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paper

APPROACHES TO CONTROLLING, PREVENTING AND ELIMINATING H5N1 HIGHLY PATHOGENIC AVIAN INFLUENZA IN ENDEMIC COUNTRIES

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APPROACHES TO CONTROLLING, PREVENTING AND ELIMINATING H5N1 HIGHLY PATHOGENIC AVIAN INFLUENZA IN ENDEMIC COUNTRIES

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Contents

Foreword

The appearance of H5N1 highly pathogenic avian influenza (HPAI) in southeast Asia in 2003/2004, and its subsequent spread to Europe, Middle East, Africa and South Asia destroyed poultry flocks, had an adverse economic impact on countries exposed to the disease, exacerbated poverty and put public health at risk, leading to over 300 deaths, and the unknown potential for a human influenza pandemic of avian origin.

FAO's collaborative HPAI Global Programme has contributed significantly to limiting the impact of the disease, establishing stronger national systems, and strengthening regional coordination for disease preparedness, prevention and control. The programme has been implemented through 170 projects, actively involving more than 130 countries, of which more than 60 have experienced outbreaks of H5N1 HPAI since 2004.

With the continuous support of the international donor community, national governments, regional and international organizations, development agencies, and international development banks, sustained coordinated action has progressively reduced the number of countries affected by H5N1 HPAI. This was achieved by assisting national veterinary services to develop preparedness and contingency plans, improving surveillance systems, acquiring laboratory resources and disease diagnosis capacity, developing response capabilities, communication and awareness, and promoting biosecurity along the value chain.

Currently, there are at least six countries – Bangladesh, the People's Republic of China, Egypt, India, Indonesia and Viet Nam – where the virus is entrenched, and a number of other countries experiencing sporadic outbreaks. It is expected that for most of the endemic countries and their affected regions, it will take several years, if not decades, to achieve freedom from the virus.

Since its onset, knowledge generated on H5N1 HPAI has increased considerably, with an impact on the disease, including in reducing outbreaks in poultry and human cases.

This document reflects the new knowledge, and is the first detailed and comprehensive analysis of the specific features of countries in which the disease has become entrenched, and the constraints for its elimination. This paper also proposes goals for the next few critical years, and a framework of innovative approaches and activities to control and ultimately, eliminate the virus in each of the six countries.

The preparation of this document was initiated in April 2010 by FAO's regional Emergency Centre for Transboundary Animal Diseases team based in the Regional Office for Asia and the Pacific (ECTAD-RAP), including experiences from Egypt.

We hope that this document will be a useful source of information for all countries in implementing measures to prepare for, prevent and control HPAI.

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We would like to express particular thanks to Les Sims, the FAO consultant who was the principal writer of the Paper; ECTAD RAP Regional Manager, Subhash Morzaria, and team members for initiating, leading and coordinating the process for developing the Paper; and Team Leaders/Chief Technical Advisors of the six countries for their significant technical inputs and for coordinating Country Team inputs; together with FAO Headquarters staff for reviewing the Paper.

We hope that this document will be a useful source of information for the endemic countries in implementing measures to prepare for, prevent and control HPAI.

Acronyms and abbreviations

ASEAN	Association of Southeast Asian Nations (ASEAN)
AVS	Additional veterinary surgeons (Bangladesh)
BCC	Behaviour change communication
C&D	Cleaning and disinfection
CAHO	Community animal health outreach (Egypt)
CAHW	Community animal health workers
CIRAD	French Agricultural Research Centre for International Development
DAH	Department of Animal Health (Viet Nam)
DGLS	Director General of Livestock Services (Indonesia)
DIVA	Differentiating between infected and vaccinated animals
DLP	Department of Livestock Production (Viet Nam)
DVE	Duck virus enteritis
EIDs	Emerging infectious diseases
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot-and-mouth-disease
GETS	Gathering evidence for a transitional strategy (Viet Nam)
GOVS	General Organization of Veterinary Services (Egypt)
HPAI	Highly pathogenic avian influenza
H5N1 HPAI	H5N1 virus sub-type of HPAI
IMCAPI	International Ministerial Conference on Avian and Pandemic Influenza (Hanoi, 2010)
ISO	International Organization for Standardization
KAP	Knowledge attitudes and practices study
LDCCs	Local Disease Control Centres (Indonesia)
LIFSAP	Livestock Competitiveness and Food Safety Project (Viet Nam)
LPAI	Low pathogenic avian influenza
MMWR	Morbidity and mortality weekly report (Viet Nam)
MoALR	Ministry of Agriculture and Land Reclamation (Egypt)
NCBI	National Center for Biotechnology Information (Bangladesh)
NCVD	National Centre for Veterinary Diagnostics (Viet Nam)
OFFLU	OIE/FAO network on animal influenza
OIE	World Organisation for Animal Health
PCR	Polymerase chain reaction
PDSR	Participatory disease surveillance and response
Perda	*Peraturan Daerah* (local government regulations in Indonesia)
PRRS	Porcine reproductive and respiratory syndrome
PVS	OIE performance of veterinary services
siRNA	Short interfering ribonucleic acid

SMS	Short message service
SOP	Standard operating procedures
TADs	Transboundary animal diseases
TOT	Training of trainers
ULO	*Upazila* livestock officers (Bangladesh)
USAID	United States Agency for International Development
VAHIP	Vietnam Avian and Human Influenza Control and Preparedness Project
WHO	World Health Organization

Executive summary

At its peak, highly pathogenic avian influenza (HPAI) caused by viruses of the H5N1 subtype was reported from over 60 countries in 2006. Since then, most affected countries have eliminated the disease, some more than once as a result of multiple incursions of virus. However, in at least six countries in Asia and Africa (the People's Republic of China, Viet Nam in the Greater Mekong subregion, Indonesia in southeast Asia, Bangladesh and India in the Indo-Gangetic Plain, and Egypt in North Africa) H5N1 HPAI virus has remained entrenched, and these countries remain endemic for the disease. It is expected that for most of these countries and their respective regions, it will take a few years to achieve freedom from the virus.

Three main factors have been identified that inhibit progress towards the elimination of H5N1 HPAI virus in the endemically infected countries.

The **first factor** is the structure of the poultry sector. Endemically infected countries generally have the following characteristics, caused in part by the rapid increase in demand for poultry and the unregulated growth of the poultry sector:

- Production and market chains are complex and poorly integrated, with a large demand for locally produced poultry and poultry products.
- A high proportion of poultry are reared and sold under conditions that afford little protection from influenza viruses.
- A significant proportion of the poultry in the country/subregion, such as domestic ducks and poultry in infected markets and collectors yards do not display symptoms of the disease when infected.
- Supporting institutions such as producer and service provider associations are weak.

Changes are being made to the poultry sector (covering both production and marketing) that will reduce the risk of infection with H5N1 HPAI but they will not eliminate all high risk practices such as free-grazing ducks) or prevent all cases of infection with H5N1 HPAI viruses. A study on some of the agro-ecological factors that are associated with persistence of H5N1 viruses (Hogerwerf *et al*. 2010) identified a number of factors that appear to be related to endemicity[1].

The **second factor** is the quality of public and private veterinary and animal production services, which have limited capacity to identify and respond to all cases of infection, fully understand the drivers of value chains and implement needed changes to production and marketing systems. The capacity for systematic outbreak investigation is inadequate and disease investigations and tracing rarely identify the source(s) of infection.

In most endemically infected countries limited linkages exist between the public and private sector, especially between government and the large commercial sector. Disease

[1] The study identified six variables that correlate with virus persistence: agricultural population density, duck density, duck by chicken density, chicken density, and the product of agricultural population density and chicken output/input ratio, and purchasing power per capita.

monitoring and surveillance systems only provide a partial picture of disease/infection status. Disease reporting systems rely on reports of disease from producers, many of whom are wary after unhappy past experiences with government veterinary services, especially those that carried out mass culling or offered poor compensation for poultry destroyed. Border controls and laboratory capacity are also affected by the quality of veterinary services although the latter, in particular, has been subject to considerable investment and improvement in recent years.

The **third factor** is the level of commitment within the poultry sector, governments and the public towards the elimination of H5N1 HPAI viruses. The fear of H5N1 HPAI does not necessarily translate into concrete plans for virus control and elimination. Among the exceptions are those producers who perceive economic benefits in keeping their poultry infection-free, especially if this determines access to markets. Support for the type of measures needed to eliminate H5N1 HPAI from zones or entire endemically infected countries will be half-hearted until most farmers regard H5N1 HPAI as a serious threat to their livelihoods and well being. Strong public support is a prerequisite for the elimination of the virus from endemically infected countries.

Although measures have been introduced in all endemically infected countries to address these three factors, all require further long term commitments and investment if the virus is to be eliminated. It is now generally accepted that the H5N1 HPAI virus is unlikely to be eliminated from poultry in these countries and regions for the next ten years at least.

To move forward, each of the endemically infected countries should implement activities that take them closer to virus elimination and reduce the prevalence of disease in poultry and humans, progressively building on the gains made since they first reported cases of disease. The Food and Agriculture Organization of the United Nations (FAO), in association with national authorities, has developed a framework, based on experiences gained so far in endemically infected countries, covering activities that, if adopted, will help to move each country along the path towards virus elimination. The framework proposed for each of the endemically infected countries/subregions is included as annexes.

Each framework comprises a mix of measures aimed at outbreak control and responses (which remain necessary whenever new outbreaks occur), gathering and analysing information (such as surveillance, disease investigations, other epidemiological studies, market chain studies and factors that influence disease reporting including compensation) and disease prevention and risk reduction. Better information allows control and preventive measures to be targeted at the areas facing the greatest threat from the disease and thus improve the focus of risk-based interventions. The framework for each country is tailored to account for local differences in the poultry sector, the stage of development of the H5N1 HPAI programme, socio-political characteristics and also the strengths and weaknesses in both the public and private sector. However, each activity has clear objectives to enable measurement of progress and to ensure that countries remain focused on the goal of virus elimination. All the activities proposed develop capacity for handling other emerging and re-emerging diseases.

As the virus is unlikely to be eliminated from poultry for some time the risk of emergence of a human pandemic strain from an avian virus will persist and will need manage-

ment. The extended time frame until viruses can be eliminated provides opportunities for research into new and innovative measures for the control and prevention of H5N1 HPAI and influenza A (H5N1). This includes better vaccines that can be delivered easily in the various poultry production sectors and do not require multiple injections of individual birds; methods of developing virus resistance in poultry through genetic manipulation and selection; or universal influenza vaccines for humans that protect against different influenza virus subtypes, therefore minimizing the risk from the virus to human health.

For endemically infected countries in which it may take several years to bring about changes to the way poultry are reared and sold, it may be necessary to explore unconventional control methods. The alternative long-term prospects described above, as well as other novel solutions for control, should be considered because there is no guarantee that the current incremental approach will eliminate H5N1 HPAI, especially if the three main limiting factors are not or cannot be addressed fully. The actions taken will not only assist in containing H5N1 HPAI but also in controlling and preventing other diseases.

Introduction

It is seven years since highly pathogenic avian influenza (HPAI) caused by viruses of the H5N1 subtype spread rapidly in east and southeast Asia. Of the nine countries that first reported infections in 2003-2004, three remain endemically infected[2]: the People's Republic of China, Indonesia and Viet Nam. Cambodia has reported sporadic cases since 2004 and recently reported its largest single outbreak among free grazing ducks near its border with Viet Nam. Japan, the Republic of Korea and Malaysia experienced several incursions of the H5N1 HPAI virus, all of which were eliminated. Thailand last reported disease in late-2008 and the Lao People's Democratic Republic in 2010; both countries also had multiple incursions of H5N1 HPAI since 2003-04 based on genetic analysis of virus isolates (see Boltz *et al*. 2010 and Suwannakarn *et al*. 2009).

Since 2005, a number of other Asian countries have reported cases of H5N1 HPAI, including Afghanistan, Bangladesh, India, Myanmar and Pakistan, and most recently Bhutan and Nepal. Parts of the Indo-Gangetic Plain region centred on the Ganges Delta (covering Bangladesh and West Bengal) are now also regarded as being endemically infected. At least two separate virus incursions have been reported in Nepal (World Health Organization [WHO] 2010). Some countries that have reported disease, such as Myanmar and Nepal, are at risk of becoming or may already be endemically infected.

A number of elements that inhibit progress towards disease control, prevention and eradication are common to the endemically infected countries/regions. These factors make disease eradication in these countries a long-term goal, a situation that has been recognized for some time (Sims 2007, FAO 2007, FAO 2008) and acknowledged by governments in the region. The Government of Viet Nam states in its Integrated Operational Plan for Avian and Human Influenza for 2006-2010[3] that it does not expect to eradicate the H5N1 HPAI virus from poultry in the five years covered by the plan but would move along the path towards that long-term goal. The People's Republic of China has opted for a programme built around mass vaccination that will contain but not eliminate H5N1 HPAI.

The need for a long-term approach is also reflected in the FAO/World Organisation for Animal Health (OIE) Global Strategy (FAO 2008[4]) which recommends that all endemically infected countries develop an adaptive plan with milestones describing how they will progressively control and eliminate H5N1 HPAI viruses (see text box below). These recommendations remain valid. In addition, given the transboundary nature of HPAI and the fact that many countries share the same disease ecology and epidemiology, long-term national strategies must be linked with cross-border collaboration and regional approaches to disease control. This approach is compatible with the recently revised FAO 'Regional Strategy

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[2] H5N1 HPAI virus has been detected in surveillance testing each year since 2004.

[3] Available at http://www.avianinfluenza.org.vn/start-download/ahi-documents/integrated-national-operational-plan-for-avian-and-human-influenza-green-book-engish-version.html

[4] Available at ftp://ftp.fao.org/docrep/fao/011/aj134e/aj134e00.pdf

for Highly Pathogenic Avian Influenza and Other Emerging Infectious Diseases of Animals in Asia and the Pacific' (FAO 2010).

BOX 1

The FAO/OIE Global Strategy on H5N1 HPAI and endemically infected countries

The Global Strategy for Prevention and Control of H5N1 HPAI issued in 2008, described endemically infected countries and made the following recommendations:

A number of countries infected with Asian-lineage H5N1 HPAI viruses have remained infected with H5N1 HPAI viruses for one year or more since the first incursion into domestic poultry, with some remaining infected for five years or longer. These countries have all implemented measures to reduce the level of infection but they pose an ongoing threat to other countries and to other parts of their own country unless progress towards elimination continues.

Elimination of infection from these countries will require many years of consistent engagement and support. A medium- to long-term approach (rather than just an emergency response) is needed to contain HPAI in these countries and subregions.

This requires:

- The continued building of capacities in key institutions, including better functioning veterinary services with the necessary powers to implement essential control measures and regulations.
- Sustainable adjustments to the poultry sector to reduce the risks of disease and infection in settings where commercial poultry production and marketing practices carry high risks of HPAI.
- Effective engagement of private sector stakeholders (including industrial poultry producers) in these risk reduction efforts.
- Sustained political commitment from the highest level of government, reflected in provision of appropriate resource allocations and enforceable regulations.
- The application of appropriate interim control measures including vaccination, to contain infection.

All of these countries must have a sound long-term technical strategy and workplan that is appropriate for local conditions and adaptively managed, addressing how H5N1 HPAI viruses will be progressively contained and high risk practices modified.

In devising this plan:

- The control and preventive methods applied must be science-based, technically feasible, grounded in an assessment of local situations, and designed to minimize gender, social, environmental and economic impacts.
- All points in the production and marketing chain should be examined to assess areas of high risk and to determine why the infection has remained entrenched/endemic.
- Planning and implementation should closely involve all key stakeholders in the poultry sector.
- Special attention must be paid to alleviating the impact of control measures on vulnerable human populations, which is possible if proper planning and analysis of proposed measures is done through the adoption of a long-term approach to disease control (allowing time for adverse effects of measures to be assessed and mitigated before they are implemented).

Current H5N1 HPAI status

Although most endemically infected countries do not have specific plans for eliminating the virus (a reflection in part of the length of the pathway and the uncertainties around the disease's behaviour), most have short-term to medium-term plans or strategies in place for the control and prevention of H5N1 HPAI.

All endemically infected countries have made progress in understanding, controlling and preventing this disease but the gains represent only small steps towards eliminating the virus in the country and the region.

FAO continues to support the concept of progressive control of H5N1 HPAI and encourages all endemically infected countries to develop timelines with milestones showing how they will reduce endemicity and increasingly develop defined disease-free compartments or zones. Concurrently, countries should continue with long-term interventions in capacity building, improving understanding of infection and transmission dynamics, developing appropriate biosecurity and hygiene measures for farms and markets, and improving early detection, diagnosis and response to this disease. The interventions adopted will vary from country to country and will need to be responsive to local conditions. However, many common factors have now been identified that endemically infected countries can consider.

This paper explores what is known about the epidemiology of H5N1 HPAI relevant to the control and prevention of the disease in endemically infected countries. It provides information on their current infection status, lessons learned in the past five years on the factors that assist and constrain disease control, and provides an assessment of the areas where progress can be made towards global eradication. The goal is to provide guidance to endemically infected countries on the way forward and to also describe how FAO can continue to assist endemically infected countries in moving towards better control and prevention of this disease and eventually virus elimination. It also addresses the problem of a number of other countries that are sporadically infected or at risk of being infected due to their proximity to the endemic countries. A summary of this information is provided in the main document and is expanded for each country in individual country annexes.

Valuable information can be gleaned from analysis of the spatial and temporal pattern of reports of disease, provided care is taken when interpreting and comparing data.

The situation by country/region and by the presence of different strains of H5N1 HPAI virus (virus clades) based on available data is provided below, with a more detailed country-by-country description in individual country annexes.

VIET NAM

Viet Nam first reported H5N1 HPAI in 2004 but by then the disease was already widespread. The temporal pattern of reported outbreaks of disease is provided in Figure 1 and shows a marked reduction in reported cases of disease since the initial peak in 2004.

So far in 2010 there have been no major changes in the number of human and avian

cases or of provinces reporting disease when compared with previous years.

BANGLADESH AND WEST BENGAL (INDIA) – (INDO-GANGETIC PLAIN CENTRED ON AND AROUND THE GANGES DELTA)

The first reported cases of H5N1 HPAI in Bangladesh occurred in 2007. Since then new cases have been reported each year with a peak in 2008. A seasonal pattern is discernible with fewer cases in the autumn.

Outbreaks have been recorded in West Bengal each year since 2008 and have been addressed by wide area culling. Disease has also been recorded in Nepal (2009 and 2010) and Bhutan (2010).

The pattern for reported disease outbreaks for 2009-2010 is provided in Figure 2.

All H5N1 HPAI viruses examined so far from Bangladesh and India fell within Clade 2.2 (Biswas *et al*. 2008, Chakrabarti *et al*. 2009). One of the recent viruses from Nepal fell within Clade 2.3.2 (WHO 2010).

PEOPLE'S REPUBLIC OF CHINA

The People's Republic of China was the first country to detect H5N1 HPAI viruses in Asia (in 1996) and experienced the first reported outbreaks of disease in 2004. Each year since then there has been a gradual reduction in the number of reported outbreaks of disease. The winter of 2009-10 was noteworthy because no outbreaks of disease in poultry were recorded and there were no reported human cases (Table 1). Wild bird cases were reported in Qinghai in May 2009 and in Tibet in May 2010. Only two wild bird cases were detected in Hong Kong Special Administrative Region (SAR) since December 2009 through the intensive dead bird monitoring programme, which is lower than in previous years.

It is important to analyse and understand why no cases in poultry or humans were reported in the winter of 2009-10 because many of the factors that should lead to persistence of H5N1 HPAI are still present. These include the large population of ducks reared outdoors; the presence of H5N1 HPAI in markets detected through the national surveillance programme as recently as January 2010 (38 isolates from markets from 13 provinces); and the large rural population with many small flocks of poultry reared with few biosecurity measures in place (See Official Veterinary Bulletin [2010], Jiang *et al*. 2010).

Vaccination continues and improvements have been made to market management but it is unlikely that the level of vaccination coverage across the country or the market improvements were capable of preventing all cases of infection and disease.

