI in the future.

The novel vaccines include

- Vaccines based on reverse genetics that provide an exact antigenic match with field strains of virus but which can be grown to high and consistent titre
- Adenovirus-vectored vaccines that can be delivered via drinking water
- Newcastle disease-vectored vaccines that can be delivered by aerosol
- Subunit vaccines
- DNA vaccines

Veterinary authorities should satisfy themselves that any vaccine used has been produced in accordance with the OIE *Manual of Standards for Diagnostic Tests and Vaccines*. The OIE *Manual* defines the 'Principles of Veterinary Vaccine Production', including vaccine types or forms, quality assurance, master seed management, documentation of the manufacturing process and record-keeping.

FAO recommends that purchasers of vaccines assure themselves of the quality assurance procedures applied by manufacturers and of the performance characteristics in the field of all vaccines under consideration.

## 5.4 Vaccine administration

Vaccination teams should comprise veterinarians, technicians and assistants ('vaccinators') trained in both the vaccination procedure and appropriate public health measures including the correct use of personal protective equipment (PPE). Team members should follow manufacturers' recommendations on the storage and delivery of vaccine. They should also ensure that detailed records of vaccination (number and species vaccinated, location, date, identification numbers of sentinel birds etc.) are recorded and entered in relevant databases so these data are captured by official information systems and available for subsequent analysis. Vaccination team members should also be well trained in biosecurity measures to ensure they follow appropriate cleaning and disinfection procedures that minimise any risk of their spreading AI viruses or other poultry pathogens between flocks.

Farmers can also be supplied with vaccine by government provided this is done under properly controlled conditions. Farmers must have received adequate training in administration of vaccine and must keep appropriate records. Unvaccinated identified sentinel birds must be placed in the flock and there must be a monitoring system in place to assess the effectiveness of vaccination and to check sentinel birds.

## 5.5 Assessing whether to vaccinate

To assess the risk of infection, veterinary authorities must consider whether the virus is present in neighbouring countries/compartments and whether there are reservoirs of infection within the country/compartment under consideration. Veterinary authorities are more likely to consider the use of vaccine as the likelihood of infection increases.

In an uninfected country with no infected neighbours, the risk of infection would be negligible and veterinary authorities would not normally consider routine vaccination. However, in a country in which domestic waterfowl, live bird markets or wild birds are reservoirs of virus, the poultry industry is at higher risk of infection. In such situations, veterinary authorities would be more likely to consider vaccination as one of the control measures.

In such cases the level of biosecurity on poultry farms is a major factor influencing veterinary authorities' consideration of the use of vaccination. In the situation where farm/village/backyard biosecurity cannot be improved and there is significant challenge from HPAI viruses, including infection in neighbouring villages, wild birds, domestic ducks or bordering countries, Veterinary Authorities should consider vaccination strategies to minimize propagation by this sector, to protect susceptible birds from infection and to manage human health risks.

The density of poultry also influences the risk of spread of infection. If a virus enters an area of high poultry density there is greater probability of its spread. Veterinary authorities would be more likely to consider vaccination of chickens in these areas than in areas with a lower poultry density. Restocking of farms in previously infected areas is a higher risk situation in which veterinary authorities might consider the use of vaccination.

Veterinary authorities must take into account the interaction between the level of challenge and the level of biosecurity (according to production sector) in considering the use of vaccine, as shown in the following table.

| | **Consideration of vaccination in each production sector** | | | |
|---|---|---|---|---|
| **Level of challenge** | **Sector 1** | **Sector 2** | **Sector 3** | **Sector 4** |
| Negligible | No | No | No | No |
| Low | No | No | Yes | Yes |
| Moderate | No | Yes | Yes | Yes |
| High | Yes | Yes | Yes | Yes |

The particular case of exporting countries is addressed elsewhere in the text (see section 5.7).

## 5.6 Birds to be vaccinated

Veterinary authorities are more likely to consider the use of vaccine for valuable birds even when the risk of infection is relatively low. Such birds might include broiler breeders and layer breeders, fighting cocks and zoological collections. In situations of high HPAI challenge FAO recommends that all measures be taken to protect high value birds, including increased biosecurity and, as appropriate to the circumstances, vaccination.