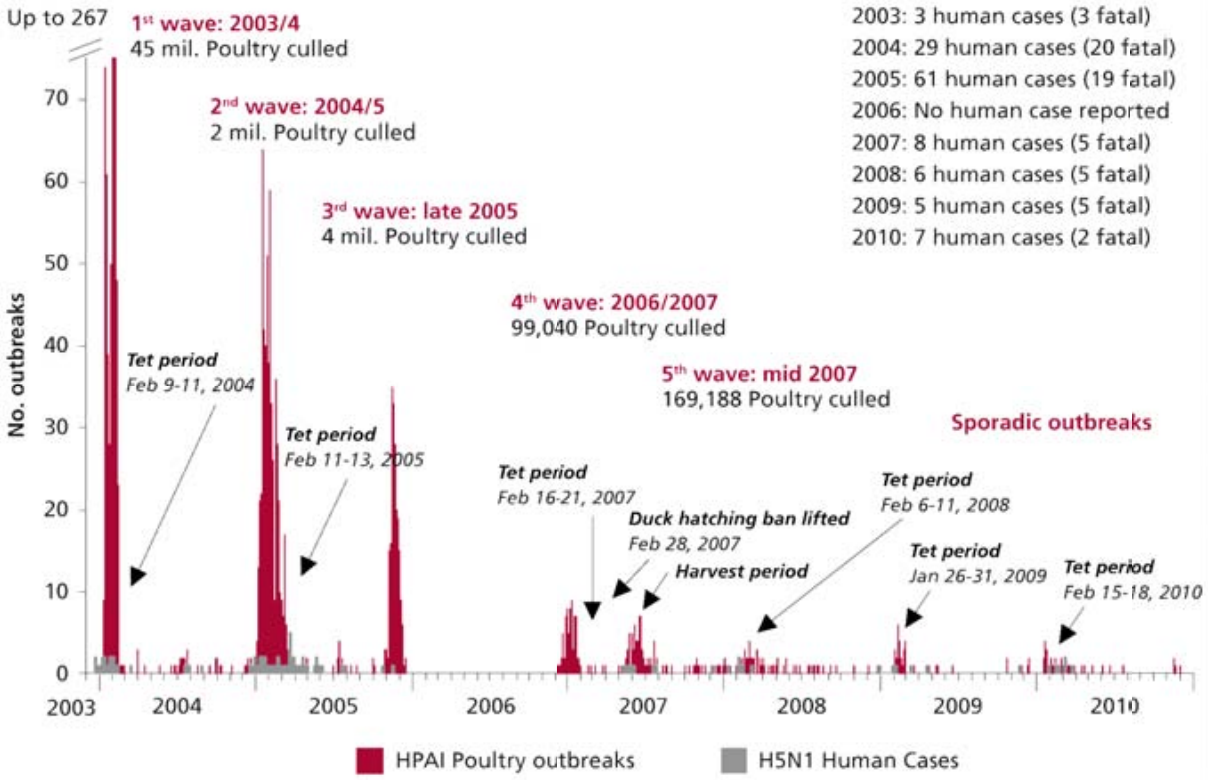
TABLE 1
Reported outbreaks of H5N1 HPAI in the People's Republic of China 2003 – June 2010

	2003	2004	2005	2006	2007	2008	2009	2010
Confirmed H5N1 HPAI poultry outbreaks	0	50	31	10	4	8	2	--
Confirmed H5N1 HPAI human cases	1*	0	8	13	5	4	7	1

* unconfirmed case

FIGURE 1

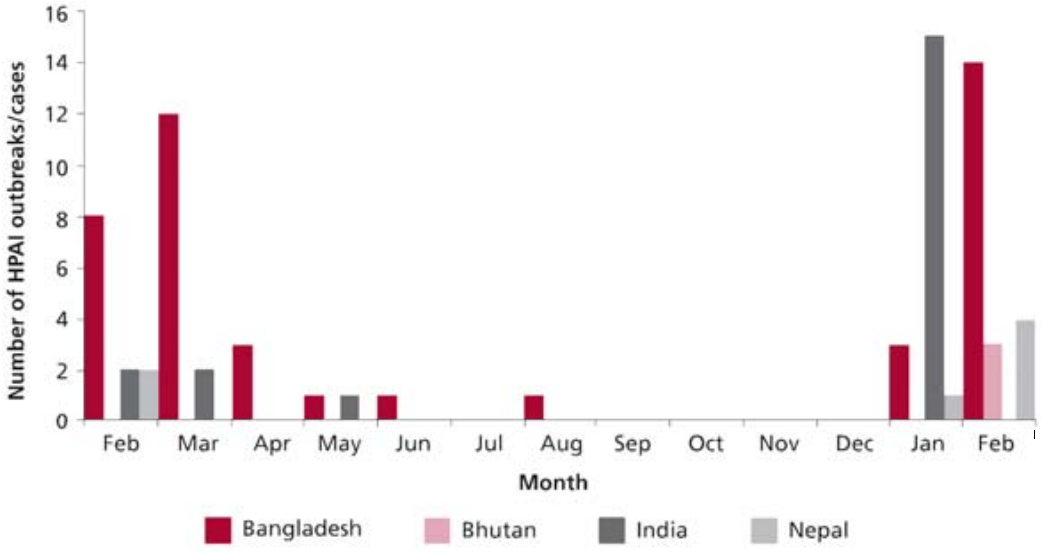
Temporal pattern of reported outbreaks of H5N1 HPAI in Viet Nam (2003-2010)



Data source: DAH and WHO (update 31 December 2010)

FIGURE 2

Reported outbreaks of H5N1 HPAI (2009-2010) in four South Asian countries



INDONESIA

Indonesia continues to report H5N1 HPAI outbreaks in poultry as it has for the past six years (Table 2). H5N1 HPAI Clade 2.1 is endemic on the islands of Java, Sumatra and Sulawesi, with sporadic outbreaks reported elsewhere. H5N1 HPAI incidence by village varies widely. Only two of Indonesia's 33 provinces have never reported any outbreaks of H5N1 HPAI. The high level of monthly reports is partially explained by the Participatory Disease Surveillance and Response (PDSR) programme that enlists the participation of village poultry production systems (mainly backyard) in reporting evidence of virus circulation in the village (Figure 3). PDSR operates in 378 of 496 (76 percent) districts through 31 Local Disease Control Centres (LDCCs) in 29 (88 percent) of 33 provinces in Java, Sumatra, Bali, Sulawesi, Kalimantan and the Eastern Islands, including all known endemic areas. Larger and less densely-populated provinces report HPAI outbreaks less often than more densely populated provinces.

EGYPT

Egypt reported the first H5N1 HPAI outbreak in February 2006. Despite a vigorous initial response to the disease, including the culling of over 40 million birds, H5N1 HPAI has not been eliminated and outbreaks are regularly reported from different governorates. In February 2010, 113 H5 HPAI outbreaks were observed in poultry (chickens, ducks and turkeys) from 17 governorates. Of these, 93 (82 percent) were reported from the household poultry sector. During February 2010, Community Animal Health Outreach (CAHO) teams visited 88 villages in 10 governorates and detected 28 (25 percent) of the above-reported confirmed outbreaks. CAHO teams operate in high-risk governorates and collect samples only from suspected cases.

VIRUSES BY CLADE

Several scientific papers providing useful information on gene sequences have been published recently, including reports on genetic and antigenic characterization of viruses globally (WHO 2010, WHO 2009a, WHO 2009b), and specific papers on viruses from Lao People's Democratic Republic (Boltz *et al*., 2010), China (Li *et al*. 2010, Jiang *et al*. 2010), India (Chakrabarti *et al*., 2009), Thailand (Suwannakarn *et al*., 2009), Cambodia (Buchy *et*

TABLE 2

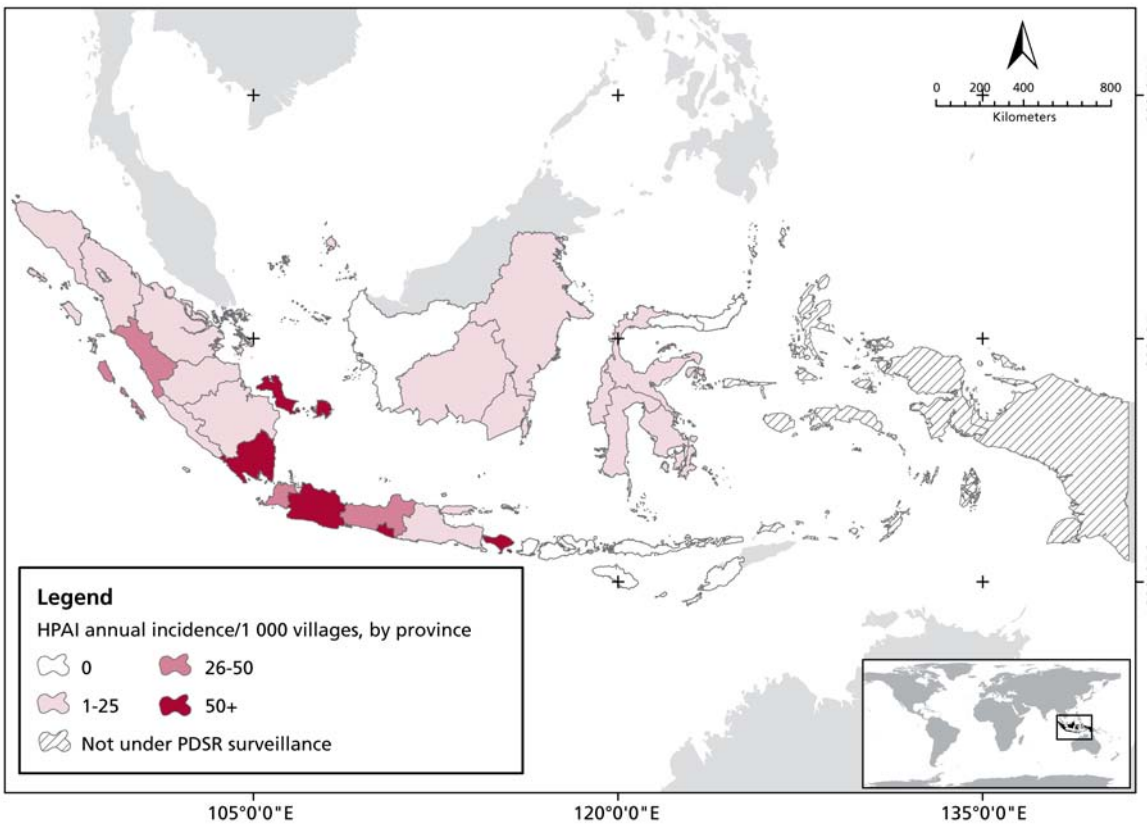
Confirmed cases of H5N1 HPAI before (dark shade) and after (light shade) introduction of the PDSR programme in Indonesia

	2003	2004	2005	2006	2007	2008	2009	2010 to mid-April
Confirmed H5N1 HPAI poultry outbreaks	60	166	159	611	2 751	1 745	2 054	575
Confirmed Influenza A(H5N1) human cases	0	0	20	55	42	24	21	1

al., 2009) and Viet Nam (Dung *et al*., 2008, Nguyen *et al*., 2009) provide detailed historic information on viruses from these countries. Figure 4 provides a simple summary of different virus strains (referred to as clades [WHO 2008]) based on characterization of H5 gene sequences detected in poultry and wild birds in 2009 and 2010. Mapping of information on different viruses (such as that produced in Boltz *et al*., 2010) linking genetic information of the viruses to specific locations has not been done in most endemically infected countries (Figure 4).

Clade 1 viruses continue to circulate in the lower Mekong area and have done so since 2003-04. In northern Viet Nam, Clade 1 viruses have not been detected since 2005. The most severe outbreak recorded in Cambodia so far involving the death of more than 16 000 ducks from disease occurred in early 2010. Only Clade 2.1 viruses continue to circulate in Indonesia (but currently not in any other country), with the majority (78 percent) classified as Clade 2.1.3, suggesting a single introduction event with subsequent evolution in-country, and demonstrating that these viruses have remained endemic in Indonesia since they were first detected in 2003. It also suggests that wild bird transmission of viruses from

FIGURE 3
Indonesia - HPAI cumulative incidence per 1000 villages, by province (May 2009 – April 2010)



Source: PDSR database: 01 May 2009 – 30 April 2010.
Date created: 01/05/2010

Indonesia back to mainland Asia or further south does not occur and that there is probably minimal movement of (infected) poultry out of the country. Clade 2.1 viruses are continuing to evolve in Indonesia with new third order clades detected along with antigenic variants.

Clade 2.2 viruses have not been isolated from wild birds since March 2009 in the areas where they had been detected previously (including Europe), suggesting that these viruses have not persisted in the wild bird population. Clade 2.2.1 viruses are endemic in poultry in parts of Egypt providing a potential source of virus for other countries in the region.

Clade 2.2 viruses have also persisted in Bangladesh since 2007 and have recurred annually in West Bengal since 2008. Multiple virus introductions to India are suspected with significant differences between viruses detected in different years and different parts of the country. Molecular evidence points to cross-border transmission from Bangladesh followed

BOX 2

Factors that affect the quality of surveillance and disease reporting data in endemically infected countries

Surveillance and reporting systems vary markedly between countries. Not all cases of disease and infection are detected or reported for a range of reasons. Even within countries, differences exist in the capacity of veterinary services at the subnational level to detect and report infection and disease. Unless allowance is made for these differences and inevitable gaps in the surveillance and disease reporting systems, mistakes will be made when analysing data. For example, Indonesia conducts intensive surveillance of village and small-scale flocks through its Participatory Disease Surveillance and Response (PDSR), a programme which does not involve the major large-scale commercial producers. As a result, reports of H5N1 HPAI cases are skewed towards the smallholder/village sector. Variations between teams in different districts are also inevitable. The responsiveness of passive surveillance to outbreaks in village poultry through PDSR is not matched by any of the other developing countries, rendering impossible comparison of Indonesia's results with those from other countries.

Viet Nam has a decentralised administrative system with each province responsible for implementing animal health and production policies and directives from the central and provincial levels within the province. Commune-based animal health workers (mainly private sector) report outbreaks of disease but variation exists between provinces in reporting capacity and not all cases detected at provincial level are reported centrally.

Variations also occur in the information that is reported officially to OIE. For example, the People's Republic of China reports outbreaks of clinical disease to OIE but only provides information on positive cases from active surveillance programmes in the monthly Official Veterinary Bulletin produced by the Ministry of Agriculture.

In endemically infected countries where vaccination is practised, reported H5N1 HPAI outbreaks in most cases represent flocks where the vaccine has not been used

by local dissemination and evolution of viruses. Sporadic outbreaks with Clade 2.2 viruses have been reported in Nepal since 2009. Recently in 2010, Clade 2.2 viruses were detected in Bhutan. For these countries, India is believed to be the origin, given the significant one-way trade of poultry and poultry products from there.

Clade 2.3.2 viruses have extended their range in Asia to the north and west since 2008. A wild bird cycle of infection with Clade 2.3.2 viruses seems possible with westward spread in 2009/2010. These viruses were found in a number of countries for the first time in 2008 (Japan, Lao People's Democratic Republic, Russia and the Republic of Korea). They were detected in Pikas in Qinghai in the People's Republic of China in 2007 (Zhou *et al*. 2009) and in wild birds in Hong Kong SAR each year from 2006 onwards. In 2009, they were found in Hong Kong SAR in both wild birds and poultry washed ashore on isolated beach-

(given that vaccination reduces the likelihood of clinical signs) or where an antigenic variant has emerged (e.g. Shanxi in the People's Republic of China in 2006).

Cases are rare among humans, since they are relatively resistant to the Influenza A (H5N1) virus. Nevertheless, human cases still provide information on places where infection in poultry is occurring, sometimes in the absence of reports of disease in poultry. In some countries human cases are probably due to undetected infection among poultry in markets, as was reported in a case control study of human cases in the People's Republic of China (Zhou *et al*. 2009b).

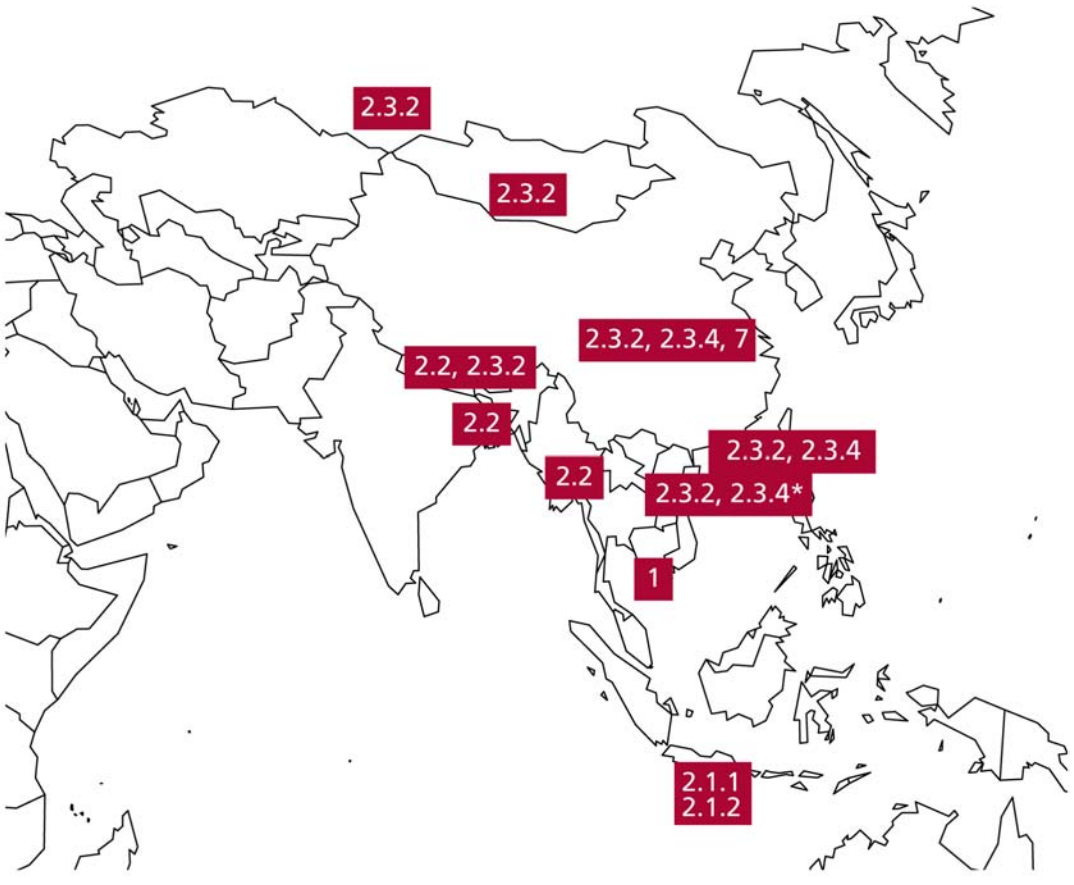
Information on the molecular characteristics of H5N1 HPAI viruses also provides valuable information but remains incomplete, with comprehensive data on viruses from Viet Nam (2009 onwards) and Indonesia (late-2009 to 2010) still not available in the public domain or in the scientific literature (see WHO 2010). Given the technology available in laboratories in most endemically infected countries and the support available from international reference laboratories, there is no technological reason why virus gene sequences should not be available more rapidly. In some places, gene sequence information is often available within a few days of virus isolation or receipt of a swab. As the genetic information provides valuable clues to links between outbreaks and also on the possible origin of viruses, it should be determined as quickly as possible after any outbreak and on samples detected through surveillance testing. There is also considerable lag time between detection of Polymerase chain reaction (PCR) positive samples and virus culture in some countries which may be one factor in the relatively low rate of recovery of viruses from samples that are PCR positive seen in some countries. Only some of the PCR-positive, culture negative samples are sent to national or international reference laboratories for further assessment. A search on the Global Initiative on Sharing All Influenza Data (GISAID) system and Genbank reveals a disproportionate number of sequences of H5N1 HPAI viruses from Egypt from 2009 onwards, reflecting a philosophy of rapidly uploading sequence information among the laboratories conducting the sequence analyses for this country.

es, Mongolia (in wild birds), Russia and Viet Nam (in poultry; the first detections since 2005, suggesting another virus incursion). One human case in Guangxi, the People's Republic of China, was caused by a Clade 2.3.2 virus and active surveillance in 2009 revealed more Clade 2.3.2 viruses than Clade 2.3.4 in poultry. Clade 2.3.2 was found in Romania in 2010 as well as in Nepal. Information on how the Clade 2.3.2 virus arrived in Nepal is not yet available but a wild bird introduction is possible given the absence of such viruses in surrounding countries with which trade in poultry occurs and the location of outbreaks near lakes that are home to migratory birds during the northern winter.

Clade 2.3.4 viruses continue to be the dominant strain in northern Viet Nam and are present in the People's Republic of China (Jiang *et al*. 2010), including one human case in Hunan province in 2009 (WHO 2010). Antigenic variants of Clade 2.3.4 viruses were detected in Hong Kong with low grade disease in some vaccinated poultry in 2008 (WHO 2010).

A number of viruses from poultry in northern Viet Nam in 2008 from smuggled poultry fall within Clade 7. Clade 7 viruses are also circulating in China. It has been proposed that viruses within this clade should be sub-divided into two second order clades (7.1 and 7.2) (Li *et al*. 2010).

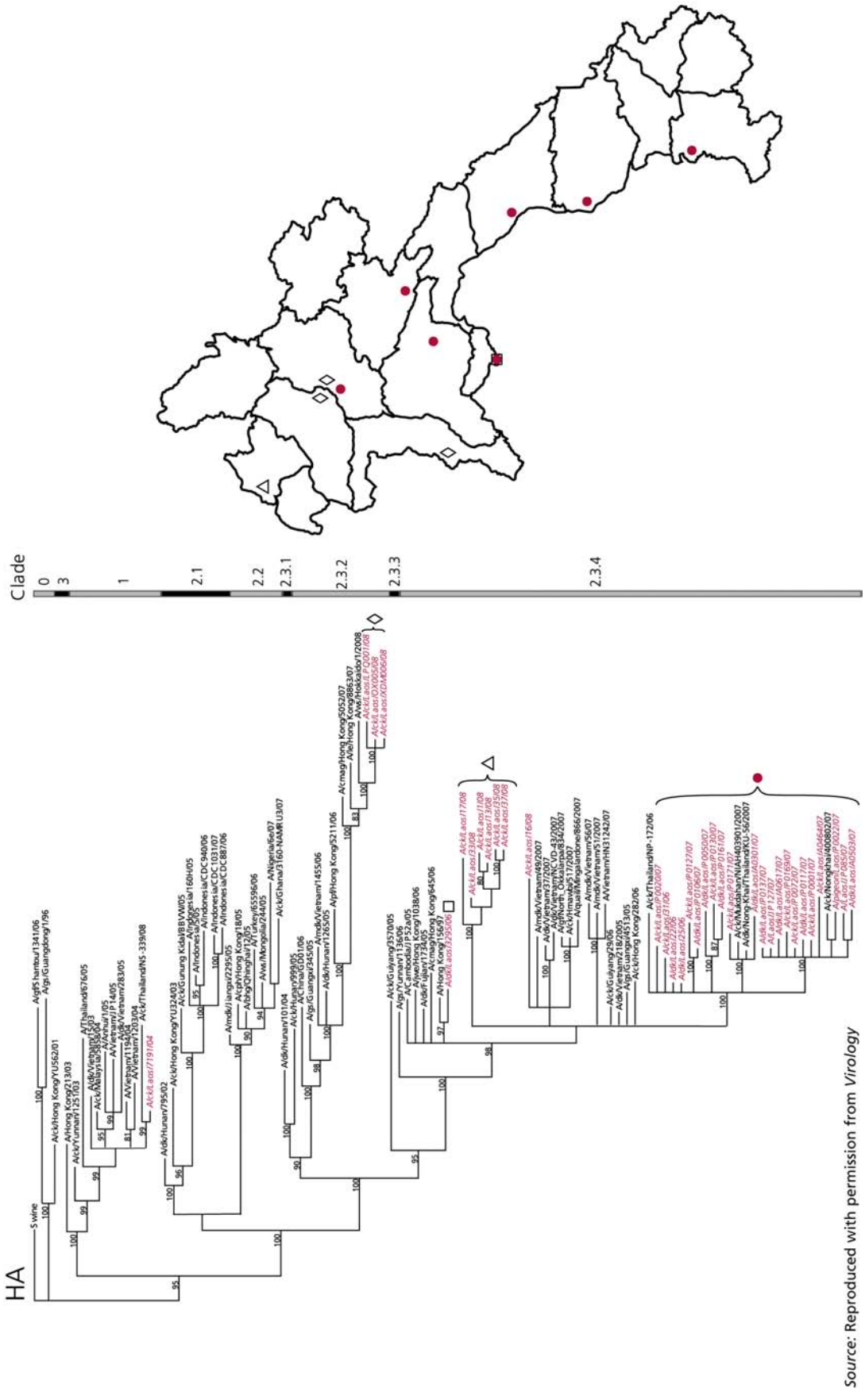
FIGURE 4
Viruses by HA Clade in Asia (2009-2010)



* Limited data available from 2010

FIGURE 5

Linking genetic material with spatial data – Lao People's Democratic Republic



Source: Reproduced with permission from *Virology*

Other clades not yet detected in 2009-10 are Clades 0, 2.3.1, 2.3.3, 2.4, 2.5, 3, 4, 5, 6, 8, and 9. The People's Republic of China has recorded the greatest genetic diversity of H5N1 HPAI viruses with all the clades mentioned being detected in different parts of the country over the past eight years.

GENOTYPES

A range of reassortant H5N1 HPAI viruses has been detected in the past but information remains incomplete for 2009-10. A standardized nomenclature for H5N1 HPAI virus genotypes has not been devised. Using the system initially developed in Hong Kong (Guan *et al*. 2009) Genotypes Z, V and G have dominated since the mid-2000's but other reassortant viruses have also been detected. There is evidence of reassortment in Viet Nam between Clade 1 and Clade 2.3.4 viruses, suggesting co-circulation (Dung *et al*. 2008). A recent report from Lao provides information on reassortants in that country (Boltz *et al*. 2010). Clade 2.3.2 viruses isolated in wild birds in Japan are also reassortants with Clade 2.3.4 viruses (Usui *et al*. 2009). A recent paper reviewing the history of reassortment events and evolution of H5N1 HPAI viruses demonstrates that many genotypes have emerged and disappeared since 1997; this process is continuing (Neumann *et al*. 2010).

Knowledge generated, lessons learned during the past five years

The panzootic of H5N1 HPAI has generated a huge amount of information on the virus and its control. In the scientific literature alone, a search for 'H5N1' and 'avian' entered into PubMed will retrieve over 2 600 papers. If the considerable information in the 'grey' literature, including consultants' reports, media reports and websites is added to the formal literature, the extent of the information (and in some cases misinformation) available becomes even more apparent. In addition, historical information on HPAI is also pertinent to the control, prevention and elimination of H5N1 HPAI viruses.

The following section distils some of the important knowledge acquired and lessons learned from experiences with H5N1 HPAI in endemically infected countries and elsewhere, that is relevant to disease control and eradication. Additional information on individual countries is provided in the country Annexes.

Historical information and lessons learned

HPAI is not a new disease: it was widespread in the early part of the 20th century in Europe and the USA. It was from these outbreaks that the role of trade and movement of poultry and items associated with poultry in the spread of the disease became clear. For instance, the rail network in the US was crucial for the movement of poultry and spread of the disease (the same role played in modern times by international air travel). In the early 20th century the cause of HPAI was not known and surveillance relied on detection of clinical disease, but it was still possible to eradicate the virus through hygiene measures and movement controls.

It is possible to control and eliminate some diseases, including HPAI, even with major gaps in knowledge about the pathogens that cause the disease.

Trade in poultry and the movement of contaminated materials remain key transmission pathways.

The current H5N1 HPAI panzootic has affected many countries across a vast geographical area including three continents. With a few exceptions (described below) the behaviour of this virus is similar to that in other outbreaks of HPAI. A major difference is that the disease was already widespread and entrenched well before concerted attempts were made to eliminate it from the countries that are now regarded as endemically infected. This was due mainly to weaknesses in disease reporting systems, compounded by the nature of the production and marketing systems. These factors are discussed in detail below.

H5N1 HPAI viruses were well entrenched in countries such as Indonesia and Viet Nam before disease was reported and control measures were implemented, making elimination very difficult to achieve

The first known H5N1 HPAI virus in Asia was detected in 1996 from sick geese in Guangdong province. However, it was not until 1997, when H5N1 HPAI viruses caused severe disease in poultry and humans in Hong Kong, that global attention began to focus on the virus, largely due to fear that it could lead to a human pandemic. Hong Kong's strain of H5N1 HPAI was eradicated following a complete cull of commercial chickens there and closure of all markets for seven weeks. This was the first demonstration that H5N1 HPAI could be eliminated locally.

When trade in poultry in Hong Kong resumed, major improvements in market hygiene, controls on poultry movement and sources, segregation of terrestrial poultry from domestic waterfowl, bans on the sale of wild birds for food, and improved farm biosecurity all helped to reduce the risk of reinfection.

The preventive measures implemented in Hong Kong were based on knowledge of the characteristics of avian influenza viruses from first principles and depended on a thorough understanding of the way poultry were reared and sold.

The knowledge and experiences gained from Hong Kong were used in developing control and preventive policies as H5N1 HPAI spread across Asia from 2003 onwards. It was evident that complex, poorly regulated and high-volume production and marketing systems contributed to the spread and persistence of H5N1 HPAI. It was also apparent that many of the changes that were implemented in Hong Kong could not be easily replicated in the countries now considered to be endemically infected because of the large scale of production, low levels of biosecurity in facilities, and the high volume of trade in live poultry, generally through poorly regulated markets.

Understanding production and marketing systems and improving these systems is vital if gains are to be made in the control and prevention of H5N1 HPAI in endemically infected countries.

Spread of H5N1 HPAI viruses from 2003 onwards

During 2003-2004, outbreaks of H5N1 HPAI were reported from nine Asian countries. The route of introduction for most of these remains unknown but it is clear from molecular studies that different virus strains were spreading independently of each other over the region. For example, outbreaks in Thailand were not directly linked to those in Indonesia.

Some countries successfully eliminated H5N1 HPAI; others have remained infected since they reported their first outbreaks.

Improved understanding of production and marketing systems, socio-economic drivers, and infections and transmission dynamics across borders is important in the efficient control of disease across regions.

Features of endemically infected countries

The poultry sectors of countries that became endemically infected shared many similarities with Hong Kong in 1997, albeit on a much larger scale. These included lack of controls on poultry movement, inadequate biosecurity and hygiene measures on most farms, and

the sale of large numbers of poultry through poorly regulated and unhygienic live poultry markets that were seldom emptied of poultry. Market chains were complex and often involved collectors who mixed up their surplus birds and kept them together in depots and yards. Transport vehicles and cages were poorly cleaned, if at all. All of these issues have since been resolved in Hong Kong but persist in parts of the endemically infected countries.

Some of the worst markets operating in 2003-2004 in endemically infected countries have since been closed while some are being rebuilt or renovated. Others remain open and continue to pose a threat as demonstrated by the isolation of the virus through market surveillance in the People's Republic of China, Egypt and Viet Nam, and through collector yard surveillance in Indonesia.

Although the People's Republic of China, Indonesia and Viet Nam are described as endemically infected countries, in some areas of these countries infection is absent or at best intermittent. Typically, these are places with low concentrations of poultry, such as eastern Indonesia, and Tibet in the People's Republic of China. Even if veterinary services in these parts of the country are deficient, the disease can be contained because there are not enough new avian hosts available to sustain the infection cycle. The virus will, however, return easily if the movement of poultry from infected areas is poorly controlled or if poultry rearing practices allow domestic poultry to be exposed to infected wild birds (see below).

Well-managed farms in endemically infected countries can remain free from infection through stringent farm biosecurity measures and, in some cases, vaccination, as evident in areas of intensive production in Shandong province in the People's Republic of China.

As a rule, the movement of poultry or items associated with poultry should be considered the most likely source of all new outbreaks of H5N1 HPAI in endemically infected countries, but in some places infected wild birds have certainly been the gateway for the introduction of the virus (such as Xinjiang in the People's Republic of China), followed by secondary spread through trade in poultry.

Endemically infected countries have a high proportion of poultry reared and sold under conditions of poor biosecurity offering little defences against influenza viruses, including very large 'backyard' poultry populations. While it is recognized that commercial poultry production plays a critical role in the maintenance and spread of H5N1 HPAI, backyard poultry can also be part of the cycle of infection, especially when there is sale and movement of backyard poultry through long and complex market chains in conditions of poor biosecurity, with unreported outbreaks. The virus may also survive among backyard poultry for extended periods due to the relatively low contact rate between individual birds.

The way poultry are reared, transported, marketed and sold has a major impact on the likelihood of being exposed to H5N1 HPAI viruses.

The role of wild birds in H5N1 HPAI transmission

Wild birds have long been known to play a role in the maintenance and transmission of low pathogenicity avian influenza viruses, but were not considered an important means of spread of HPAI, other than having a potential role in local spread when wild birds are infected by infected poultry. However, events from 2003 onwards in Asia suggest that wild birds also play some role in the transmission of the H5N1 HPAI virus over relatively long distances,

although the wild bird species responsible and mechanics of transference are still unclear.

This conclusion is based on the detection of H5N1 HPAI in wild birds in places such as lakes in Mongolia, which are devoid of poultry. It is now generally accepted that wild birds played a role in long distance transportation of virus during 2005-2006 when Clade 2.2 viruses were transferred from Asia to Europe and Africa. Multiple introductions of viruses to Japan and South Korea are best explained by wild bird introductions. The pattern of westward spread of the virus has been repeated recently with Clade 2.3.2 viruses being detected in Mongolia and Russia in 2009 and Romania in 2010.

Nevertheless, the major focus for the control and prevention of H5N1 HPAI should still be on poultry, which should be protected from contact with wild birds wherever possible to prevent avian influenza and a range of other diseases. This is not always possible within many of the production systems in endemically infected countries.

Scientific studies over recent years have yielded new information on migratory patterns of wild birds through satellite tracking of birds fitted with radio transmitters. The studies have shown that the prevalence of infection in healthy wild birds is extremely low, with levels sometimes beyond the detection of the sampling programmes. Dead wild birds remain a far more useful target, as shown by studies conducted in Hong Kong, but even here the prevalence of infection in 'routine' dead birds is low, requiring intensive surveillance to detect a small number of cases (about 1 in 1 000 or fewer dead wild birds tested are positive). Most of a range of wild birds experimentally infected with H5N1 HPAI in trials succumbed to disease but some excreted the virus for a few days before showing signs of illness.

An encouraging development is that Clade 2.2 viruses seem to have disappeared from migratory bird populations — no new cases associated with this virus have been seen in Europe in the past 12 months. So far Clade 2.3.2 viruses have not resulted in major losses in poultry in other parts of Asia and Europe, in contrast to the experience with Clade 2.2 viruses when they travelled west during 2005-2006.

Virus survival in birds and in the environment

Studies so far suggest that there is no long-term carrier state for H5N1 HPAI viruses in individual poultry[5]. It tends to kill most non-immune chickens and in warm tropical conditions the virus is unlikely to survive for more than a few weeks in the environment. Yet, H5N1 HPAI has persisted in the region, including in areas that remain hot throughout the year such as southern Viet Nam and Java in Indonesia, demonstrating that sufficient susceptible birds are available in these places to allow the viruses to cycle.

Poultry are unlikely to remain infected for extended periods (depending on the contact structure in the flock and the number of new susceptible birds introduced). Infected non-immune chickens and young ducks usually die within a few days of being infected.

Depending on the level of immunity against the circulating virus, the period of viral

[5] The longest period of viral shedding that has been recorded experimentally is 17 days in an unvaccinated duck although the possibility of excretion beyond this time under some circumstances cannot be ruled out. A recent study has suggested that influenza viruses could potentially survive on feathers coated with secretions from uropygeal glands through preening (Delogu *et al* 2010). The significance of these findings for virus survival and transmission of virus needs to be assessed.

shedding can last longer in vaccinated poultry compared to unvaccinated, but normally does not exceed 14 days. The overall quantity of virus shed by well-vaccinated birds is lower than their non-vaccinated counterparts and the infection may even die out in the flock if immune coverage is sufficient.

The role of live poultry markets

A key lesson, initially from Hong Kong but confirmed in other parts of Asia and Egypt, is that poorly managed live bird markets and traders' yards can play a major role in the persistence and transmission of the avian influenza virus especially if poultry remain in the market over 24 hours, providing opportunities for transmission within market stalls. When H5N1 HPAI became established in endemically infected countries, the prevailing systems of rearing, transporting and marketing poultry provided an ideal environment for the virus's transmission and persistence.

Market and farm hygiene measures in Hong Kong were improved after the experience of H5N1 HPAI, with regular cleaning and disinfection and market rest days during which stalls are emptied for 24 hours. However, viruses were eliminated from the live bird markets only after measures were taken to ensure that all poultry arriving in markets were from vaccinated flocks. Experiences from live poultry markets in the eastern states of the USA are also pertinent given the difficulties experienced there in eliminating low pathogenicity avian influenza viruses and preventing reinfection.

Healthy poultry arriving in infected markets can become infected and could be incubating disease at the time they are slaughtered. During slaughter, airborne particles are generated that can transmit the virus over short distances, putting other poultry and humans at risk. Items contaminated with virus excreted by infected poultry can also play a role in disease transmission.

Market hygiene (cleaning and disinfection programmes) improvements are being introduced in a number of endemically infected countries. These will help to reduce the risk of infection with the avian influenza virus but will not prevent all cases of infection.

Not all live poultry markets are equal in terms of the risk they pose. Small, well-managed markets that have strict controls over the sources of poultry do not allow overnight stays and from which no live poultry exit (other than direct to slaughter) represent a very low risk. As markets get bigger, controls on entry tend to become looser, and risks become correspondingly higher. The source of poultry is often unknown; poultry may be mixed or kept in holding stations before their arrival in the market; poultry may be allowed in the market overnight or longer; species are often mixed; and live poultry are allowed to leave the market for other destinations.

It is possible to assess, from first principles, the likely risk that a particular market would pose in an infected area by looking at the way the market operates, including the sources of poultry. A simple scoring system has been developed for markets that provide an indication of the level of risk they represent in infected areas.

It is noteworthy that Thailand, one of the countries severely affected in 2004, and that has not reported any cases for over 12 months, has few large live poultry markets. Further information on restructuring markets and market chains is provided on page 23.

The role of domestic ducks

From about 1999, the H5N1 HPAI virus became established in domestic ducks. Although infection in these birds does not always produce signs of disease, it is now recognized that ducks play an important role in the persistence and transmission of these viruses and that ducks reared outdoors in places such as the Mekong Delta are at risk of being infected.

The People's Republic of China and Viet Nam are home to about 75 percent of the global duck population. The majority of these are reared outdoors on ponds, channels and paddy fields. Some ducks are also reared in other endemically infected countries, notably Bangladesh, Egypt and Indonesia. The role they play in the persistence of infection in these countries is still being studied. Some ducks in Viet Nam travel considerable distances to graze on harvested rice fields Although individual ducks do not excrete virus for very long (see above), on a flock basis it is likely that virus could persist for an extended period depending on the age structure of the flock and the number of susceptible birds. There is considerable variation in the effects of different H5N1 HPAI viruses in ducks (e.g. studies on Indonesian viruses versus Viet Nam viruses (Bingham *et al*. 2009)) and age-related resistance to disease has been seen. Because mature ducks do not necessarily develop disease but still excrete virus when infected, active surveillance is required to detect infection. Duck farmers also have little incentive or motivation to prevent infection in their flocks, more so since infection is often sub-clinical, especially in older ducks. Studies are continuing to assess the prevalence of infection in ducks reared outdoors and the role of different duck populations (e.g. layers versus meat ducks) in the transmission and persistence of H5N1 HPAI.

Places with large numbers of domestic ducks reared outdoors appear to be at risk of becoming endemically infected with H5N1 HPAI viruses.

Information on control and preventive measures

Stamping out

The standard first line of approach to HPAI involves detecting cases early, destroying any known infected flocks after introducing movement controls to prevent onward transmission, and tracing both forward and backward to identify dangerous contact premises.

The outbreak in Hong Kong in 1997 was brought under control by stamping out the entire commercial poultry population, followed by a seven-week period in which farms and markets were thoroughly cleaned and disinfected and new equipment, such as plastic cages were introduced.

Subsequent outbreaks were contained by culling only affected and dangerous contact premises and short term market closures demonstrating that wide area culling is not always necessary to eliminate H5N1 HPAI provided good active surveillance systems are in place to detect any other infected farms and to stop poultry movement.

Controls based on stamping out were used successfully in Japan, Malaysia and South Korea to eliminate the virus, but was done early when the virus was not widespread and stamping out was supported by strong tracing programmes. These countries also had different production and marketing systems and relatively stronger veterinary services com-

pared to those which remain endemically infected.

Stamping out was also used but less successfully in places where infection was already widespread such as the People's Republic of China, Egypt and Viet Nam. The process did not eliminate the virus from these countries largely because weaknesses in disease reporting, tracing and surveillance systems made it difficult to find and destroy all infected poultry. Some poultry owners also moved or sold their poultry before action could be taken to cull their birds. Wide area culling can also alienate farmers if healthy birds are destroyed, or inadequate compensation is provided or is provided too late. Some 40 million birds were culled in both Egypt and Viet Nam when the disease was first reported. Similarly in West Bengal extensive culling of poultry, predominantly in small holder commercial and backyard poultry on a cyclical basis, is now socially and economically not acceptable to farmers.