Veterinary authorities would not normally consider the vaccination of chickens that are processed at an early age (e.g. broiler chickens processed before 45 days of age). However, in the situation where there is a high challenge and biosecurity is insufficient to prevent infection, it may be appropriate to consider vaccination of broiler chickens.

In backyard production systems where the chickens are fully susceptible to infection with HPAI and there is a high risk of infection, it may be appropriate to vaccinate all chickens.

There is little information available on the efficacy of AI vaccines in avian species other than chickens. Nonetheless, ducks are being vaccinated in some parts of Asia using conventional inactivated vaccines. Further research is urgently needed to determine the effectiveness of existing vaccines in ducks. Until such research is completed, FAO cannot make firm recommendations on the use of AI vaccines in ducks.

### 5.7 The implication of vaccination for exporting countries

In the case of countries that export poultry products, the most favourable status is country freedom from notifiable avian influenza (NAI) (see footnote 2). Countries that become infected usually lose their export markets and need to take steps to regain their former trading status as quickly as possible. The OIE Terrestrial Code chapter on Avian Influenza provides more specific guidance on the requirements to be satisfied by countries experiencing an outbreak of NAI. In the event of new outbreaks, the first approach will be to stamp out infection. In the situation where stamping out cannot be quickly achieved at the country level and other strategies must be considered, the use of vaccine does not imply automatic loss of export markets (see footnote 3). However, this is subject to full compliance with OIE recommendations, particularly those concerning the strict application of active surveillance. When vaccinating, active surveillance using the DIVA strategy is a key condition in order to provide the necessary assurances that notifiable AI viruses are not circulating in any compartment from which export is proposed or occurring. In addition to that, the placement of identified, unvaccinated sentinel chickens within vaccinated flocks and strict record-keeping on vaccine use will be important elements in ensuring and demonstrating the absence of virus circulation.

The application of the compartmentalisation concept (see footnote 4 and section 2.5) can accelerate the resumption of export, provided that establishments apply the required surveillance, control and biosecurity measures for the purpose of international trade.

In order to satisfy importing countries as to the status of an HPAI-free compartment within an infected country it is recommended that countries use only vaccines produced in compliance with OIE recommendations and in accordance with strict quality assurance procedures.

### 5.8 Public health factors relating to use of vaccines

Human health authorities have expressed two main concerns about the potential public health effects of vaccination of poultry:

- Concerns about persistent excretion of AI virus in vaccinated poultry.
- Concerns about generation of new strains of AI virus as a result of vaccination.

Although vaccination does not eliminate the possibility of infection, field surveillance and experimental trials have shown that in properly vaccinated poultry exposed to the current strain H5N1 HPAI virus, infection is highly unlikely to undergo sustained transmission within, or to result in persistent infection of, the flock.

Experimental results have shown that properly vaccinated birds subsequently inoculated with HPAI H5N1 virus are less likely to become infected, are less likely to excrete virus (in fact most do not excrete virus) and, if they do excrete, will excrete lower quantities of virus than

their non-vaccinated counterparts (it is usual to obtain at least a 100-fold reduction in the amount of virus excreted).

If H5N1 HPAI virus enters a vaccinated flock it will encounter birds that have an increased resistance to infection, which reduces the likelihood of birds becoming infected. If some birds do become infected the quantity of virus they excrete is reduced, reducing the risk of onward transmission. In properly vaccinated poultry exposed to field virus, infection is highly unlikely to proceed through the flock.

Concerns have been expressed that the use of vaccination against HPAI virus in birds might lead to the emergence of mutant strains that are more likely to transmit from person to person. Influenza viruses undergo spontaneous mutation when they multiply. Selection pressures do occur when vaccines are used against viruses, but these pressures also occur during natural infection. However, it is unlikely that vaccination of poultry will exert a selection pressure on the cell receptor of the HA protein that might lead to an increase in the transmissibility of the virus to mammals. Thus vaccination can actually reduce the opportunity for natural mutation or reassortment by reducing the quantity of circulating virus.