For countries such as Bangladesh and India where vaccination is not used, case detection and stamping out remain the key platforms of HPAI control programmes. Experience from other countries has shown that success from stamping out depends on early detection and farmers' willingness to report, neither of which is guaranteed, especially where compensation is not effective or where previous experiences with stamping out exercises and with public officials has been negative.

The recurrence of H5N1 HPAI in the same areas is strong evidence that the prevailing production and marketing systems are not providing sufficient protection from virus incursions. It should be viewed as a sign of the failure of disease prevention and control mechanisms if poultry must be stamped out repeatedly in the same villages, communes or farms over a number of years. Such events justify other measures for disease prevention, including vaccination and modification of production practices, but implementation of these measures is not always practical.

Repeated outbreaks in the same area also suggest that stamping out alone will not result in sustained disease elimination because the poultry sector here will remain vulnerable to re-infection with H5N1 HPAI or similar viruses. Appropriate modifications to production and marketing methods to reduce the risk of exposure to the virus are also required in these situations.

In some endemically infected countries modified stamping out programmes have been used, reflecting the fact that infection was already widespread and well entrenched before the first cases were reported and in some cases that mass culling did not result in disease elimination. Modified stamping out involves destruction only of clinically affected flocks and those on epidemiologically linked premises. Besides being far less distressing for affected communities than area-wide culling, it also reduces risk of disease spread in the immediate vicinity and can be especially useful for outbreaks on broiler farms where farmers are prone to quickly selling off their remaining birds to salvage their investment.

As the endemically infected countries move towards disease elimination, they will need to review and modify their control and prevention strategies. However, wide area culling should be treated as an option only if the stamping out campaign has a high probability of eliminating the virus. In most endemically infected countries this will not be the case unless some modifications are also made to production and marketing systems.

Vaccination

Vaccination has been used in four of the endemically infected countries and was introduced because H5N1 HPAI was causing high and unacceptable economic losses and human infections. The following lessons have been learned regarding vaccination against H5N1 HPAI:

- Used properly[6], vaccination increases resistance of poultry to infection and markedly reduces excretion of virus if an immune bird is subsequently infected.
- If a large scale vaccination programme is poorly designed (e.g. inadequate coverage, inadequate dosage, improper age groups, etc) it will be ineffective. The mass vaccination campaign in Egypt provides a good example of the limited effectiveness of large-scale vaccination campaigns when the vaccine is not used appropriately.
- In places where vaccine programmes are being implemented, failure to vaccinate or improper vaccination schedules are more common explanations for disease breakdowns than vaccine product failures (in which immune poultry develop disease or excrete large quantities of virus). Cold chain failures have also been reported. All clinical breakdowns in vaccinated poultry should be investigated to establish whether the vaccine failure is due to the emergence of an antigenic variant or the way the vaccine was handled and administered.
- Not all producers, especially duck farmers see the need to vaccinate and therefore do not participate in vaccination campaigns.
- Some countries such as India and Bangladesh perceive the benefits in vaccination but have refrained from using it as part of their control and prevention strategy for a range of valid reasons including practical issues related to the administration of the vaccine and the nature of the poultry production sectors. Technical and cost-effectiveness issues have also influenced the decision not to use vaccination.
- Government-sponsored mass campaigns involving vaccination of village level and smallholder poultry can be implemented if they are planned properly and there is support for the campaign from all levels including public and private. This approach has been attempted in Indonesia. Mass campaigns are expensive and difficult to sustain, although the People's Republic of China has been an exception, maintaining a free vaccination service, delivering billions of doses of vaccine for years on end. However, few countries are in a position to support government-funded programmes of this magnitude.
- Mass vaccination campaigns as applied in places such as the People's Republic of China and Viet Nam will never achieve sufficient levels of population immunity across the whole country to prevent all transmission of the virus, but will protect individual flocks and reduce the number of fully susceptible poultry.
- Mass campaigns have not fared well in other countries. They were either stopped or not applied at all because the cost was too great and the chance of achieving high-level coverage across broad areas was low due to the rapid turnover of poultry. Other countries are looking at ways to modify their vaccination programmes through applied research.

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[6] Properly formulated and stored vaccines produced using good manufacturing practices (GMP) containing an appropriate antigen and adjuvant capable of generating a strong immune response to the circulating field strains and given at the recommended age.

- The high financial and human cost of sustaining a government-sponsored mass vaccination programme has resulted in some countries seeking ways to reduce their reliance on vaccination or even stop blanket vaccination ('exit strategies') and reverting to other control measures.
- Some countries, such as Indonesia, have evidence to suggest that emergency vaccination in the face of outbreaks spreads infection. Others, like the People's Republic of China, have found it an effective tool when coupled with wide area culling. If emergency vaccination is used, extreme care needs to be taken by vaccinators to avoid spreading virus, which in turn requires information on areas where the virus is and sufficient knowledge of preventive medicine in those conducting the campaign to ensure that vaccinators take appropriate measures. In places where veterinary services are still developing, this knowledge cannot be assumed.
- In several countries where vaccination has been used, antigenic variant viruses have been detected, although it is not yet clear whether the vaccine was responsible. In the People's Republic of China this problem has been addressed by introduction of new vaccine antigens. In countries such as Egypt and Indonesia, despite access to the necessary technology, it has proven difficult to make the necessary changes to vaccines quickly. Systems need to be in place to detect antigenic variants rapidly through antigenic testing and experimental challenge of vaccinated poultry with suspected antigenic variants, and to make adjustments to vaccines.
- Vaccination does not produce sterilizing immunity in all vaccinated poultry, but experimentally, a high proportion of well-vaccinated poultry with a strong immune response do not shed virus if subsequently infected.
- Vaccination can complicate serological testing. Methods for detection of infection in vaccinated flocks such as the use of sentinels and Differentiating between Infected and Vaccinated Animals (DIVA) testing, although widely promoted, are rarely used in the endemically infected countries. The sensitivity and specificity of DIVA tests for vaccines containing sub-unit antigens or containing a heterosubtypic neuraminidase (NA) antigen have not been determined under field conditions in Asia with H5N1 HPAI. Other methods may be needed as countries practising vaccination move towards virus elimination, especially if there is a transition period during which vaccination is still allowed.
- Vaccination against HPAI in large commercial farms should be regulated by the public sector regardless of the size of the farms involved or whether the farmers pay for the vaccine. Whenever possible, other means of risk reduction should also be used including enhanced farm biosecurity measures and management practices.

Decision trees developed for the introduction of vaccination for western countries do not take into account the many constraints that have to be faced in developing countries. The questions that were raised before and during implementation of the vaccination campaign in Viet Nam are well described in a study entitled *APEC AI Tool Kit Case Study on Vaccination in Viet Nam*[7], and may be of value to other endemically infected countries considering vaccination.

The strengths, weaknesses and likely effects of all control and prevention measures, including vaccination, should be assessed by endemically infected countries taking into

account local factors likely to affect implementation. If, for example, there is rapid turnover of village poultry then a state-sponsored mass vaccination campaign involving these birds are likely to be expensive and unlikely to be very effective due to the low level of population immunity that would be achieved.

Monitoring and surveillance

There has been considerable investment in surveillance for avian influenza in endemically infected countries and the work is continuing. Different monitoring and surveillance programmes are being implemented in different countries.

Surveillance testing is costly and will not yield answers to specific questions unless its purposes are clearly defined, which has not always been the case in the endemically infected countries. The goal of all surveillance should be to provide information for improving the control and prevention of the disease.

Some countries, notably the People's Republic of China, conduct significant post-vaccination monitoring of serological responses, some of it probably to assess the effectiveness of vaccination in individual flocks. This can help decide whether to revaccinate or allow poultry to go to market, as in Hong Kong where a pre-market sample is taken to ensure that live poultry going to market show evidence of a suitable immune response to vaccination. It should be noted, however, that non-random samples do not yield a reliable indication of the overall immune status of different poultry populations.

In Viet Nam at least five different donor-funded projects support poultry surveillance. This information is being integrated and analysed and will provide valuable insights into areas where viruses are known to exist and also into the epidemiology of the disease.

As described earlier, Indonesia's highly responsive passive surveillance in villages, established through its PDSR programme has provided data on cases of disease in villages and increased awareness about the extent of outbreaks that went undetected in this sector. We may expect further insights into the complex dynamics of virus spread amongst various poultry production and marketing systems as complementary tools are introduced for improving the reporting of suspected commercial farm outbreaks to local veterinary services, monitoring H5N1 HPAI in poultry markets, and conducting active surveillance via structured surveys. Programmes incorporating some of PDSR's principles are being introduced to Egypt.

Major gaps exist in the surveillance networks of most countries, where many outbreaks go unreported and high risk poultry populations remain untested or infrequently tested, thereby preventing early detection of infection. Detecting disease and detecting infection are distinctly different objectives which require different methodologies and both need to be incorporated into surveillance and disease reporting systems.

Market surveillance in Hong Kong in the past and more recently in Indonesia, the People's Republic of China and Viet Nam, has demonstrated the presence of virus in live poultry markets. No matter how much surveillance testing is done in endemically infected countries, there will always be gaps in knowledge about H5N1 HPAI and where it is occur-

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[7] Available at http://www.aitoolkit.org/site/DefaultSite/filesystem/documents/CASE%20STUDY_07-09-09%20final.pdf

ring, especially given the mobility and rapid turnover of poultry populations. Results mostly reflect the situation at a particular point in time. However, in areas with endemic infection, disease incidence measured over a suitable period and geographic area can serve as useful means of assessing the risk of new outbreaks.

As endemically infected countries move towards the establishment of disease-free zones in which the H5N1 HPAI virus has been eliminated, the extent of risk-based surveillance will need to increase to monitor the status of infection in these areas. This will also require early reporting of suspected outbreaks.

Understanding and modifying the poultry sector - production and market chain studies and value chain studies

When H5N1 HPAI emerged, government officials in technical departments generally had limited knowledge of poultry market chains. Since then, studies in endemically infected countries have demonstrated their complexity, identified key points in the chains where infection could and does occur and helped to understand the motivations of various players within the chains. This information is important for developing strategies for modifying systems to improve disease control and prevention.

In some places drastic changes have been made to marketing practices, such as closing down some live poultry markets or banning the sale of live poultry in other markets in major cities in the People's Republic of China (including Hong Kong) and Viet Nam. However, some of these changes shocked and undermined producers and traders. In future, it would be better for modifications to markets to involve and take into account the behaviours and motivations of the traders and producers who supply those markets.

Cross-border studies have also helped understand the drivers of trade, both legal and illegal. These studies are important when trade occurs with endemically infected countries or where virus is found on both sides of an international border.

The countries and areas that have had the greatest success in controlling and preventing HPAI are those in which:

- most poultry are reared under intensive conditions matched by appropriate biosecurity measures on farms; and
- tight controls on the movement of poultry are enforced, with sales of live poultry either direct to slaughter or through well-managed live poultry markets.

Implementing strict farm biosecurity measures, including isolation from other premises rearing poultry, does not prevent all cases of H5N1 HPAI, but if a case occurs on an isolated farm and is reported, it can be easily stamped out. However, in parts of Asia and in Egypt, poultry farms are located close together and there is often a mix of different farm types, with commercial farms in close proximity to village level backyard production, making it difficult to prevent the entry of viruses (bioexclusion) or their spread to other farms within the same area (biocontainment). This situation is complicated by the sale of live poultry through intermediate collector yards and markets.

Maps of poultry distribution in countries such as Indonesia and Viet Nam show a very high density of poultry in some parts of Asia. This is not necessarily an indicator of risk, which depends more on the manner in which poultry are reared and the measures in place to prevent the virus from entering farms in areas with dense poultry populations. For exam-

ple, in some parts of Asia, areas with a high poultry density may comprise single large farm complexes with all farms operating under the same strict biosecurity standards. The risk increases with multiple farms operating independently and without a consistent standard for biosecurity measures.

FAO does not recommend that all poultry be reared under industrialised conditions. It does recommend the use of appropriate, affordable and well-designed management and biosecurity systems for commercial farms, markets and places where traditional village-based flocks are reared. The measures should be designed to reduce the risk of the introduction, persistence and spread of transmissible diseases of poultry and will vary with the nature of the enterprise. Farmers need to see the benefit in implementing the measures otherwise they will not adopt them. Considerable work has been devoted to providing biosecurity information and measures, and training farmers. Models suitable for adoption by small scale producers who currently practice few biosecurity measures are being developed in Viet Nam. Structural changes to the poultry sector which will reduce the risk of infection with H5N1 HPAI will require many years to become reality in the endemically infected countries. Some changes will occur as countries become richer or more export oriented but many countries in Asia are building from a low base with most poultry reared using methods that afford little protection from H5N1 HPAI and other pathogens. Livelihood issues need to be considered when changes are driven by the government.

It is pertinent to examine the development of the poultry industry in the People's Republic of China as an example of how economic development and investment into improved farms can bring about significant changes. The richer parts of the People's Republic of China now have far fewer small and backyard farms than before, and live bird markets have been banned in the centre of large cities such as Beijing. Much of the broiler and egg industry in the country is controlled by large companies who contract farmers to grow poultry, and require them to adhere to stringent production standards and vaccination programmes. The companies employ veterinary graduates to ensure that disease does not limit productivity and to ensure that appropriate preventive measures are in place.

Yet despite these developments in the richer parts of the People's Republic of China, poultry are still reared and sold under conditions of rudimentary biosecurity in many rural areas in the less developed provinces or in remote parts of rich provinces. Given the size of the rural population – of both humans and poultry – preventing avian influenza in this part of the poultry sector is a major challenge.

CONSTRAINTS TO VIRUS CONTROL, PREVENTION AND ELIMINATION

The factors which constrain disease control, prevention and elimination in the endemically infected countries fall into three groups:

i) the structure of the poultry sector (i.e. methods of rearing and selling poultry);
ii) the quality of veterinary services and animal production services; and,
iii) the commitment from the public and the private sectors to eliminating the virus.

Each of these must be addressed if H5N1 HPAI is to be eliminated from endemically infected countries.

i) The structure of the poultry sector

In most of the endemically infected countries, the poultry sector was growing rapidly in the period before H5N1 HPAI emerged, but the growth was largely an unplanned and unregulated response to increased demands for poultry products, in some places approaching 10 percent annually.

Endemically infected countries generally share the following characteristics:

- they have complex, poorly integrated production and marketing chains with a large demand for locally produced poultry and poultry products;
- a high proportion of poultry in these countries is reared and sold under conditions that afford little protection from influenza viruses;
- most poultry in the country or subregion do not show signs of disease when infected, for example, domestic ducks and poultry in infected markets and collector yards which become infected just before or during the marketing process and are incubating disease at the time of sale; and
- they have weak supporting institutions such as producer and service provider associations.

Changes to the poultry sector, covering both production and marketing systems, that will reduce the risk of infection with H5N1 HPAI are being made in the endemically infected countries but will not eliminate all high risk practices, such as free-grazing ducks, or prevent all cases of infection.

The changes include increases in the proportion of poultry reared under industrial conditions, improved farm biosecurity measures, shifts from the sale of live poultry to chilled carcasses from centralized slaughtering plants, and improvements to live poultry markets (see Box 3 on Indonesian markets). These changes are discussed in more detail in the individual country reports.

When changes are proposed to the way the poultry sector operates, the structure of the industry needs to be fully understood, along with the motivations and views of farmers, transporters and poultry traders. Implementing the changes will require commitment from key stakeholders, including consumers.

In most endemically infected countries the necessary information on poultry value chains is only available for some areas. Although market chain studies are not necessary in all places, the key points in all production and market chains where H5N1 HPAI infection is likely should be identified.

ii) The quality of veterinary and animal production services

In general, veterinary services in the endemically infected countries have insufficient capacity to identify and respond to all cases of infection for a range of reasons, including: limited staff; lack of training for frontline staff; and in some cases, provincial or district autonomy for animal health and production services without strong guidance and direction from the central level or adequate budgets for animal health from local authorities. Training should provide information on ways to detect subclinical infections.

Veterinary services need to engage with the communities they serve and this cannot be driven by a top-down approach. Transparency is also crucial so that all suspected cases of H5N1 HPAI (and other important diseases) are reported.

Considerable reliance is placed on village or commune-based animal health workers (veterinary para-professionals) who may not have the necessary skills to understand or recognize disease, especially when it presents itself in an atypical form, which is likely where vaccination is used.

The drivers of value chains are not well understood by veterinary and animal production staff, and the skills to design and implement appropriate changes to production and marketing systems are often lacking in veterinary and production departments. There is also limited crossover between animal production and animal health staff even on issues where both play a role.

H5N1 HPAI outbreak investigations and tracing rarely identify the sources of infection. In most endemically infected countries limited linkages exist between the public and private sector, especially between government and the large commercial sector. Disease monitoring and surveillance systems only provide a partial picture of disease/infection status. Staff at the lower level often do not understand the purpose of sample collection.

Disease reporting systems rely on reports of disease from producers and animal health workers based in communes or villages. Past experiences with government veterinary services, especially when mass culling was used, have made some producers wary of reporting. Some countries provided little or no compensation when culling was undertaken, or delayed compensation, thus reducing incentives for commercial farmers to report subsequent disease outbreaks.

Border controls are generally weak and there are few initiatives to look at ways to legalize trade across borders through the use of methods such as compartmentalization. Laboratory capacity is also affected by the quality of veterinary services, although in the past few years it has received considerable investment and improvement. All available epidemiological information is not fully collated.

Field staff often have little incentive to undertake field investigations, and in a number of endemically infected countries, government veterinarians are paid low salaries. In Indonesia, this issue was addressed by providing central funding for travel expenses of field investigations by local government animal health officers.

Specific issues related to veterinary services are examined in more detail in the individual country reports.

iii) Commitment to the control and elimination of the H5N1 HPAI virus

The wish to live lives free of H5N1 HPAI does not necessarily translate into concrete plans and actions to control and eliminate the virus. For example, many duck farmers do not regard H5N1 HPAI as a significant threat to their poultry or their health, and are consequently reluctant to implement vaccination unless it is a mandatory requirement when moving poultry to other provinces or to the market.

Similarly, there has been minimal uptake of basic low-cost biosecurity measures by small holders and villagers and even by some larger commercial producers, despite the potential benefits in terms of reduced disease, reduced mortality and better growth rates. Until farmers are convinced that the benefits outweigh the costs and have the necessary resources, they will be reluctant to invest in these measures.

Exceptions are producers who perceive the economic benefits of remaining free from

BOX 3

Live poultry markets and collectors' yards in Indonesia

The current marketing system in Indonesia relies heavily on the sale of live poultry through markets and collectors' yards, both of which have been shown to be havens for harbouring the H5N1 HPAI virus. Infected markets are likely to be an important source of the virus for other parts of the production and market chain.

A market chain programme has been established that aims to reduce the risk of infection at key points along the poultry market chain, both via immediate improvements in cleaning and disinfection practices as well as longer-term market restructuring.

The market chain programme also uses active surveillance to monitor the efficacy of the overall HPAI Control Programme, as well as to identify high risk production areas.

The programme is backed up by an official order (PERDA no 4/2007) from the Jakarta provincial government to eliminate the sale of live poultry in markets by 2010.

The programme also requires value chain analysis of poultry market chains to understand poultry movements and associated risks in the greater Jakarta market system.

The programme is being implemented by fostering greater engagement between the government and private sector market chain stakeholders. A policy of engaging proactively with private sector players has been adopted, covering the poultry market chain and producers.

Specific activities under the programme include:

- Training of local government livestock services to monitor cleaning and disinfection (C&D) activities.
- Training and technical support on C&D to market traders and vendors.
- Strategic improvements to infrastructure so as to facilitate C&D and reduce the risk of the virus spreading from collection points.
- Technical and facilitation assistance to key government agencies responsible for market restructuring.
- Awareness raising on the advantages of safe, healthy, wholesome and Halal poultry meat, targeting vendors, traders, and consumers.
- Provision of high-pressure washers; permanent C&D stations based in poultry collector yards.

The challenges that remain include:

1. Successfully completing Jakarta's poultry market restructuring programme.
2. Sustaining effective C&D activities at poultry collection points.
3. Ensuring that quality poultry products are consistently provided to urban markets.
4. Uniting private sector stakeholders to improve the quality of Indonesia's poultry.

infection, especially if this determines access to markets.

Resources from donors will almost certainly help to maintain commitment from government. The commitment by government services at the highest level not just to containment but to virus elimination is essential. Given that H5N1 HPAI has now been circulating in parts of Asia for more than seven years it should not be surprising that many see virus elimination as a distant goal. Consumers in some countries prefer to purchase live poultry, often because of a belief that live poultry is healthier[8]. As long as this demand persists, there will be sales of poultry through live poultry markets.