To overcome these concerns, FAO recommends implementation of surveillance systems that measure the response to vaccination and detect the presence of field virus in clinically normal vaccinated poultry. FAO further recommends that viruses isolated be fully characterized at an appropriate OIE/FAO or WHO reference laboratory to provide early warning of any significant antigenic or genetic changes that might be occurring.

## 6. ADOPTION OF THE MOST APPROPRIATE CONTROL STRATEGIES

### 6.1 Basic principles

The strategy adopted by governments concerning their countries, zones or compartments is determined by the perceived importance of the disease politically, socially and economically. Issues that must be considered include public health, economics, sustainability of farming enterprises and adverse publicity associated with repeated outbreaks of the disease. This paper focuses largely on the technical issues.

FAO recommends that the following items be addressed in all control programmes for HPAI:

- HPAI is notifiable; appropriate penalties for non-compliance are considered
- If “stamping out” is used, farmers are compensated in some form (direct or indirect) for loss of stock
- Probity and accountability in government decision-making and use of public funds
- Effective surveillance and reporting to OIE according to member country obligations.

It is likely that the policies adopted to control HPAI will vary over time. FAO recommends that disease control strategies be developed iteratively, in light of experience, advances in scientific knowledge, changes in international standards and evolution of the disease situation. For example, a country that embarks on eradication after the first incursion of virus may add vaccination as an additional control measure if repeated incursions occur or appear to be inevitable, thus providing additional protection for its commercial poultry.

The response to detection of infection or disease should also vary with the local situation. In a country where infection is endemic and vaccination is practised, FAO recommends that the detection of virus in domestic waterfowl not automatically lead to the destruction of the infected flock. This is particularly the case if the positive result is obtained as part of a planned surveillance programme that is designed to assess the prevalence of infection. The decision on disposition of the infected birds should be based on an assessment of the risk to human and public health and the economic costs, and benefits, of maintaining the flock. On the other hand, a country that is free of HPAI infection would normally destroy all poultry found to be infected.

## 6.2. Disease eradication

Although it is possible to eradicate specific AI viruses (including H5N1 viruses) from compartments or countries and keep them free of disease for extended periods of time, it is likely to be impossible to eradicate H5N1 HPAI virus from the entire Asian region in the near future. This means that countries or compartments that are free of infection and those that do eradicate the virus will continue to be at risk of reinfection and will be obliged to implement measures to prevent viral incursion.

In the case of a new occurrence of infection in country or compartment that is historically free of HPAI, eradication is an appropriate immediate objective. Particularly for countries such as Japan and South Korea, which are historically HPAI-free and located at a distance from infected countries, this strategy is feasible. The investment of resources in active surveillance, enabling early detection of incursions and quick implementation of control measures greatly improves the prospect of eradication. FAO recommends that the system for management of disease incursions be based on systematic contingency planning, including the conduct of disease simulation exercises.

In developing strategies for the control and eradication of HPAI, FAO recommends that governments conduct a risk assessment, taking into account the likelihood of reinfection and the economic costs and benefits of implementing the strategies needed to mitigate these risks.

## 6.3 Moving from control to eradication

Countries or compartments with high levels of infection may approach control in a progressive manner, first reducing the level of infection before moving to eradication. This may include the use of vaccine. Enhanced targeted surveillance must be part of an official vaccination programme and will provide a better understanding of the risk faced if/when vaccination is withdrawn. It is essential to have a good understanding of the nature and extent of reservoirs of infection before embarking on a programme of HPAI eradication.

## 6.4 Developing a vaccination element in a control strategy

The main objectives of vaccination are to reduce the production losses caused by the disease, to reduce the risk of spread of AI virus to animals and humans by reducing the shedding of viruses in the environment, to create (by way of vaccine induced immunity) barriers between infected and free areas/compartments and to help in the control and eradication of the disease. As already noted, several measures must be used in combination to control or prevent this disease. If vaccination is adopted, it must be used in conjunction with the other measures.

It is difficult to prescribe a set of rules for vaccination of poultry against HPAI that cover all situations. However, FAO recommends that the following fundamental principles (which should be adapted to suit national or regional objectives) be considered in developing a vaccination strategy:

- Vaccination can not be used as a panacea or in isolation from other measures that must be be applied in the face of ongoing outbreaks (e.g. stamping out, biosecurity, disinfection).
- Flocks of birds that are infected must not be vaccinated.
- The vaccination strategy should be developed in consultation with all stakeholders, including the private sector.
- The types of poultry and production sectors to be vaccinated must be determined and clearly documented.
- Sufficient quantities of appropriate vaccines must be available for the planned duration of the vaccination programme.
- Countries may develop their own vaccines and reagents but these should be subject to appropriate QA/QC measures as specified by the OIE.
- Countries or regions may consider 'banking' of vaccine and appropriate diagnostic tests and reagents.
- A surveillance strategy must be developed that includes the capacity to identify and monitor both field exposure to HPAI and the use of vaccine.
- Logistic arrangements must be in place for delivery and administration of vaccine.
- The effectiveness of the vaccination strategy should be reviewed within an appropriate timeframe. It is suggested that initially 12 months of vaccination should be completed before this assessment is done to allow for the influence of seasonal factors.
- An exit strategy (after which vaccine would no longer be used) should be identified.
- OIE recommendations should be followed, including in relation to the implementation of a DIVA strategy.

Three broad vaccination strategies may be described:

i) vaccination in response to an outbreak

This may involve vaccination around an infected area (ring vaccination) or vaccination of only designated, high-risk poultry (which may include village chickens), in combination with destruction of infected poultry. The objective is to bring the disease under control as quickly as possible with a view to subsequent eradication.

ii) vaccination in response to a defined 'trigger'

Early warning of a viral incursion may be provided via targeted surveillance of high-risk birds (e.g. unexpected mortalities in domestic waterfowl, wild birds or poultry in live bird markets). This may trigger the use of prophylactic vaccination to prevent cases of infection in domestic poultry. Village chickens may be included in such a vaccination scheme.

For example, vaccination might commence after detecting H5N1 HPAI virus in dead wild waterfowl in an area near poultry farms before virus is detected in chickens on these farms.

In both of these situations, an adequate supply of appropriate vaccine must be kept on hand for emergency purposes.

When performing emergency vaccination, chickens of all ages must be vaccinated. Experience from Hong Kong suggests that the response to a single dose of vaccine can be poor in older chickens. Time is also needed for immunity to develop in the vaccinated birds. Up to 2 weeks is required for flock immunity to develop to a sufficient level to protect the majority of the chickens.

iii) "baseline" vaccination

Pre-emptive "baseline" vaccination of all or part of a population of poultry may be used if the risk of infection is high and/or the consequences of infection are very serious. This approach might be considered in the following circumstances:

- protection of valued genetic material (grand-parent and parent breeder chicken flocks)
- restocking village chickens after stamping out and/or large scale losses due to disease
- safeguarding zoological collections
- to protect long-lived chickens, such as commercial layers and breeder flocks, in areas subject to high viral challenge (e.g. due to infected waterfowl or unsecured borders with infected countries)

As stated above, the need for vaccination should be reviewed regularly and an exit strategy developed, even if the exit point (i.e. halting vaccination) is not likely to be reached for several years.

## 7. CONCLUSIONS

In determining the strategy for control of H5N1 HPAI, all available control measures should be considered and those that are feasible and likely to be cost effective in the local situation should be adopted. The selection of measures should be based on risk assessment and a thorough understanding of the HPAI status in the country or compartment. Stamping out and vaccination are not mutually exclusive. Targeted vaccination has considerable value as part of a phased response strategy, allowing veterinary authorities to bring infection under control as a preliminary step on the road to eradication in specified compartments or the entire country, as appropriate to the circumstances.