Support is unlikely for the types of measures needed to eliminate H5N1 HPAI viruses from zones or the whole of endemically infected countries until most farmers, government staff at all levels and the public see H5N1 HPAI as a serious threat to their livelihoods and well-being.

Although action has been taken in all endemically infected countries to address these three factors, all require long-term commitments and investment if the virus is to be eliminated, something considered extremely unlikely for at least the next ten years.

Specific constraints identified by FAO in endemically infected countries

FAO officers in each of the endemically infected subregions were asked to describe the constraints that the endemically infected countries faced in eliminating the H5N1 HPAI virus. Using responses from India as an example (see Box 4) it is evident that each constraint falls within one or more of the three broad categories described above.

Other considerations

Successes and failures from other disease control and eradication programmes both in Asia and elsewhere, such as tuberculosis, brucellosis, rinderpest, foot-and-mouth disease and Newcastle disease, have been assessed for useful lessons that can be applied. This approach can be helpful provided the differences in the epidemiology of the disease and livestock sector involved are taken into account. However, methods that work for one disease may not always be applicable for others, and many success stories for earlier diseases have involved long-lived, large, high value animals that can be individually identified (in particular cattle and buffalo), rather than small short-lived highly mobile poultry reared in flocks.

Many small scale producers accept deaths in poultry as the norm. This is a key constraint, implying that disease will not always be reported or even be seen as a problem, especially in low input farming systems and areas where Newcastle disease is endemic. Another constraint is that germ theory is generally not well understood and accepted by some sections of the rural community.

As has been seen in Asia, countries that are free from H5N1 HPAI are at risk of virus incursion either from infected poultry or, in some situations, wild birds. Movement of the former across borders is known to occur in places where the import of poultry is illegal or tightly controlled, but where price differences provide attractive financial rewards for

[8] For example, a knowledge, attitudes and practices (KAP) study of customers in three traditional live bird markets in Makassar, Sulawesi, Indonesia, reported the most common reason consumers prefer live poultry is because they believe live poultry is healthier than frozen or fresh carcasses.

BOX 4

Some specific constraints to H5N1 HPAI control and elimination in eastern India identified by FAO

- Porous, long and contiguous land borders between neighbouring countries with minimal control points and quarantine facilities.
- Lack of understanding of the dynamics of poultry production systems, value/supply chains and trade in poultry and poultry products within India.
- Critical gaps in epidemiological information and methods due to lack of skilled human resources and facilities to conduct effective epidemiological studies on the management of HPAI and other transboundary animal diseases (TADs).
- Poor biosecurity.
- Insufficient information on the impact of HPAI on livelihoods of households rearing backyard poultry.
- Insufficient elucidation of infection and transmission dynamics of the virus in the local environments where the virus persists.
- Lack of epidemiological support and in-depth epidemiological analyses.
- Serious vulnerabilities in disease surveillance, exposed by recent HPAI outbreaks.
- Lack of structured surveillance.
- Lack of prompt intervention during outbreaks to reduce response time between the diagnosis, reporting and adoption of control measures.
- Hostility from households towards rapid response teams for culling operations, with repeated culling now a political issue.
- Delay in the development of laboratory infrastructure and laboratory capacity to address HPAI in the entrenched region.
- Logistical delays in sample handling and transport to national laboratories.
- Lack of public outreach on risk communication.
- Lack of involvement of private sector.
- Inadequate engagement and management of the media, local political leaders and village leaders in reporting the disease.
- Lack of good working relationships with villagers.
- Limited regional approach with neighbouring countries for containment and control.
- Lack of tracing and case finding, related to poor training, shortage of personnel and sometimes to motivation of local officials.
- 'Linking persons' identified in the Government of India's Action Plan are not being fully utilized to assist with critical activities at the village level.
- Lack of wet market and environmental studies.

successful smugglers. Ways need to be examined to legalize such cross-border trade: this will be facilitated by compartmentalization and also by overall regional improvements in disease status.

Realistic goals for the next five years

Each endemically infected country will be encouraged to develop pathways showing how it intends to progressively control H5N1 HPAI and move towards virus elimination.

It is very unlikely that any of the endemically infected countries or subregions will eliminate H5N1 HPAI in the next five to ten years, because it will take many years for all constraining factors to be overcome and the necessary preventive measures introduced universally. However some infection-free zones and compartments could be established and their status confirmed through on-going surveillance studies and disease investigations. This is already possible in parts of Indonesia and the People's Republic of China.

The FAO submission to the review of Viet Nam's integrated operational plan for avian and human influenza for the period 2006-2010 (the '*Green Book*') provides a set of clear milestones that, if adopted, provide a pathway towards elimination and would clearly demonstrate the achievements made in moving forward from 2010-2016 (see Annex 2). Similar plans should be developed for other endemically infected countries. The Association of Southeast Asian Nations (ASEAN) is developing a roadmap for HPAI freedom in ASEAN-member countries by 2020.

Given the challenges and the need for long-term support, sustainable funding, at least at the current level, will be crucial for the next five years to achieve progressive control. Successful elimination of the H5N1 HPAI virus in the poultry sector will have to move forward towards improved control and prevention of other livestock diseases and emerging infectious diseases (EIDs).

The country reports in Annex 1 provide information on the predicted achievements in the next five years.

Innovative approaches to meeting goals

The approaches to meeting goals will be based around progressive control, which has formed the foundations of FAO's response.

Each of the constraints to the control and prevention of HPAI listed from page 24 will be addressed but improvements will be necessarily gradual. The road to overcoming these constraints is long and governments and donors must understand that there are no quick fixes to the various institutional and structural problems that led to the disease becoming endemic in the first place.

A range of measures will be implemented building on those already in place (see individual country annexes for additional details). These would not only be aimed at avian influenza but other diseases as well, and include:

- Greater engagement of the smallholder commercial sector to enhance surveillance, farm biosecurity and the delivery of vaccines.
- Improved engagement with large commercial farmers.
- Cross-border and regional approaches within clusters of countries in the Greater Mekong subregion and the Indo-Gangetic Plains. Enhanced regional collaboration is crucial to develop disease control plans jointly and harmonize some approaches, since many of these countries share similar socio-economic, farming, agro-ecological and epidemiological environments.
- Well-designed integrated studies for improved understanding of the farming systems, socio-economic background, production and market chains and the epidemiology of the disease would be worthwhile in the long term for HPAI as well as for other diseases of poultry at both the country and regional level.
- Holistic health services for smallholder poultry owners, covering entire communities and going beyond avian influenza (the 'Commune Health' concept) and possibly development of 'AI-free Communities'.
- Review and development of better systems of compensation such as high value compensation paid rapidly as part of stamping out campaigns – provided the moral hazard can be overcome using experiences from Nigeria as a guide. Alternatively, establishing compensation mechanisms funded by the private sector and not dependent on public sector veterinary services.
- Development of better communication and advocacy strategies to improve commitment to H5N1 HPAI control and elimination.
- Increased focus on the non-technical issues including socio-economic, socio-cultural, institutional and political aspects of disease control and prevention.
- Better decision trees for vaccination and other control measures in endemically infected countries and longer term research on the effects of vaccination versus alternatives.

- Improved capacity of veterinary services to conduct effective investigations, and implement outbreak control operations and prevention measures.
- Compiling lessons learned from other endemic diseases (for example, why is the uptake of Newcastle disease vaccine so poor?).
- Consider the utility of a clade-based approach for long-term surveillance and control by looking at the characteristics of H5N1 clades, their origin, potential for survival and advantages/domination over other clades that they possess especially in countries with multiple clades circulating.
- Obtaining better data to help build better models for decision making than currently available.
- Measures to improve the quality of veterinary services.

None of the 'endemically' infected countries are expected to eliminate H5N1 HPAI viruses in the next five to ten years, and even if they do will remain highly susceptible to the re-introduction of virus. Thus, there is room for concurrent research into other innovative technical methods for disease control that require longer term investments. In particular, measures that can be implemented regardless of the state of veterinary services or the structure of the poultry sector should be pursued until such time as veterinary services have the capacity to implement sound disease control and preventive programmes. Areas that should be considered further include:

- Better vaccines that protect against avian influenza and other diseases, which do not require individual injection of each bird, and provide prolonged immunity.
- Development of genetically resistant poultry.
- Methods for temporarily increasing the resistance of poultry if feasible (for instance, through the administration of short interfering ribonucleic acid [siRNA] prior to sale of poultry through live poultry markets).
- Improved 'universal' vaccines for humans against Influenza A.
- Reconsidering the potential benefits and costs of novel vaccines including live influenza virus vaccines (which are not currently recommended for influenza for poultry). Proper assessment of marker vaccines and DIVA strategies based on field application.

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Annex 1

Country briefs

Viet Nam

BRIEF HISTORY OF THE DISEASE

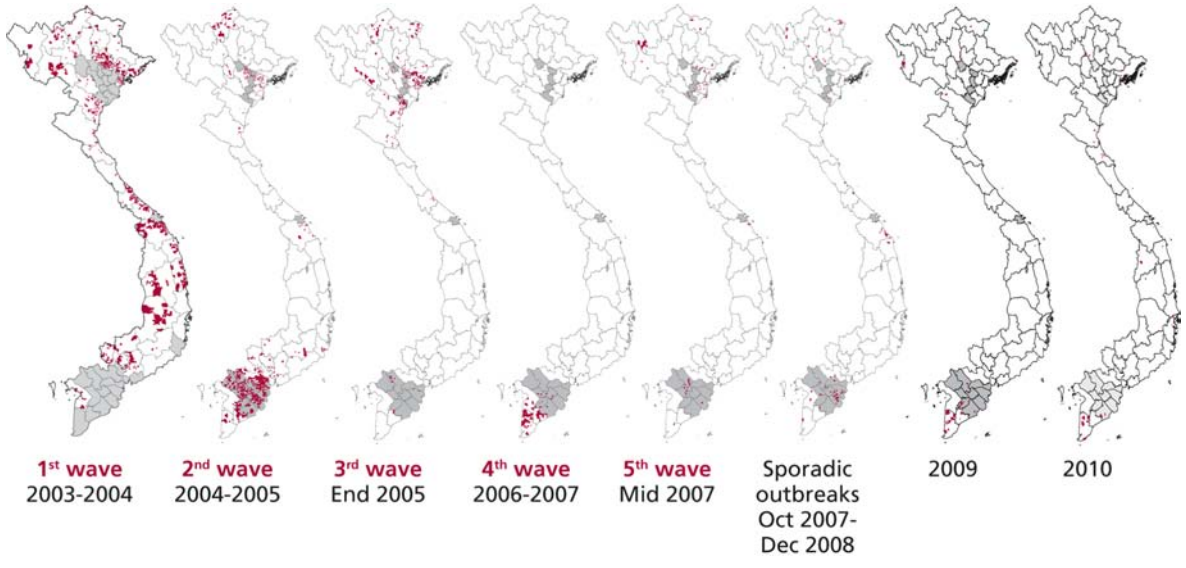
By the time Viet Nam first reported cases of H5N1 HPAI in late-2003, the disease was already widespread and well entrenched. A range of control and preventive measures has been implemented beginning with wide area culling in 2004, temporary bans on duck breeding, changes to marketing practices in urban centres, and the introduction of vaccination as one of the preventive measures in 2005. Wide area culling was scaled back in late 2004 to modified stamping out only involving culling of known infected and high risk in-contact poultry.

Active surveillance has demonstrated cases of infection with H5N1 HPAI viruses that would have gone unreported if reliance had been solely on owner reports, demonstrating that the number of reported outbreaks does not reflect the full extent of infection.

The H5N1 HPAI virus continues to cause disease sporadically in humans and poultry, with most reported avian outbreaks centered on the two river deltas. Some cases have also occurred in isolated mountainous regions of some provinces although investigations have not established how these occurred. The main viruses detected in the north since 2007 are of Clade 2.3.4. In addition, Clade 2.3.2 viruses also occur and Clade 7 viruses have been detected in smuggled poultry and markets in northern Viet Nam.

Clade 1 H5N1 HPAI viruses have persisted in the lower Mekong area since 2003 (Buchy *et al*. 2009, WHO 2010). It is highly likely that duck management systems play a role in the persistence and spread of viruses in this area.

FIGURE A1.1
Spatial distribution of HPAI in Viet Nam (2003-2010)



Differences in duck husbandry systems exist, especially in the south, with both meat ducks and layers being reared. Some large flocks are transported long distances across provincial (and sometimes national) boundaries to graze on harvested rice fields while other ducks only move locally, returning to their home base at night. The former could play a role in dissemination of the virus over long distances whereas the latter may result in greater exposure of other poultry kept in the same household.

In 2010, scattered outbreaks have been reported in provinces in all six regions with more outbreaks occurring in the south. In the past, cases have centred on the Red River Delta but this pattern has been less apparent in 2010.

A seasonal pattern of cases is discernible (Figure 1 in main document) but sporadic cases are reported throughout the year. Case investigations rarely determine the source of virus in outbreaks. Surveillance programmes have detected virus infection in smuggled poultry, live bird markets and unvaccinated ducks and Muscovy ducks.

The key feature apparent from the graph of reported cases (Figure 1) is the fall in the number of reported avian cases since the peak in 2004. Several other notable events are evident in Figure 1 including the absence of a peak in cases during the Tet festival in 2006 (immediately following the first round of vaccination and implementation of other measures) and a peak in May 2007 associated with an increase in the duck population (after a ban on duck breeding was lifted).

OTHER KNOWLEDGE GENERATED IN THE PAST FIVE YEARS

Control and prevention of H5N1 HPAI

Although the exact contribution of the government's measures towards the control of H5N1 HPAI cannot be quantified, there is general agreement that they have reduced the impact of the disease.

H5N1 HPAI at present is not causing widespread losses in the livestock sector in Viet Nam; however, sporadic human infection still occurs. The annual cost of control and prevention to the government alone still runs into the tens of millions of dollars and the resources devoted to this disease have at times been provided at the expense of control/prevention of other important animal diseases such as foot-and-mouth-disease (FMD), rabies and porcine reproductive and respiratory syndrome (PRRS). H5N1 HPAI has affected the capacity to deal with other concurrent serious diseases of livestock and has demonstrated the chronic under-resourcing of veterinary services in Viet Nam.

Stamping out

Stamping out of infected farms or flocks is still used in the event of reported outbreaks or positive surveillance results. Compensation is provided but the level paid does not cover the full cost of destroyed poultry, thereby providing little incentive to report disease or for active surveillance to be conducted.

Understanding and modifying the poultry sector, improving farm and market biosecurity and hygiene

Considerable training in farm biosecurity measures has been undertaken with a greater emphasis recently on practical measures that can be applied by smallholders.

Vaccination

Vaccination, used in Viet Nam as a control measure, was first introduced in 2005 when it became evident that existing measures were not preventing human cases. The programme and lessons learned from it have been described in detail elsewhere.

The blanket vaccination campaign sponsored by the government proved difficult to sustain, as predicted. It is evident from informal studies and interviews that individual provinces have adapted the national programme so that the coverage of small flocks of poultry is reduced and greater emphasis is placed on the vaccination of ducks. The process of modifying the vaccine campaign will be helped greatly by the results of on-going research projects including the United States Agency for Internaitonal Development (USAID)-funded Gathering Evidence for a Transitional Strategy (GETS) programme, managed by FAO.

Although the epidemiology of the disease is not fully understood due to limited case investigations and tracing, some evidence suggests that most reported cases occur in unvaccinated or poorly vaccinated poultry. This is not surprising given that vaccinated poultry with a reasonable immune response, if infected, do not normally display clinical signs of disease unless the virus is an antigenic variant. Vaccination can also reduce the extent of spread of virus in a flock because birds with high-level immunity are more resistant to infection and shed far less virus than their non-immune counterparts.

Many duck farmers do not see the need to vaccinate against H5N1 HPAI in contrast to other diseases such as Duck Virus Enteritis (DVE). The impact of the disease can be reduced using the existing vaccines and some management measures to reduce the risk of spread, but limited progress will be made towards eradication unless new vaccines are available that farmers wish to use.

More information is needed on the efficacy of vaccination under field conditions. The studies conducted to assess this will not answer all of the questions.

Surveillance and disease reporting

Considerable AI-related surveillance is being undertaken but there are still large gaps in knowledge about where, when and how H5N1 HPAI circulates in Viet Nam. It is assumed that the main sources of infection are free-grazing domestic ducks and large, poorly managed live poultry markets and that the levels of infection in these two 'reservoirs' probably fluctuate over time, depending partly on the size of the susceptible populations. However there is still limited data to determine the relative contribution of these two factors in Viet Nam, and also the role of other potential sources of virus, including spent layer hens, and day-old chicks and ducklings exposed to virus after hatching.

A gap still exists between the central level surveillance planning and the provincial (and lower) authorities that undertake the plans. It is evident that not all provinces are fully aware of or understand the objectives and benefits of conducting surveillance. Until there is greater involvement from the provinces in designing local programmes there is lit-

tle likelihood of surveillance being conducted efficiently and effectively. The provinces will need considerable support if progress is to be made. Epidemiology skills in some provinces remain weak and additional training in this area, which is currently being undertaken, remains a priority.

The results of a number of longer term epidemiological studies being conducted (such as Henning *et al*. 2010[9]) will become available in 2010, providing more information on how H5N1 HPAI is maintained and spreads. These studies are also providing valuable post-graduate training for Vietnamese veterinarians. However, they will not answer all of the current questions: additional targeted studies to answer specific questions will be required in the future.

The proportion of avian cases of infection and disease that go undiagnosed is unknown. However, such cases do occur, as demonstrated by the detection of the virus during market surveillance, and the outbreak of human cases before avian cases in the same location. The occurrence of undiagnosed infection is not surprising given the stage of development of veterinary services, the reluctance of farmers to report disease, the presence of a large duck population in which disease may not always be seen or diagnosed, and the vaccination of poultry (which alters the course of infection, so that it may go unreported). A key objective should be to reduce the number of undiagnosed infections and disease especially as certain parts of the country move towards virus elimination.

Most disease investigations conducted so far have not been of sufficient quality to determine why outbreaks occurred. In none of the recent investigations of human cases has the source of the virus been determined. Even with well-conducted investigations, the reports of the outbreak, when available, made it difficult to assess the quality of the investigations. Training in this area is a focus for a number of programmes and it is important to introduce a measure of the quality of the investigations conducted by both veterinary and joint investigation teams. Suggestions for ways to achieve this are provided in the milestones.

To eliminate H5N1 HPAI from certain zones and compartments, better epidemiological information is needed on the sources of infection for cases in areas targeted for virus elimination, and stronger surveillance and disease reporting systems in these areas for early detection of infection and disease.

LESSONS LEARNED

It is evident that the poultry sector in Viet Nam was an ideal target for the H5N1 HPAI virus when it emerged in Asia, due to the rapid growth of the poultry sector. The submission by the Minister of Agriculture to the International Ministerial Conference on Avian and Pandemic Influenza (IMCAPI) meeting in Hanoi in 2010, acknowledges these issues and the need for appropriate changes to production and marketing practices implemented in a manner that does not put smallholders at a disadvantage. Unless the conditions that allow H5N1 HPAI to persist are tackled and better preventive tools made available, including

[9] Henning, J., Henning, K.A., Morton, J.M., Long, N.T., Ha, N.T., Vu, L.T., Vu, P.P., Hoa, D.M., Meers, J. 2010. Highly pathogenic avian influenza (H5N1) in ducks and in-contact chickens in backyard and smallholder commercial duck farms in Viet Nam. *Prev.Vet.Med.*,E published 29 June 2010.

improved vaccines that farmers want to use, the prospects of sustained virus elimination from Viet Nam within the next 10 years are poor.

Based on opinions from veterinarians working in Viet Nam, sustained elimination of H5N1 HPAI is considered to be extremely unlikely in the Mekong Delta as long as there are large populations of grazing ducks and while Viet Nam has to rely on existing vaccines. At best, the elimination of H5N1 HPAI is possible in some of the lower density zones by 2016 but this will not be achieved without strong support for such a programme from government, donors and the public in the affected areas.

Substantial long-term investments are still needed to improve veterinary services and it is crucial to clearly document the funds and time needed to develop veterinary services that meet international quality standards and the requirements of the developing livestock sector. This process will have to start at the undergraduate level. Without additional investments, the quality of veterinary services will limit the potential for development of the livestock sector (including intensification), for the elimination of H5N1 HPAI and for the detection and prevention of other emerging diseases. Similar constraints also affect animal production services, and institutions that support the poultry sector are poorly developed.