## ANNEX 1

| FAO Conclusions and Recommendations | Section |
|---|---|
| In regions/countries where HPAI occurs, the overall objective, even if a long term one, should be eradication of the virus and recovery and rehabilitation of the production sector. | 1 |
| The strategy to be employed can only be decided once the epidemiology of the disease and ecology of the virus are fully understood. Therefore, FAO recommends acceleration and intensification of investigations into<br>- the significance of H5N1 infection of pigs, and<br>- the role played by wild birds and domestic waterfowl in the maintenance and spread of HPAI viruses. | 1 |
| The strategies chosen by veterinary authorities to control H5N1 HPAI are determined by a number of factors including the following:<br>• The level of infection<br>• The presence of wildlife reservoirs<br>• Farming and marketing systems<br>• Likelihood of infection or re-infection<br>• Involvement in international trade<br>• Animal health infrastructure<br>• Economic, Political and Social issues<br>• Public health issues | 2 |
| Based on farm biosecurity and the system used to market products, FAO has broadly defined four production sectors. | 2.3 |
| Veterinary authorities must implement disease awareness programmes that clearly explain the reasons for reporting disease and the consequences for those reporting. | 2.6 |
| Economic, political and social issues have a significant impact on the choice and implementation of strategies. Analysis of the costs and benefits is recommended to provide guidance on the most appropriate approach to control and eradication. | 2.7 |
| WHO and relevant national human health authorities should be consulted on strategies that are implemented by Veterinary Authorities to protect public health in responding to H5N1 HPAI. | 2.8 |
| FAO recommends a general strengthening of animal disease surveillance and more emphasis on timely reporting to the OIE and other International (FAO) and Regional Organizations. | 4.1 |
| Control of H5N1 HPAI is achieved by reducing the amount of virus circulating in poultry and on farms. Measures such as stamping out, cleaning, disinfection and vaccination are implemented to reduce the amount of virus present. Additional measures, such as movement controls, enhanced biosecurity and, as appropriate, vaccination are implemented to create barriers between uninfected poultry and foci of infection | 4.1 |
| As a transboundary animal disease H5N1 HPAI must be managed on a regional basis — ideally through the formation of regional epidemiological and laboratory networks. | 4.1.1 |
| Countries should adopt minimum, standardized requirements for diagnosis and surveillance of HPAI as set out in the document "Guiding Principles for Diagnosis and Surveillance of Highly Pathogenic Avian Influenza" (conclusions of the FAO Expert Meeting, 21-23 July 2004, Bangkok) | 4.1.1 |

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| Official Veterinary Services are key players in this process. There must be a strong chain of command and scientific capabilities and infrastructure related to disease diagnosis, surveillance, data analysis, reporting, and disease control must be continually reinforced and augmented. | |
| Emergency preparedness planning requires preparation, in advance, of both generic and disease-specific contingency plans and operating procedures. | 4.2 |
| FAO recommends that Veterinary Services conduct animal disease simulations to give staff practical experience in emergency response. | 4.2 |
| Control strategies for avian influenza must be based on knowledge of the major pathways of spread of the virus. Spread appears to be most efficient via faeces and by direct contact between birds. | 4.3 |
| Special care must be taken to prevent contaminated equipment or people wearing contaminated clothing and footwear from entering farms. | 4.3 |
| FAO recommends against the destruction of wild birds to control HPAI. | 4.3 |
| The main measures to prevent, control and eradicate H5N1 HPAI are:<br>• Efficient disease surveillance for early detection and reporting of outbreaks<br>• Enhanced biosecurity of poultry farms and associated premises.<br>• Control of movement of birds and products that may contain virus, including controls at the interface of infected and uninfected areas.<br>• Changes to industry practices to reduce risk.<br>• Rapid, humane destruction of infected poultry and poultry at high risk of infection.<br>• Disposal of carcases and potentially infective material in a biosecure and environmentally acceptable manner.<br>• The proper use of vaccination.<br><br>None of these risk reduction measures, implemented alone, will be sufficient to prevent, control or eradicate HPAI. | 4.4 |
| Steps should be taken to exclude vermin, pet animals and wild birds from poultry sheds. | 4.4.1 |
| Certain sectors e.g. village-based poultry production are not biosecure and other measures may be required to prevent infection in these sectors. | 4.4.1 |
| Wild waterfowl should be excluded from ponds or, if this cannot be done, drinking water for poultry that is obtained from these sources should be treated, e.g. with ultraviolet radiation or chlorination. | 4.4.1 |
| All commercial poultry farms should develop and implement a formal biosecurity plan as appropriate to the farm. | 4.4.1 |
| In situations of high viral challenge, targeted vaccination may be the most appropriate means of ‘dampening down’ an HPAI outbreak. | 4.4.1 |
| Controls on movement of people, poultry and objects from the infected place and the area surrounding the infected place should be implemented in response to an HPAI outbreak. | 4.4.2 |
| When an HPAI outbreak occurs, live bird markets in the area around the outbreak and those linked to the outbreak should be closed. If there is reason to suspect that infected birds have been in the market, the facilities should be depopulated, thoroughly cleaned and disinfected. | 4.4.2.1 |
| Controls on the international movement of birds and products should be based on OIE recommendations and Veterinary Authorities should consider the possibility of “leakage” across borders when developing disease control and prevention strategies.. | 4.4.2.2 |

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| Veterinary authorities should critically review industry practices (e.g. poultry production, transportation and marketing) in infected and "at risk" countries and compartments to assess how they might be modified to reduce risk. | 4.4.3 |
| FAO recommends the adoption of requirements for live bird markets, similar to those introduced in Hong Kong and Macau, with the goal of breaking the chain of transmission of AI and other poultry pathogens. | 4.4.3 (i) |
| FAO recommends that the practice of raising, transporting and marketing waterfowl and quail with other poultry be limited or prohibited. FAO recommends against the rearing, transport and marketing of pigs and domestic poultry together. | 4.4.3 (ii) |
| Pigs that are reared on premises where poultry are found to be infected with HPAI should be subject to official veterinary inspection. Pigs with clinical disease suggestive of influenza should be destroyed and samples submitted for laboratory diagnosis. Otherwise, samples from normal pigs on these farms should be tested to rule out the possibility of sub-clinical infection with H5N1 HPAI. If active infection is confirmed in any of these pigs the herd should be destroyed | 4.4.3 (ii) |
| If there is active infection with HPAI in sector 3 or 4 poultry farms and/or evidence of a high prevalence of infection in wild birds, Veterinary Services should consider establishing 'poultry-free zones' around commercial farms. Alternatively, vaccination programmes could target backyard/village chickens to minimize disease propagation by this sector. | 4.4.3 (iii) |
| FAO recommends that, where possible, commercial farms operate on an 'all-in, all-out' basis and that catchers and other workers coming into direct contact with poultry practise strict biosecurity before entering and at the time of leaving farms. | 4.4.3 (iii) |
| Poultry cages, farm structures and equipment should be constructed of materials that can be easily cleaned and disinfected. There should be facilities for cleaning and disinfection of transport cages before they are taken back to farms and an official system for monitoring its effectiveness. | 4.4.3 (iii) |
| Stamping out is likely to be successful when it is implemented rapidly, before secondary spread, and combined with rigorous movement controls, proper decontamination of infected farms and careful monitoring and surveillance. | 4.4.4 |
| FAO recommends that policy on the culling of "at risk" poultry as part of a stamping out policy be risk based, taking into account the likelihood that the birds are infected. | 4.4.4 |
| When diagnosis can be presumptively based on clinical, pathological and epidemiological evidence, FAO recommends that culling not be delayed while awaiting laboratory confirmation of infection with HPAI. Samples should be taken before or at the time of culling to enable retrospective analysis of the infection status of the flocks destroyed. | 4.4.4 |
| FAO recommends that Veterinary Authorities take steps to obtain the necessary legal authority to destroy infected poultry and, if required, those on surrounding farms. | 4.4.4 |
| Countries should ensure that workers contacting potentially infected poultry wear appropriate personal protective equipment in accordance with WHO recommendations and receive training in the correct fitting of this equipment. | 4.4.4 |