CONSTRAINTS

Some of the major constraints identified in Viet Nam are listed below:

- Management systems of ducks that allow persistence of infection in areas with high duck populations.
- Complex market chains, involving sale and transport of live poultry, with limited controls on movement.
- Insufficient knowledge of where infection is occurring.
- Inadequate biosecurity measures on farms.
- Difficulties in controlling illegal cross border movement of poultry.
- Limited incentives for reporting disease (including issues related to compensation).
- Difficulties encountered in conducting detailed case investigations.
- Insufficient targeted surveillance to determine the prevalence of infection.
- Difficulties in sustaining a large scale vaccination campaign.
- Limited development and capacity of institutions to support the poultry sector.
- Dispersal of the poultry population into over seven million flocks.
- Difficulties encountered in restructuring and development of poultry production zones.
- Limited veterinary capacity in both the public and private sector.
- Outdated veterinary legislation and enforcement capacity.
- Gaps in the understanding of market chains.

PROGRESS ON CONSTRAINTS TO VIRUS ELIMINATION

Factor 1: The structure of the poultry sector

Since H5N1 HPAI was first reported in Viet Nam some restructuring has occurred in the poultry sector as one way to combat the disease. This followed from decisions made, centrally, by the Ministry of Agriculture and Rural Development through the Department

of Livestock Production to promote industrialized livestock production. At the Provincial level, changes were made to marketing and slaughtering practices, including bans on the sale of live poultry in markets in major urban centres such as Ho Chi Minh City, as well as through the development of provincial poultry development plans that incorporated designated poultry production zones. Decisions were also made by the private sector to invest in improved farm facilities and slaughterhouses.

Although there are plans at the central and provincial levels for developing and restructuring the poultry sector, most of the investment required to achieve the plans will be made by private sector investors provided they perceive a reasonable potential for profit and also have access to capital. Based on events since 2004, banks may view poultry production as a risky enterprise.

If livestock production zones are developed, they will require strict guidelines on facilities and management, hygiene and farm practices, and on veterinary support and disease reporting obligations.

Investments have already been made into the Ha Vi wholesale poultry market in Hanoi. Construction of the new market facilities will be completed in 2010 and the changes are expected to reduce the risk of H5N1 virus circulating in the market if it is managed correctly. Future plans for this market include improving the traceability of live poultry into and beyond the market. This can only be achieved if traders and transporters are included in specific training and awareness programmes.

No matter how much restructuring is conducted, Viet Nam will still have a substantial population of free grazing ducks and village poultry. Scavenging chickens remain an important source of supplemental income for low-income persons. As long as there are significant numbers of rural poor, there will be a need for this production sector.

Restructuring must not put smallholders at a disadvantage. Before any changes are made, the impacts of the restructuring should be examined and additional measures devised to protect or support groups that might be adversely affected.

Some of the early restructuring measures during the emergency phase of the outbreak response resulted in considerable disruption of trade for farmers and traders. For example, decisions made by urban authorities to ban the sale of live poultry in markets and to close small urban slaughterhouses had significant implications for smallholders in provinces around urban centres. These producers used to sell live birds to the urban areas where the decision was made and were locked out of these very markets.

Restructuring will continue, involving a gradual shift towards industrialized production although land constraints are likely to limit the extent of consolidation. New industrialized farms should have enhanced biosecurity measures in place to prevent disease. Well-implemented biosecurity measures are still regarded as key defence mechanisms against HPAI and other diseases. Setting and enforcing legally binding standards for all commercial farms would be a great benefit. The systems being developed to regulate hatcheries should ultimately be extended to farms.

Marketing and slaughtering practices will also evolve with more poultry slaughtered centrally and sold as fresh or chilled carcasses. Systems are already in place to allow the sale of certified native poultry carcasses, albeit involving larger scale production than that used by smallholders. Until there is a shift in consumer demand for live poultry, the sale of

live birds will continue and will need to be managed.

Some provinces have produced poultry production plans but not all have been assessed by external experts for feasibility or the impact of externalities created.

Better information has been obtained on production and market chains that have identified some key points where control and prevention measures should be focused. Farmers' views on biosecurity measures on farms have also been obtained.

Factor 2: Veterinary and animal production services

The livestock sector is predicted to expand considerably in the next two decades. A much larger team of technical experts will be needed in both the Department of Livestock Production (DLP) and the Department of Animal Health (DAH) and their provincial counterparts to ensure that the expansion does not create negative consequences such as environmental pollution, or increased transmission of new or existing diseases. The private sector will also play a key role in managing their enterprises and will require qualified veterinarians and animal husbandry experts to support their enterprises. Enlightened companies will invest in this manpower because they will see a return on their investment. The links between the private sector and the public sector will need to be strengthened, and between DAH and DLP. There will be a greater need for private sector support to the livestock industries.

The activities of the past five years have led to incremental improvements in the quality of veterinary services but considerable work is still needed to meet the standards defined in OIE's Performance of Veterinary Services (PVS) process. An initial evaluation of veterinary services was conducted under the OIE PVS scheme in 2006, providing a baseline against which to judge improvements in veterinary services. This process has been repeated recently and the assessors are likely to find some improvements in the quality of management decisions, the extent of engagement with the international community and in diagnostic capacity, although gaps remain in all these areas. A gap analysis of veterinary services is also being conducted to support the development of a plan for Viet Nam's veterinary services to meet OIE quality standards.

Veterinary laboratory capacity has been enhanced substantially but a recent assessment shows the need for more investment to improve laboratory infrastructure and build new laboratories. Quality management systems for national and regional laboratories are being introduced in 2010 but additional time and resources will be needed for accreditation of all laboratories, including better testing facilities. One of the glaring absences in Viet Nam is the lack of veterinary pathologists and case managers in most veterinary laboratories. Twinning arrangements with international reference laboratories are currently being explored.

Despite considerable training and support, border controls are unable to completely prevent poultry smuggling. The factors that lead to smuggling need to be better understood and the penalties reviewed for appropriateness. Consideration should be given to working with China to develop a compartment for safe and legal movement of day-old chicks from Guangxi Zhuang Autonomous Region, given that there is a demand for these birds (known from intercepted illegal traffic).

Some work has been done to improve veterinary legislation and to improve the timeliness and relevance of compensation for poultry destroyed in HPAI control programmes but both require further work.

As the next step in strengthening veterinary services, a fully costed and detailed plan for strengthening veterinary services (including veterinary laboratories) has already been requested by the Minister of Agriculture. This plan must examine and define the role of the various players (public sector and private sector veterinarians and veterinary paraprofessionals) and also the role of state veterinary services in national development, including the control of zoonotic diseases.

The first PVS review highlighted the issue of breaks in the chain of command from the central to local level as a result of provincial autonomy. As part of the overall review of veterinary services, practical measures to strengthen these links must be explored and developed.

Further consideration should also be given to developing twinning arrangements between one or more veterinary schools in Viet Nam and overseas institutions to bring the training in veterinary public health, preventive medicine, epidemiology and pathology in line with best practices. This is presently being explored by DAH.

Considerable effort has been expended on training community-based animal health workers over the past five years, reflected in the increase in disease reports received from them at the district level. However, it is still unclear how much these reports have improved the quality of disease analysis. A monitoring system to assess the quality of these reports and ways to improve them is required.

The technical skills of animal production staff will also need to be strengthened. As with veterinary services, animal production services will need to be enhanced through additional training. In 2010, training will be provided in spatial planning. A costed plan for the development of DLP and provincial livestock services should also be developed in 2010, similar to the one for veterinary services, in which the possibility of twinning with an overseas tertiary institute with special skills in animal production should also be considered. This plan should take into account training and other support to be provided under the World Bank's Livestock Competitiveness and Food Safety Programme (LIFSAP) which starts in 2010.

Factor 3: Commitment

The strong commitment for action against H5N1 HPAI at the highest levels of government still filters down to the field level. However some who have been dealing with the disease for more than six years show signs of fatigue and are less enthusiastic about mounting a response to it than they were in 2004-2005.

At present work is being undertaken to build systems that will allow well-managed farms to demonstrate freedom from H5N1 HPAI backed up by a set of strong farm biosecurity measures that are audited to demonstrate that the risk of virus entering the premises is extremely low. However, there are few incentives for participation in such a scheme.

Vaccination of ducks also needs to be strongly promoted but at present H5N1 HPAI is not seen as a threat by many duck producers, with the exception of the few who have suffered outbreaks.

If attempts are made to eliminate H5N1 viruses from a zone then support will be needed from all levels of government and also from producers, traders and the general public within the zone. All stakeholders will need to perceive some advantage stemming from being involved in such a programme.

MEASURES PROPOSED FOR VIET NAM BY FAO FOR THE NEXT FIVE YEARS

A series of recommendations was made on the way forward for Viet Nam in the FAO submission to the Green Book review. This included milestones for a range of activities for the period from 2010 to 2016 (Annex 2).

The objectives and outputs in Table A1.1 were suggested at recent meetings examining the future direction for influenza activities.

TABLE A1.1
Proposals for future activities for Viet Nam

Objective	Intended Outcome
POULTRY SECTOR ANALYSIS	
Poultry sector review and zonal profiles, based on ecosystems-health approach	Provides a description of the population at risk, disaggregated by epidemiologically appropriate zone and production type
Mapping of poultry movement and modeling of poultry population dynamics	Provides a description of the dynamics of the poultry population, supporting risk analysis and for estimating/monitoring impact of disease control interventions
Institutional analysis and organizational gap analysis and capacity assessment	Describe institutions and review their capacity building requirements to create a balanced, enabling environment for policy and operational development of the poultry sub-sector
Market prices and farm economics and performance/ profitability analysis service established	Provide policy makers with information on incentives and provide producers with information to make more effective decisions on the management of their enterprises
STRUCTURAL STRENGTHENING/GOVERNANCE OF POULTRY SECTOR	
Institutional/organizational capacity building programme	Prioritize and address the key weaknesses in establishing a balanced and enabling institutional environment
Establish a forum/partnership to promote public-private sector dialogue	Co-planning and most effective allocation of resources, create synergies and capitalize on comparative advantages
Engage financial institutions through investment guides and small enterprise business incubators for the poultry sub-sector	Build partnerships between poultry sector and financing institutions to leverage investment for appropriate development of the poultry sub-sector
Initiate industry driven Poultry Improvement Plan(s)	Bring industry and government together - learn from each other, identify needs and gaps
Develop technical, evidence based guidelines for good poultry sector planning practices	Ensure that equitable and effective guiding principles are applied to the development of the poultry sector in a situation where determination of the specific direction that development should take is premature
BIOSECURITY AND GOOD PRODUCTION PRACTICES	
Biosecurity Good Practices/Codes and biosecurity Improvement Plan (National and Provincial)	Establish benchmarks and standards, providing peer driven mechanisms for upgrading and a means by which to monitor progress and measure the existing situation

(cont.)

(cont.)

Strengthen biosecurity Knowledge Management through biosecurity Working Group	Accelerate knowledge acquisition and lesson learning amongst development practitioners and policy makers
Farmer field school type approach to developing demand driven extension and support programmes	Develop appropriate, demand-driven extension programmes and pilot a farmer-led approach to extension more broadly
Environmentally sound waste management/ environmental impact reduction plan	Prevent environmental degradation
Capacity building programme for specialist technical advisers in poultry production and health-serving commercial poultry producers	Create a cadre of good quality service providers necessary to support the growth of a healthy poultry sector
Livelihoods strengthening programme for rural development which incorporates support for scavenging poultry producers	To ensure that maximum benefits are obtained from village poultry and the role it plays in poverty alleviation and rural livelihoods
Inclusion of biosecurity and good production practices together with practical poultry health into an effective undergraduate programme	Create a cadre of good quality service providers necessary to support the growth of a healthy poultry sector
LIVE BIRD MARKET AND POULTRY MARKETING STRENGTHENING	
Develop and implement commercially viable strategy for poultry marketing, based on proven business models	To ensure that public and private interests are balanced in a sustainable, viable manner which ensures good veterinary public health and consumer protection whilst promoting poultry production
Upgrade physical poultry marketing infrastructure and its management and behaviour of traders	Provide a stimulus to support and influence sub-sector development in the direction of safe production and processing
Test and implement a farm registration/assurance scheme	Traceability of poultry products contributing to safe food production systems
Implement certification/tracing of poultry products	Traceability of poultry products contributing to safe food production systems
DISEASE CONTROL STRATEGY DEVELOPMENT AND CROSS BORDER ANALYSIS	
Complete a comprehensive value chain analysis on a sub-regional level which maps cross-border poultry movement and trade	To support epidemiologically appropriate disease control approaches for transboundary control of HPAI
Support facilitation of bilateral agreements on managed cross border livestock trade	To balance the needs of producers with those of disease control authorities and to achieve this through equitable risk management processes
Risk analysis capacity building and perform sub-national risk analyses	Sub-national risk analysis approach piloted and capacity development in RA approaches
Establish a zonal approach to disease control	Logical, integrated disease control approaches with implementation plans for each of the sub-national zones identified
Disease transmission analysis and development/ use of decision support tools such as modelling	To better understand the epidemiology and transmission of HPAI
Develop a Preventative Veterinary Medicine training programme targeting Provincial and District Officers	To address a specialist and unmet need within the State Veterinary Service

Bangladesh

BRIEF HISTORY OF THE DISEASE

Bangladesh reported its first case of H5N1 HPAI in March 2007 with one human case the following year. As of 25 March 2010, 350 outbreaks have been reported (Figure A1.2), 297 in commercial farms and 53 among backyard poultry. It is highly likely that the reported cases represent only a proportion of the total cases of infection and disease (see constraints).

Out of 64 districts, 49 have reported cases of H5N1 HPAI since March 2007. The number of affected *Upazila* (subdistricts) is 142 and Metro Thana is 14.

The monthly reported cases are shown in Figure A1.3.

The disease peaked in 2008, with 226 reported outbreaks between January and March. The incidence and frequency of reports waned during 2009 (32 reported outbreaks). After three months' absence, outbreaks started again in January 2010. H5N1 HPAI outbreaks since the beginning of the year 2010 are shown in Figure A1.4.

As of 25 March, the occurrence of H5N1 HPAI in 2010 remains comparable to the same period in 2009. However, multiple cases in Cox's Bazar during 9-21 February 2010 were clustered within a very narrow area, with at least six reported cases regarded as being part of the same outbreak. It is considered likely that the decreasing trend in incidence of the past two years is continuing.

Outbreaks of H5N1 HPAI have also been recorded in countries neighbouring Bangladesh and elsewhere in South Asia. In Bhutan, the first outbreak occurred on 18 February 2010, followed by those on 20 and 25 February, and 11 and 14 March.

In India, the first outbreak occurred in 2007, but the virus was eliminated. In March 2008 the first cases occurred in West Bengal and other states surrounding Bangladesh. A new outbreak occurred in Nagar and Hazrabati, Murshidabad, West Bengal on 12 January 2010 after a three-month break, followed by those on 14, 18 and 19 January.

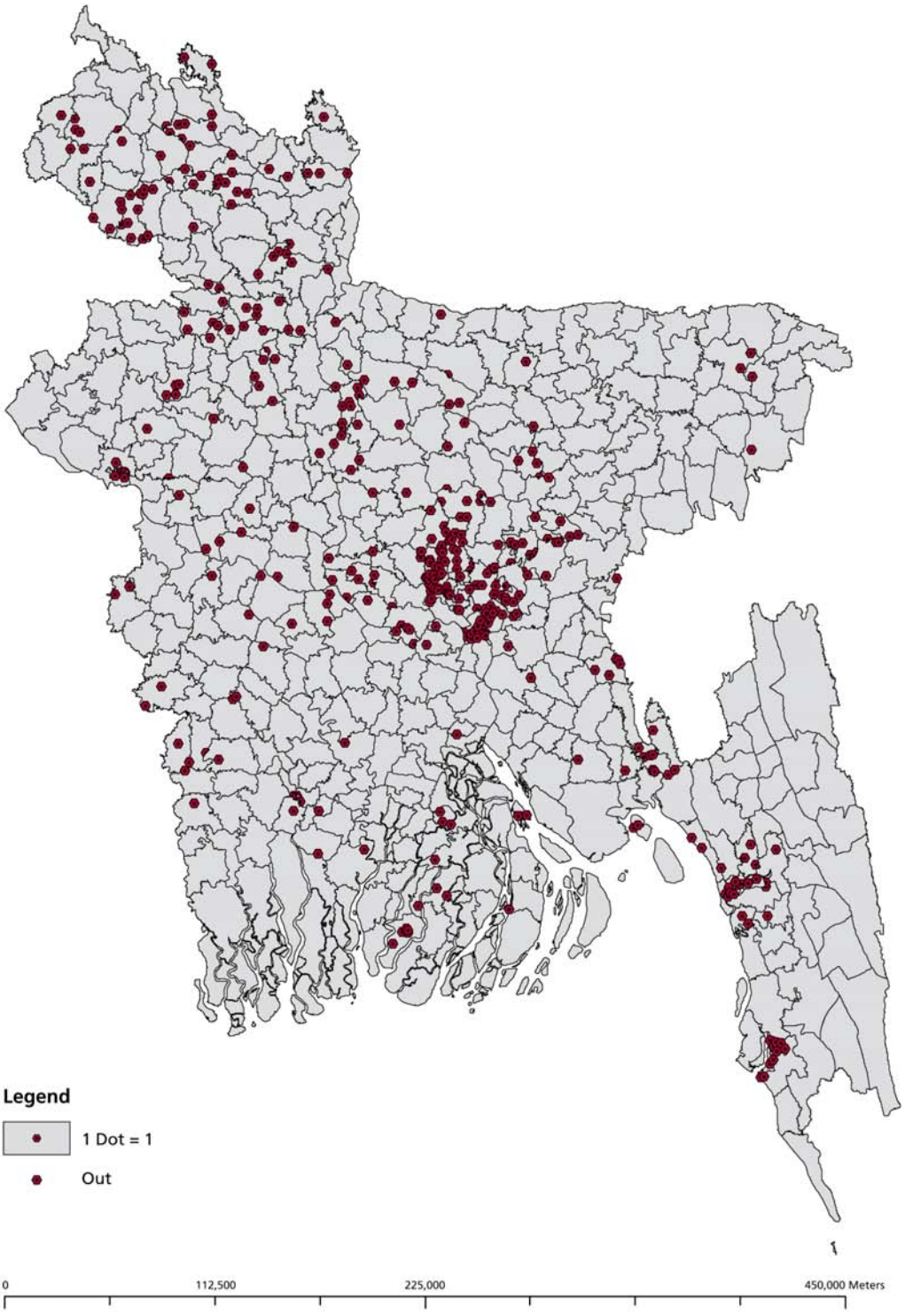
In Nepal, the first outbreak occurred on 26 January 2009 followed by multiple outbreaks in February and March. Two different viruses - Clade 2.2 and Clade 2.3.2 — have been detected in Nepal.

Multiple virus incursions have occurred in Myanmar since it first reported H5N1 HPAI in 2006. The latest outbreaks were reported in February and March 2010. Links to cases in Bangladesh have not yet been established.

Eleven virus samples, including three from outbreaks in 2010, have recently been analyzed genetically. The sequence information from these three isolates showed that they belonged to Clade 2.2 and showed the greatest similarity to viruses previously isolated within the country between 2007 and 2009 (based on results from HA, NA and NS genes), suggesting that the same virus or closely related viruses have been circulating in the country continuously.

So far, 35 nucleotide sequences of H5N1 influenza viruses from Bangladesh have been

FIGURE A1.2
Highly Pathogenic Avian Influenza (HPAI) Outbreaks in Bangladesh (the total number is 350 as of 25 March 2010)



deposited in the National Center for Biotechnology Information (NCBI) GenBank.

All tested Bangladesh isolates belong to clade 2.2 and are most closely related to viruses detected in Afghanistan, Mongolia and Russia (Biswas *et al*. 2008). Viruses in India are similar to those in Bangladesh and the results of genetic testing of Indian isolates suggest multiple incursions of virus from Bangladesh to India (Chakrabarti *et al*. 2010).

OTHER KNOWLEDGE GENERATED IN THE PAST FIVE YEARS

Control and prevention of H5N1 HPAI

Control of outbreaks, based around early detection and stamping out, appears to have reduced the number of cases but the virus has not been eliminated. The major achievement in this area is a marked decrease in the average time taken between detection, laboratory testing or field diagnosis and stamping out of the infected flocks from five days in 2007 to 12 hours in 2010. Early reporting allowed quicker diagnosis and a more rapid response which is believed to have helped reduce the spread of the virus.

National strategies for controlling H5N1 HPAI have been developed, and the Animal Slaughter and Meat Quality Control Act 2010 have been approved in principle by the cabinet.

FAO works for developing Standard Operating Procedures (SOP) of national policy in collaboration with the World Bank, USAID and other donors.