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| FAO recommends compliance with WHO advice on the vaccination of workers on infected farms with current human influenza virus vaccines before anticipated exposure to AI viruses in a response to HPAI, including advice on the vaccination of workers with current human influenza vaccines. | 4.4.4 |
| Veterinary Authorities should conform with recommendations of WHO and relevant national health organizations with respect to public health considerations in responding to HPAI. | 4.4.4 |
| The method used for destruction of poultry should be humane and should not cause spread of disease. Asphyxiation using carbon dioxide is the method of choice for destruction of chickens. Physical methods such as cervical dislocation using cattle castration forceps are preferable for the humane destruction of waterfowl. Destruction of infected poultry should be performed on site. Sites where destruction is taking place must be secure to prevent unauthorised entry or exit of people and vehicles. | 4.4.4.1 |
| Before the destruction of poultry for disease control, samples should be submitted for laboratory testing and all investigations that rely on the presence of live birds should be completed. | 4.4.4.1 |
| Accurate records of the age and type of birds killed and, as appropriate, records of valuation, should be kept to facilitate payment of compensation in situations where this may be required. | 4.4.4.1 |
| Cleaning and disinfection of infected places and equipment are a crucial part of control strategies for avian influenza. Farms that have been cleaned and disinfected should be the subject of an official inspection before restocking is permitted. Effective cleaning results in no visible feathers or faeces remaining in the shed. | 4.4.5.3 |
| Restocking should not occur less than 21 days following completion of cleaning and disinfection after destocking. | 4.4.5.3 |
| Recognizing that it may not be either desirable or feasible to proceed with massive culling in some situations, vaccination is a suitable option. | 5 |
| The main objectives of vaccination are to reduce production losses caused by the disease and to reduce the risk of spread of AI viruses to animals and humans by reducing the shedding of viruses in the environment. | 5.1 |
| Vaccination reduces susceptibility to infection and decreases shedding (both in duration and titre) and is therefore an appropriate tool to reduce the incidence of new cases and viral load in the environment. This reduces the potential for spread to humans. | 5.2 |
| Vaccination can be used either as a tool to support eradication or as a tool to control the disease and reduce the viral load in the environment. Controlling the disease through vaccination may be a prelude to eradication. | 5.2 |
| Unvaccinated identified sentinel birds must be kept in vaccinated flocks and there must be a monitoring system in place to assess the effectiveness of vaccination, to check sentinel birds and to detect the presence of field virus in clinically normal vaccinated poultry. | 5.2 |
| Veterinary authorities should satisfy themselves that any vaccine used has been produced in accordance with the OIE *Manual of Standards for Diagnostic Tests and Vaccines*. | 5.3 |
| FAO recommends that purchasers of vaccines assure themselves of the quality assurance procedures applied by manufacturers and of the performance characteristics in the field of all vaccines under consideration. | 5.3 |
| Vaccination teams should be trained in biosecurity measures, in vaccination procedures and in public health measures, including the correct use of personal protective equipment (PPE). | 5.4 |

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| Detailed records of vaccination (number and species vaccinated, location, date, identification numbers of sentinel birds etc.) should be recorded and entered in relevant databases. | 5.4 |
| In assessing the risk of infection, veterinary authorities must consider whether H5N1 virus is present and whether there are reservoirs of infection within the country/compartment under consideration. | 5.5 |
| The level of biosecurity on poultry farms, the density of poultry and the value of birds are relevant to veterinary authorities' decisions on the use of vaccination. | 5.5 |
| In situations of high HPAI challenge FAO recommends that all measures be taken to protect high value birds, including increased biosecurity and, as appropriate to the circumstances, vaccination. Where biosecurity is insufficient to prevent infection, vaccination of broilers may be considered. | 5.6 |
| Further research is urgently needed to determine the effectiveness of existing vaccines in ducks. Until such research is completed it is not possible to provide firm recommendations on the use of AI vaccines in ducks. | 5.6 |
| In the situation where stamping out cannot be quickly achieved at the country level and other strategies, including vaccination, must be considered, the use of vaccine does not imply automatic loss of export markets. However this is subject to full compliance with the strict application of the compartmentalisation concept (see footnote 4 and section 2.5). | 5.7 |
| Active surveillance using the DIVA strategy; the placement of identified, unvaccinated sentinel chickens within vaccinated flocks and strict record-keeping are key elements in establishing the separation of compartments and ensuring and demonstrating that notifiable AI viruses are not circulating in any compartment from which export is proposed or occurring. | 5.7 |
| Properly vaccinated chickens subsequently inoculated with HPAI H5N1 virus are less likely to become infected, are less likely to excrete virus and, if they do excrete, will excrete less virus than non-vaccinated chickens. | 5.8 |
| FAO recommends that HPAI control programmes address the following:<br>• Effective surveillance and reporting to OIE<br>• HPAI is notifiable; appropriate penalties for non-compliance are considered<br>• If "stamping out" is used, farmers are compensated in some form (direct or indirect) for loss of stock<br>• Probity and accountability in government decision-making and use of public funds. | 5.8 |
| FAO recommends that all viruses isolated be fully characterized at an appropriate OIE/FAO or WHO reference laboratory to provide early warning of significant antigenic or genetic changes. | 5.8 |