FIGURE A1.3
Occurrence of H5N1 HPAI in Bangladesh since March 2007

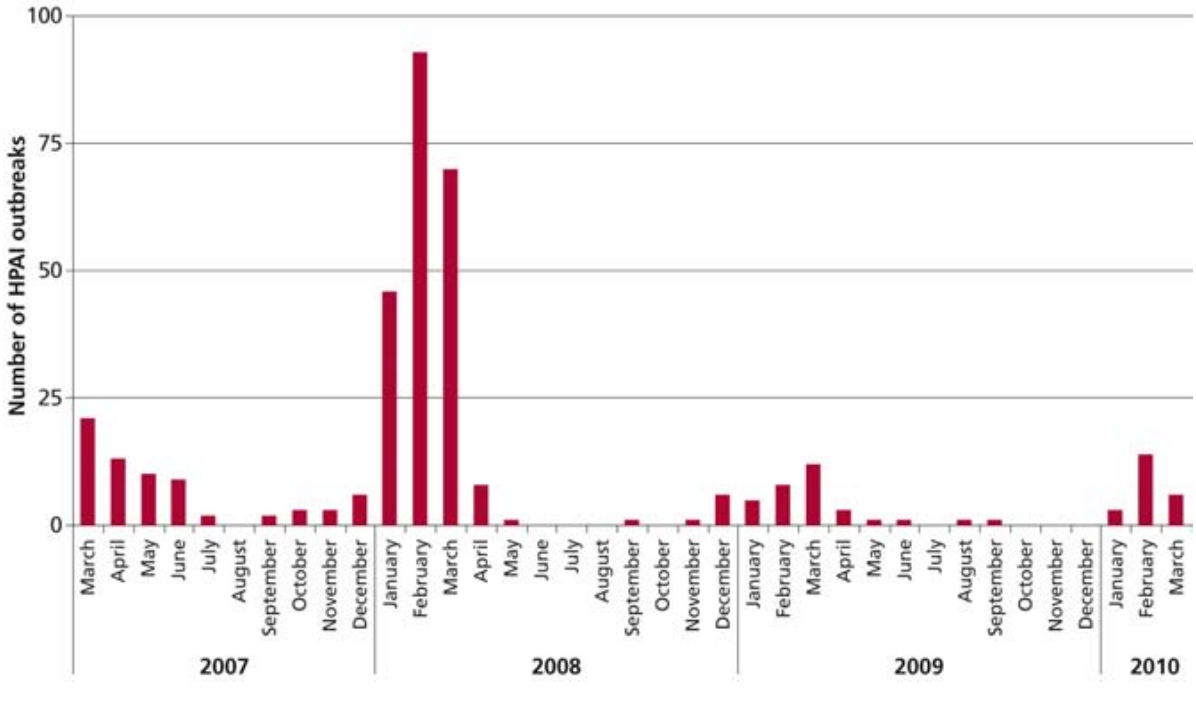
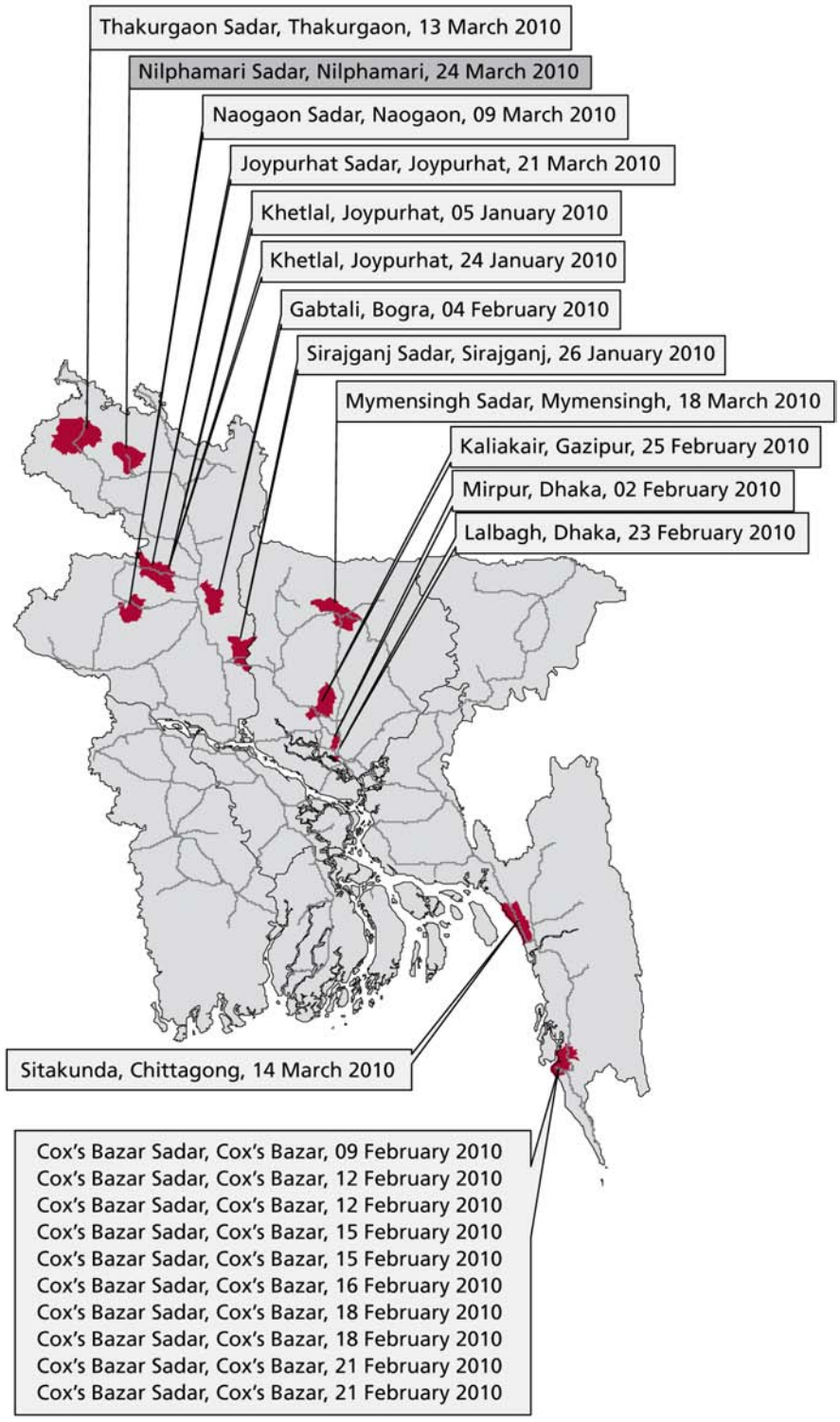


FIGURE A1.4

Distribution map of subdistricts affected with H5N1 HPAI in Bangladesh since 1 January 2010 (as of 25 March 2010)



Stamping out

Stamping out remains the main method used for control of H5N1 HPAI. The effectiveness of stamping out depends on rapid detection of infected poultry and quick and effective culling.

Understanding and modifying the poultry sector, improving farm and market biosecurity and hygiene

Seventy percent of the human population of Bangladesh, representing about 150 million people, is predominantly rural, and poultry production is an important part of their livelihoods. The total poultry population is about 260 million (more than 84 percent chickens and 15 percent ducks) with over 80 percent of farms being small commercial (sector 3) or backyard/household (sector 4) operations. Few biosecurity measures are implemented in any of these farms.

A Knowledge Attitudes and Practices (KAP) survey was undertaken in 2007 to evaluate people's knowledge of H5N1 HPAI and food safety issues.

A study of the social and economic impact of H5N1 HPAI and a poultry sector review were conducted in 2008. These studies provided valuable information on the socio-economic impact of the disease and the structure of the poultry sector.

Vaccination

Vaccination has not been used in South Asia as a tool for the control and prevention of avian influenza but is used for other endemic and epidemic diseases of poultry.

Surveillance and disease reporting

Major improvements in disease reporting systems have been described above using the Short Message Service (SMS) Gateway system. Bangladesh is conducting active surveillance on HPAI in 260 out of 490 subdistricts as part of an USAID-funded FAO project. A total of 780 community animal health workers (CAHW), 87 Additional Veterinary Surgeons (AVS) and 260 *Upazila* Livestock Officers (ULO) are using the SMS Gateway to collect data and report on disease and death in poultry.

Two case-control studies conducted in Bangladesh have demonstrated several important risk factors, including feeding scraps from purchased poultry to backyard birds[10] (Biswas *et al*. 2009a and Biswas *et al*. 2009b).

[10] Biswas, P.K., Christensen, J.P., Ahmed, S.S., Barua, H., Das, A., Rahman, M.H., Giasuddin, M., Hannan, A.S., Habib, A.M., Debnath, N.C. 2009a. Risk factors for infection with highly pathogenic influenza A virus (H5N1) in commercial chickens in Bangladesh. *Vet.Rec*. 164: 743-746.
Biswas, P.K., Christensen, J.P., Ahmed, S.S., Das, A., Rahman, M.H., Barua, H., Giasuddin, M., Hannan, A.S., Habib, M.A., Debnath, N.C. 2009b. Risk for infection with highly pathogenic avian influenza virus (H5N1) in backyard chickens, Bangladesh. *Emerg.Infect.Dis*., 15: 1931-1936.

LESSONS LEARNED AND MAJOR CONSTRAINTS IDENTIFIED IN BANGLADESH

Major constraints identified in Bangladesh

1. Areas where knowledge and understanding are weak and need improving:

- The risks associated with mixed farming of chicken and ducks.
- The risk associated with free-ranging scavenging farming in the presence of commercial farms.
- Importance of regular disinfection of poultry sheds.
- The risks associated with raising poultry near lakes or rivers.
- The risk associated with the egg collectors, egg sellers, poultry worker movements from one place to another, chick boxes, egg boxes and vehicles for transportation.
- The importance of preventing backyard poultry from contacting wild migratory birds.
- The role of ducks in the spread and reccurrence of HPAI in chickens.
- The role of wild birds.
- The role of live bird markets in spreading the disease.
- Marketing chains.
- Marketing value chains.
- The exact location of poultry farms (being addressed).
- The exact location of live bird markets (being addressed).

2. Practices that could allow spread or persistence of H5N1 HPAI viruses that need to be reviewed and improved:

- The design and structure of traditional poultry sheds and the limited biosecurity measures applied on smallholder and backyard flocks.
- No source tracing and checking at live bird markets.
- The large number of live poultry markets that provide opportunities for virus transmission from sick birds to healthy birds (but these exist because cool chains/refrigeration for food are not well established).
- Attention to food safety and hygiene in poultry marketing.
- Few slaughterhouses (tradition of live bird sales prevents introduction of slaughterhouses).
- Potential for contact between migratory birds and free ranging ducks in the many ponds and rivers where these birds mingle.
- Limited decontamination programme for live bird markets in very limited locations.
- Cleaning and disinfection in poultry farms, live bird markets and transport vehicles is lacking.
- High concentrations of small-scale poultry farms.
- Free-ranging poultry not confined within premises.

3. Reporting and surveillance constraints:

- Poultry owners do not report small numbers of dead poultry.
- Some farmers are reluctant to report outbreaks of HPAI.

- Active surveillance alone is not sufficient in ensuring early reporting.
- Delays in confirming diagnosis.
- Current surveillance system is deficient and of poor quality.
- Both active and passive surveillance are sub-optimal.
- Initial diagnosis is sometimes wrong.
- Diagnostic capacity needs to be strengthened.

4. Constraints for disease control and responses:

- The requirement of a government order before culling delays early response.
- The quality of post-outbreak disposal, cleaning and disinfection is substandard.
- The location of commercial farms in densely populated areas makes movement control of people and animals difficult.
- Borders are long and porous.
- The source of infection is unknown.
- Tracing infection forward or backward is difficult.

5. Poultry production and marketing constraints:

- Biosecurity measures in small commercial farms and backyard flocks are minimal.
- Almost no regulations exist for poultry marketing system including live bird markets.
- Live bird markets need to be improved.
- Poultry slaughter houses need to be modernized.
- Decontamination procedures are not sufficiently monitored.
- Infrastructure in poultry production needs to be upgraded including building poultry processing plants.
- Limited integration of small-scale farming into larger corporate farming enterprises.
- Animal Slaughter and Quality Control Act will be revised but uncertainty around its implementation.
- Existing regulations are not well executed or enforced.

6. Constraints associated with governance and programme support:

- Planning and coordination between the government, international organizations and NGOs needs to be optimized.
- Existing government veterinary structure is not sufficient.
- Trainees are often not appropriate to their training programmes.
- Training of trainers (TOT) programmes have limited effectiveness because of the lack of follow-up mentoring programmes.
- It is difficult to get feedback from participants on the impact of training programmes, resulting in poor evaluation of training.
- Manpower in the veterinary services, particularly for diagnosis, is not sufficient.
- In some *Upazilas*, the posts of both *Upazila* Livestock Officers and Veterinary Surgeons are vacant, resulting in overworked ULOs in charge of three-to-four *Upazilas* each, and difficulty in monitoring surveillance activities.
- Limited supervision of live bird markets by Department of Livestock Services and City Corporation staff.

- Refurbishment of AI Diagnostic Laboratories considering BSL-3 progressing too slowly.
- Diagnostic capacity of veterinary services still at a moderate level.
- Limited skilled manpower for laboratory diagnosis.
- Veterinary services need to be strengthened.
- State Veterinary Authority has little access to big poultry establishments, such as grandparent, parent and commercial farms.
- Local veterinarians unwilling to investigate suspect cases and submit samples to laboratory.

7. Constraints associated with awareness

- Low awareness of the importance of reporting among backyard farmers.
- Due to the low literacy rate among the general public, the effects of media campaigns are limited.
- Communication for behaviour change is limited in the poultry husbandry sector.
- Some farmers hide HPAI cases due to low compensation.
- Farmers do not understand the benefit of integration of small-scale commercial farms into larger corporate farms.
- Insufficient advocacy on separation of terrestrial birds from aquatic fowls in backyards.

PROGRESS ON CONSTRAINTS TO VIRUS ELIMINATION

Factor 1: The structure of the poultry sector

Eighteen live poultry markets (eight in Dhaka and two LBMs from each of five divisions) were selected for upgrading, including floor and wall tiling, drainage facilities, mini slaughterhouses, installation of water and power supply. Training has been conducted on cleaning and disinfection for market cleaners and for veterinarians at the Central Veterinary Hospital directly related with the supervision of live bird markets.

Training and workshops on biosecurity have been organized for poultry feed suppliers. More than 640 school teachers were selected from three *Upazilas* in the high risk areas and trained for early reporting and biosecurity. Biosecurity guidelines were developed for backyard poultry production.

Training in biosecurity for commercial producers has been conducted.

Factor 2: Veterinary and animal production services

The epidemiology unit of the Department of Livestock Services was created with assistance from FAO and collaboration with FAO was improved by locating the FAO Avian influenza technical unit (staffed by international and national avian influenza experts) in the same building as the Department of Livestock Services.

Some 780 Community Animal health Workers (CAHWs) in 260 *Upazilas* and 88 Additional Veterinary Surgeons (AVSs) were recruited for active surveillance, and trained in the use of the SMS gateway. The new Internet-based SMS gateway, launched in May 2009, allows any subscriber to send SMS's concerning suspect outbreaks. Anyone sending a mes-

sage receives an immediate reply. A CAHW who sends an SMS about a suspected case automatically generates an alert message for a local veterinarian. The active surveillance system only covers about 50 percent of districts at present.

SOPs for responses to outbreaks were developed in collaboration with neighbouring Nepal and India. Laboratory capacity has been enhanced and an international consultant helped to design a reference laboratory at the Bangladesh Livestock Research Institute. Outbreak investigations have been conducted around farms affected by HPAI and 200 field veterinarians have been trained in outbreak management including culling, carcass disposal and decontamination.

Factor 3: Commitment

FAO has taken initial steps to improve the environment of live bird markets as a model. A new project aimed at mapping poultry farms and markets in the country has also been started. The Government of Bangladesh revised the Animal Slaughter and Quality Control of Meat Act in 2010, and if enacted, antemortem inspection by veterinarians will be obligatory and slaughtering outside slaughterhouses will be prohibited. This law will give momentum to reform in live bird markets throughout the country and should contribute to risk reduction. Post-outbreak investigations have been intensified from the beginning of 2010 by collecting samples from free-ranging ducks in backyards near affected farms to be examined for HPAI or low pathogenic avian influenza (LPAI) viruses.

MEASURES PROPOSED FOR BANGLADESH FOR THE NEXT FIVE YEARS

- Improve early reporting in surveillance by extending the surveillance network to the rest of the country.
- Identify natural reservoirs of HPAI as well as LPAI viruses and segregate them from other populations.
- Improve biosecurity particularly in Sector four (backyard household productions) by confining poultry within premises.
- Promote better live bird markets by improving selected LBS as a model in biosecurity and hygiene through renovation (floor and wall tiling, drainage facility, mini slaughter house, water and power supply) and conducting hands-on training for cleaning using Karcher sprayer and other pressure washers and decontamination of cages and vehicles.
- Promote the integration of small commercial farms into a larger corporate management system with better biosecurity and biosafety.
- Promote reform in animal slaughtering practices after the revised Animal Slaughter Act is enacted.

Egypt

BRIEF HISTORY OF THE DISEASE

HPAI was first detected in Egypt in February 2006. The first wave of infection continued from February to April 2006, affecting mainly commercial farms, particularly broilers. The most heavily affected area was the south-east Nile Delta where poultry population density is high. There was a clustering of outbreaks, suggesting spread to neighbouring farms. Since then HPAI outbreaks have been reported in 24 out of 29 governorates both in upper (north) and lower (south) Egypt. The disease has had a higher incidence in the winter months. There have been three further waves, with H5N1 HPAI still evident and widespread between them. It is accepted that H5N1 HPAI is endemic throughout the country and all production sectors.

There were 1 000 recorded outbreaks of H5N1 HPAI in 2006, of which 84 percent were among commercial flocks. Due to the halt in compensation, there was a progressive reduction in outbreak reports, – with only 123 recorded in 2008 and a change in sectoral distribution with only 22 percent in commercial farms. The reduced annual records of H5N1 HPAI incidence is not reflected in the occurrence of human cases. This implies a declining level of reporting and does not necessarily suggest a progressive reduction in the disease incidence.

OTHER KNOWLEDGE GENERATED IN THE PAST FIVE YEARS

Control and prevention of H5N1 HPAI

H5N1 HPAI is now endemic in Egypt and it is apparent that virus elimination from Egypt is not going to be achieved for many years.

Deficiencies in the chain of command and the absence of effective coordination both within various organizations in the Ministry of Agriculture and Land Reclamation (MoALR) and between central and governorate veterinary services has contributed to the endemicity of the disease and made it difficult to control H5N1 HPAI. This has also resulted in a perception of poor transparency and lack of equity in interventions, widespread conflict of interests between core institutions, and inconsistent application of available policy instruments. It is believed that a lack of effective hygiene measures among control teams moving between poultry farm facilities and flocks may have contributed to the spread of disease.

Stamping out

Control efforts initially focused on mass culling of infected farms and dangerous contact flocks, with compensation provided to commercial producers but not to household producers. Compensation was later stopped until a more sustainable scheme could be developed and the necessary funding secured. After the initial outbreaks of 2006, most suspected cases of HPAI have been reported from the household sector although it is believed that this only reflects the reluctance of commercial farms to report outbreaks rather than the actual

distribution of HPAI. This reluctance may be associated with the stopping of compensation.

Understanding and modifying the poultry sector, improving farm and market biosecurity and hygiene

Factors distinguishing infected areas are mainly related to abattoir capacity, commercial farm density and cultivated areas, which highlight the role of trade and the production chain in HPAI transmission.

It appears that many of the proposed risk factors for HPAI are closely associated in Egypt, where population density and activity is governed by the area of irrigation from the Nile River, the majority of the population is involved in agriculture and the majority of families keep poultry. Thus, human and poultry populations, the density of roads, irrigation canals and agricultural land are related to HPAI incidence, with 65 percent of recorded HPAI outbreaks having occurred in the six Governorates that contain 73 percent of the national commercial poultry population.

Risk factors for the maintenance and transmission of H5N1 virus appear to include movements from table egg layer farms, broiler fattening marketing through abattoirs and live bird markets and informal trading activities of the household poultry sector.

Biosecurity in the smallholder sector remains poor.