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| Unvaccinated identified sentinel birds must be kept in vaccinated flocks and there must be a monitoring system in place to assess the effectiveness of vaccination, to check sentinel birds and to detect the presence of field virus in clinically normal vaccinated poultry. | 6.2 |
| For vaccination programmes, FAO makes the following recommendations:<br>• Vaccination can not be used as a panacea or in isolation from other measures that must be be applied in the face of ongoing outbreaks (e.g. stamping out, biosecurity, disinfection).<br>• Flocks of birds that are infected must not be vaccinated.<br>• The vaccination strategy should be developed in consultation with all stakeholders, including the private sector.<br>• The types of poultry and production sectors to be vaccinated must be determined and clearly documented.<br>• Sufficient quantities of appropriate vaccines must be available for the planned duration of the vaccination programme.<br>• Countries may develop their own vaccines and reagents but these should be subject to appropriate QA/QC measures as specified by the OIE.<br>• Countries or regions may consider 'banking' of vaccines and appropriate diagnostic tests and reagents.<br>• A surveillance strategy must be developed that includes the capacity to identify and monitor both field exposure to HPAI and the use of vaccine.<br>• Logistic arrangements must be in place for delivery and administration of vaccine.<br>• The effectiveness of the vaccination strategy should be reviewed within an appropriate timeframe. It is suggested that initially 12 months of vaccination should be completed before this assessment is done to allow for the influence of seasonal factors.<br>• An exit strategy (after which vaccine would no longer be used) should be identified.<br>• OIE recommendations should be followed, including on the implementation of a DIVA strategy. | 6.4 |
| Three broad vaccination strategies may be described:<br>i) vaccination in response to an outbreak<br>ii) vaccination in response to a defined 'trigger'<br>iii) pre-emptive "baseline" vaccination. | 6.4 |
| In determining the appropriate strategy for control of H5N1 HPAI, all available control measures should be considered and those that are feasible and likely to be cost effective in the local situation should be adopted. | 7 |

LIST OF ABBREVIATIONS

| | |
|---|---|
| AI | Avian influenza |
| ASEAN | Association of Southeast Asian Nations |
| DIVA | Differentiating infected from vaccinated animals |
| EMPRES | Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases |
| EMPRES-*i* | EMPRES Global Animal Disease Information System |
| FAO | Food and Agricultural Organization of the United Nations |
| GEMP | Good Emergency Management Practice |
| H | Haemagglutinin type of an influenzas virus (e.g. H5) |
| HPAI | Highly pathogenic avian influenza |
| LPAI | Low pathogenic avian influenza |
| N | Neuraminidase type of an influenza virus (e.g. N1) |
| NAI | Notifiable avian influenza |
| OIE | World Organisation for Animal Health (Office International des Epizooties) |
| PRC | People's Republic of China |
| QA/QC | Quality assurance/Quality control |
| SAARC | South Asian Association for Regional Cooperation |
| TAD | Transboundary animal disease |
| TCP | Technical cooperation programme |
| Terrestrial Code | Terrestrial Animal Health Code 13$^{th}$ Edition OIE 2004 |
| WHO | World Health Organization |

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