Vaccination

Driven by commercial interests and also by the need to reduce the incidence of human cases of H5N1 infection, producers commenced widespread vaccination and government-supported mass vaccination of household poultry. There is little or no data on vaccination in commercial farms as no monitoring was done. A recent study by FAO and the General Organization of Veterinary Services (GOVS) indicates that mass vaccination of household poultry was not effective as delivery was poor, with less than 20 percent coverage, less than 10 percent flock immunity levels, and poor hygiene practises by the vaccination teams, which may have contributed to disease spread (FAO, CIRAD 2009[11]). In late-2009, GOVS made a decision to stop mass AI vaccination in the household poultry sector.

A range of vaccines have been used and antigenic variants have been detected in Egypt.

Surveillance and disease reporting

The capacity of government veterinary services to undertake surveillance, investigate outbreaks and implement containment is challenged by the high number of outbreaks, which has limited the effectiveness of the current approach.

LESSONS LEARNED AND MAJOR CONSTRAINTS IDENTIFIED IN EGYPT

The experiences with HPAI control in Egypt have been similar to those in other countries with widespread infection. Some key conclusions are:

(i) **In an environment of multiple risk factors and weak veterinary services, surveillance and culling do not succeed in controlling HPAI.** This has been the

[11] See Peyre, M., Samaha, H., Makonnen, Y.J., Saad, A., Abd-Elnabi, A., Galal, S., Ettel, T., Dauphin, G., Lubroth, J., Roger, F., Domenech, J. 2009. Avian influenza vaccination in Egypt: Limitations of the current strategy. *J.Mol. Genet.Med.*, 3: 198-204.

experience of Egypt and also Viet Nam, Indonesia and Bangladesh. The risk factors shared are high poultry population density, with many kept under conditions of poor biosecurity and with ample opportunity for the movement of the virus along the value chain. In Nigeria, where the disease was brought under control, there was much lower poultry density and fewer ducks to act as a subclinical reservoir of infection. In Thailand, control was achieved because a large proportion of the poultry population is managed under conditions of good biosecurity and because of excellent cooperation between government regulatory authorities and the poultry industry, driven by a goal of re-establishing export markets.

(ii) **Mass AI vaccination of household and scavenging poultry is inefficient and unsustainable.** The study by FAO and GOVS in Egypt demonstrated the difficulties in implementing a successful vaccination campaign for smallholders. Vaccination is a valuable tool for protecting flocks but it must be applied using appropriate vaccines, careful delivery and monitoring of immune response. Current vaccines cannot be successfully applied before one week of age and two immunisations are required, limiting its usefulness for short-cycle poultry such as broilers. Huge numbers of household flocks make such exercises highly labour intensive and the lack of age-uniformity and frequent changes to flock numbers through additions and sales make it impossible to sustain high level flock immunity. Occasionally poor hygiene by vaccination teams can contribute to the spread of infection. The decision to stop widespread vaccination of household poultry was not communicated to all stakeholders.

(iii) **Poultry producers, from large scale commercial enterprises to households, are reluctant to report outbreaks of disease, fearing the consequences.** A deficiency in producer associations in the different poultry production sectors makes development of consensus on acceptable measures very difficult to achieve and this is a particular problem for the very large number of small scale poultry production units. The conclusion is that where the disease is widespread and endemic, it is more effective to assist industry to prevent infection of flocks than it is to undertake unpopular reactionary measures in the event of outbreaks. It is unrealistic to expect producers to report suspected outbreaks of HPAI if compulsory culling does not attract appropriate compensation.

(iv) **Deficiencies in veterinary services are a major contributory factor for the H5N1 HPAI endemic.** Common issues are difficulty in detecting and culling infected flocks before secondary spread occurs, inability to control poultry movement both in regular markets movements and in outbreak containment, poor regulation and delivery of vaccines, inadequate veterinary public health engagement in markets and slaughterhouses, and lack of effective quarantine of imported poultry products. Sustainable control of the disease in endemic countries will require improvements in veterinary services, including epidemiological and strategic planning capacity, technical knowledge, competence and commitment of field personnel and effective veterinary hygiene measures along the poultry value chain and partnership between industry and government veterinary services.

(v) **Achieving sustainable H5N1 HPAI control in endemic countries requires a long-term approach.** National governments, international support agencies and donors accept this reality and it is now appropriate to institute a longer term revised strategy in Egypt.

PROGRESS ON CONSTRAINTS TO VIRUS ELIMINATION

Factor 1: The structure of the poultry sector

Efforts to better regulate the poultry value chain have been made, especially in the post-production market chain. The main interventions have been in banning live bird markets and poultry shops, such that only slaughtered and dressed carcases can be sold. Although legislated to be applied in the six major urban areas only, these interventions have been applied more widely but have been poorly accepted and enforced.

HPAI control efforts have been hampered by a very limited partnership between government veterinary services, commercial interests and communities. This is particularly challenging at the level of small-scale producers who have no representation by industry associations. Biosecurity is poor in production units, especially smaller scale units, and efforts have been made since 2008 to assist producers in improving this aspect. Proposals have been made to link the mandatory registration of commercial farms to credible demonstrations of appropriate biosecurity facilities and practices, and possibly to eligibility for future compensation in the event of culling operation on that farm. Improving biosecurity in the many thousands of poultry productions units in Egypt represents an enormous challenge and cannot be achieved without industry engagement and support.

Factor 2: Veterinary and animal production services

Considerable investment has been made in training veterinary staff in basic disease investigations and emergency responses.

Factor 3: Commitment

Most stakeholders recognize that eliminating H5N1 HPAI is unlikely to happen within the next 10 years and have varying levels of commitment to H5N1 HPAI control and elimination. It has proven difficult to bring all those involved to work towards common goals using a common strategy. Engagement of the large commercial sector is still weak.

MEASURES PROPOSED FOR EGYPT FOR THE NEXT FIVE YEARS

The measures will be directed to achieving two key outcomes:

i) improving biosecurity in the context of poultry production to progressively reduce the incidence of HPAI;

ii) managing the movement of poultry and products along the value chain to minimise the opportunities for spread of HPAI viruses.

The strategy is described in three sequential but overlapping phases:

1. Control phase

This is an extension of the current phase directed toward understanding the epidemiology

of HPAI in Egypt, improving the capacity to determine the incidence of the disease and monitor the impact of control measures, and planning and implementing sustainable and socially equitable HPAI prevention and control measures.

2. Consolidation phase

During this phase HPAI will be greatly reduced in incidence by supporting biosecurity measures which will be recognized, at least in larger scale poultry enterprises, as being cost-effective and will therefore be largely self-regulated. Measures will be introduced or revised to improve the regulation of poultry movement along the value chain and the conduct of slaughtering and retail markets. It is anticipated that human infections with H5N1 HPAI will become rare events.

3. Elimination phase

Prospects for elimination of H5N1 HPAI virus will depend on progress with effective implementation of the above-described phases.

TABLE A1.2
Objectives of the control phase

Objective	Planned outcome by the end of the control phase
1. Strengthen those elements of government veterinary services that are essential for improved livestock disease control	Veterinary service capability is not a major limiting factor for HPAI control
2. Define the prevalence, incidence and other epidemiological parameters of HPAI in Egypt	Available data facilitates effective strategic planning for continuing HPAI control
3. Describe the economic and cultural elements of poultry production and marketing that influence the maintenance and spread of HPAI	Information is available that enables socially equitable, culturally acceptable and economically viable options for HPAI control to be formulated
4. Improve the biosecurity of commercial and household poultry production units	The incidence of outbreaks of HPAI detected by appropriately structured surveillance is progressively reduced
5. Improve vaccination in commercial poultry production units	A progressive increase in effective flock immunity in long-cycle poultry flocks is tangible
6. Improve veterinary hygiene management along the poultry value chain	Successive studies indicate a reduction in circulating HPAI virus in key locations
7. Increase incident reporting through appropriate outbreak response measures.	A progressive increase in poultry disease incident reporting by producers and communities is noticeable.

Indonesia

BRIEF HISTORY OF THE DISEASE

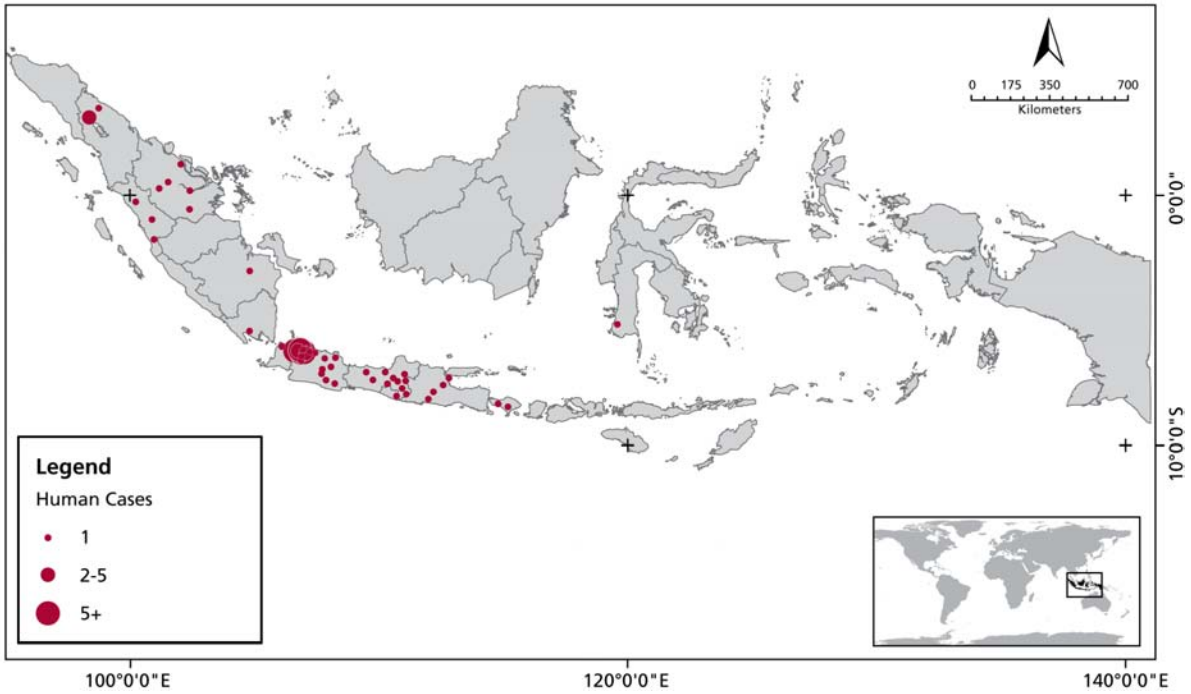
Indonesia first reported cases of H5N1 HPAI in 2003. By the time the disease was officially reported it was already widespread and entrenched. The disease has been reported widely in humans and poultry as shown in Figure A1.5 and Figure 3 (in the main document).

Currently HPAI outbreaks occur frequently on Java and Sumatra islands. Recent improvement has been observed in South Sulawesi and Bali, and it appears that the risk to these and other islands in Indonesia may be due to continued poultry movements from Java and Sumatra.

Cases reported in Indonesia increased dramatically in 2006 with the introduction of the Participatory Disease Surveillance and Response (PDSR) programme (Table 2 and Figure 3 in main document).

The incidence of H5N1 HPAI poultry outbreaks appears to increase from December to March each year, and then gradually decrease from April, reaching a nadir in November. It is still unclear whether this is due to seasonal climatic factors (the December-March period

FIGURE A1.5
Human cases of H5N1 HPAI in Indonesia



Source: Ministry of Health, Republic of Indonesia: Human Cases, 2005 – 2010.
BPS Administration Boundaries, 2005

is during the rainy season), due to human activities such as the major festival periods of Ramadan and Christmas, or due to changes in the reporting of suspected outbreaks.

Biologic characterization and analysis has been done on 164 H5N1 HPAI virus isolates from 215 samples representing 98 of Indonesia's 450 districts at the Australian Animal Health Laboratory in collaboration with Indonesian laboratories. This recent study (through OIE/FAO network on animal influenza [OFFLU]) has provided insights into H5N1 HPAI in Indonesia, especially viruses circulating in village-based poultry during 2007 (86 percent of total viruses analyzed).

Phylogenetic analysis has shown that all Indonesian isolates are HA Clade 2.1 viruses, with the majority (78 percent) classified as clade 2.1.3. This suggests a single introduction event with subsequent evolution in-country.

The oldest lineage (circa 2003) comprises viruses in clade 2.1.1, which was still detected in 2007 samples from Bali. While there have been no Clade 2.1.2 isolates characterized in this particular study, the HPAI sub-lineages distributed in Indonesian poultry continue to evolve as shown by the recent detection of antigenically diverse viruses from West Java and identification of a potentially new third order clade among 17 percent of viruses from 2005-2007 originating in central Java and Bali.

OTHER KNOWLEDGE GENERATED IN THE PAST FIVE YEARS

Control and prevention of H5N1 HPAI

The complex and weakly regulated structure of the poultry sector has hampered the control and prevention of avian influenza in Indonesia. Though a range of measures were put in place but have not helped move towards country-wide elimination of the virus. Some areas of the country with low human and poultry density have had smaller numbers of outbreaks and the virus did not persist in these areas.

Stamping out

Stamping out is now limited to individual infected flocks in villages, but is hampered by the lack of an appropriate compensation scheme.

TABLE A1.3
Annual poultry production - Indonesia 2009

	2009 Production	Percentage
Broiler	930 318 000	68.79
Native	261 398 000	19.33
Layer	110 106 000	8.14
Duck	42 090 000	3.11
Quail	6 945 900	0.51
Pigeon	1 511 200	0.11
Total	**1 352 369 100**	**100.00**

Understanding and modifying the poultry sector, improving farm and market biosecurity and hygiene

More than 1.3 billion poultry are produced ever year in Indonesia with production centred on Java and Sumatra (Table A1.3). They are sold through very complex non-integrated chains that are heavily reliant on the sale of live poultry through live poultry markets.

Vaccination

Vaccination, in use by the commercial sector for a number of years, was also introduced for sector four poultry in mass campaigns that proved to be unsustainable and delivered only short-term gains in immunity. It was also used as an emergency measure in the event of outbreaks, but this practice was also stopped due to concerns about the spread of virus by vaccination teams.

Vaccine efficacy has been hampered by the rapid turnover of poultry and also the emergence of antigenic variant strains of the virus against which existing vaccines afford limited protection. Vaccination continues to be used on integrated farms, breeder farms and layer farms. Some broiler farmers vaccinate seasonally.

Surveillance and disease reporting

PDSR has provided information on the incidence of disease in the village poultry sector. This process has been facilitated by the introduction of rapid antigen testing. For provinces under PDSR surveillance, those with high commercial poultry populations appear to experience a higher incidence of H5N1 HPAI outbreaks in village poultry throughout the year compared to those with lower commercial poultry numbers. These include Central Java, Yogyakarta, West Java and Lampung.

Recent surveillance of markets and collectors' yards has revealed that environmental contamination with H5 subtype influenza viruses is detected throughout the year in markets. More than 50 percent of markets tested in and around Jakarta were positive for the influenza A virus, and in most months more than 50 percent of the influenza viruses were H5 subtype viruses.

LESSONS LEARNED

- Controlling endemic HPAI in Indonesia requires comprehensive long-term surveillance, outbreak control, and a prevention strategy focused on poultry health and involving all sectors (backyard, commercial) and marketing systems.
- Use of ring vaccination in village poultry during outbreak response is not effective.
- Government-funded mass vaccination of backyard poultry is not feasible.
- Strengthening veterinary services to address all diseases of local importance is fundamental to sustainable HPAI control.
- A large-scale operational research programme was not effective in addressing its objective of identifying more effective HPAI control options.
- Commercial production systems are crucial in maintaining and spreading HPAI.
- Operational support for utilizing trained skills in the field is essential for trainees to build competencies and confidence.

- The village, not the household, is the more appropriate epidemiological unit for control of HPAI in backyard poultry.
- Gaining control of HPAI is difficult in the absence of an effective compensation mechanism for affected farmers.
- Backyard poultry production should not be approached as a 'problem,' but rather as an opportunity to improve community nutrition and health.

CONSTRAINTS

The major constraints to progress identified in Indonesia are listed below:

- Weak understanding of germ theory and mechanisms of disease transmission.
- Poor understanding of the duck production system and its transmission.
- Large chicken producers channelling products to traditional metropolitan live bird markets.
- Lack of a coherent policy on vaccines and vaccination.
- No enforcement of disease control.
- No compensation system to support disease reporting.
- Need to integrate new emergency animal health system.
- Poor early warning and reporting system when H5N1 HPAI occurs on commercial farms.
- Limited capacity to stamp out initial outbreaks.
- Culling is largely ineffective.
- Failure to engage private sector in outbreak response at an early stage.
- Weak governance due to decentralization.
- Poor coordination between DGLS and local government at all levels (no national veterinary authority).
- Limited political and financial commitment.
- Animal health and veterinary legislation was outdated until new legislation was passed in 2009.
- Low technical capacity.
- Lack of communication and trust between commercial sector and government.
- Government supports only small-scale sector not industry.
- Restricted geographic focus of donors and international agencies.
- Reluctance of donors to contribute to one country trust fund.
- Donor-driven strategies.
- Yearly funding cycle (both national government and international donors).

PROGRESS ON CONSTRAINTS TO VIRUS ELIMINATION

A number of activities have been performed to address the constraints described above. Specific activities undertaken related to the three factors identified as major constraints to the long-term goal of virus elimination include:

Factor 1: The structure of the poultry sector

Studies have been undertaken to understand the complex structure of the poultry industry and to map the locations of farms. Major changes to live bird markets and collectors yards

in Jakarta Province are being undertaken and are described in the text box in the main document.

Factor 2: Veterinary and animal production services

The main area of progress has been the involvement of government staff in the PDSR programme with training of over 2 000 local government staff in participatory techniques and community engagement focused on village poultry. The local government programme is now being expanded to address commercial poultry.

Factor 3: Commitment

Commitment to action against avian influenza has been improved through the use of participatory methods that aim to gain the trust of community village level producers and through the engagement of market traders.

MEASURES PROPOSED FOR INDONESIA FOR THE NEXT FIVE YEARS

The overall goal is to support the development of a comprehensive programme addressing surveillance, prevention and outbreak control in villages, commercial farms and market systems via local government, central government and private sector based initiatives. Specific elements include:

1. Supporting healthier poultry by establishing a certification programme for poultry.
2. Strengthening veterinary services by supporting the development of a National Veterinary Service (NVS) and building the capacity of animal health services to effectively address other animal and zoonotic diseases of concern.
3. Facilitating the establishment of a functional and dynamic public-private partnership between the poultry industry and the government for improving poultry production quality in Indonesia.

TABLE A1.4
Main objectives and indicators of success in Indonesia

Objective	Indicator of success
Strengthen pre-existing biosecurity initiatives for poultry producers and market chains for immediate risk reduction	Recommended risk reduction activities routinely conducted by programme beneficiaries
Develop an evidence-base to determine efficacious and cost effective biosecurity measures	Efficacious biosecurity measures identified and integrated within control programme training and communication materials
Determine the role of ducks in the epidemiology of HPAI in Indonesia	Role of ducks in maintenance and spread of HPAI in Indonesia published
Improve understanding of HPAI in commercial poultry via market chain surveillance	Results of market chain surveillance routinely utilized to guide control programme strategy and activities
Provide technical assistance to local market chain restructuring initiatives	Sale of live poultry in urban markets eliminated
Improve knowledge of basic disease transmission principles	Behaviours to reduce disease spread routinely practiced by programme beneficiaries

(cont.)

(cont.)

Objective	Indicator of success
Improve surveillance, control, and prevention components of the PDSR system in endemic areas and integrate the PDSR system more fully into the National Veterinary Service	Cost-effectiveness of PDSR system increased
Improve engagement between local governmental veterinary services and small-scale producers	Small-scale producers routinely reporting disease occurrences to local government veterinary services
Support unification of commercial industry for a more functional public-private partnership with the government of Indonesia	National Poultry Quality Improvement Programme ratified by all parties and implemented
Build consumer-driven poultry production and marketing certification programme, linking farm to fork	Market chain poultry certification programme implemented in targeted areas
Develop an evidence-base for improved use of vaccine in Indonesia	Evidence-based recommendations on vaccine usage published
Develop centrally-managed system to monitor circulating viruses and sustain vaccine efficacy	Circulating viruses regularly identified and compared to vaccine strains utilizing antigenic cartography
Support the development of a central government strategy to strengthen veterinary services	Veterinary services strategy ratified and implemented
Generate and increase farmer demand for higher quality veterinary services by providing veterinary services directly to farmers	Poultry health services provided by independent private sector veterinary practice
Improve use of HPAI knowledge for disease control by developing an integrated knowledge-base to include all available data sources (e.g. market surveillance, antigenic characteristics of viruses, commercial surveillance)	Knowledge-base routinely utilized to guide control programme strategy and activities

The People's Republic of China

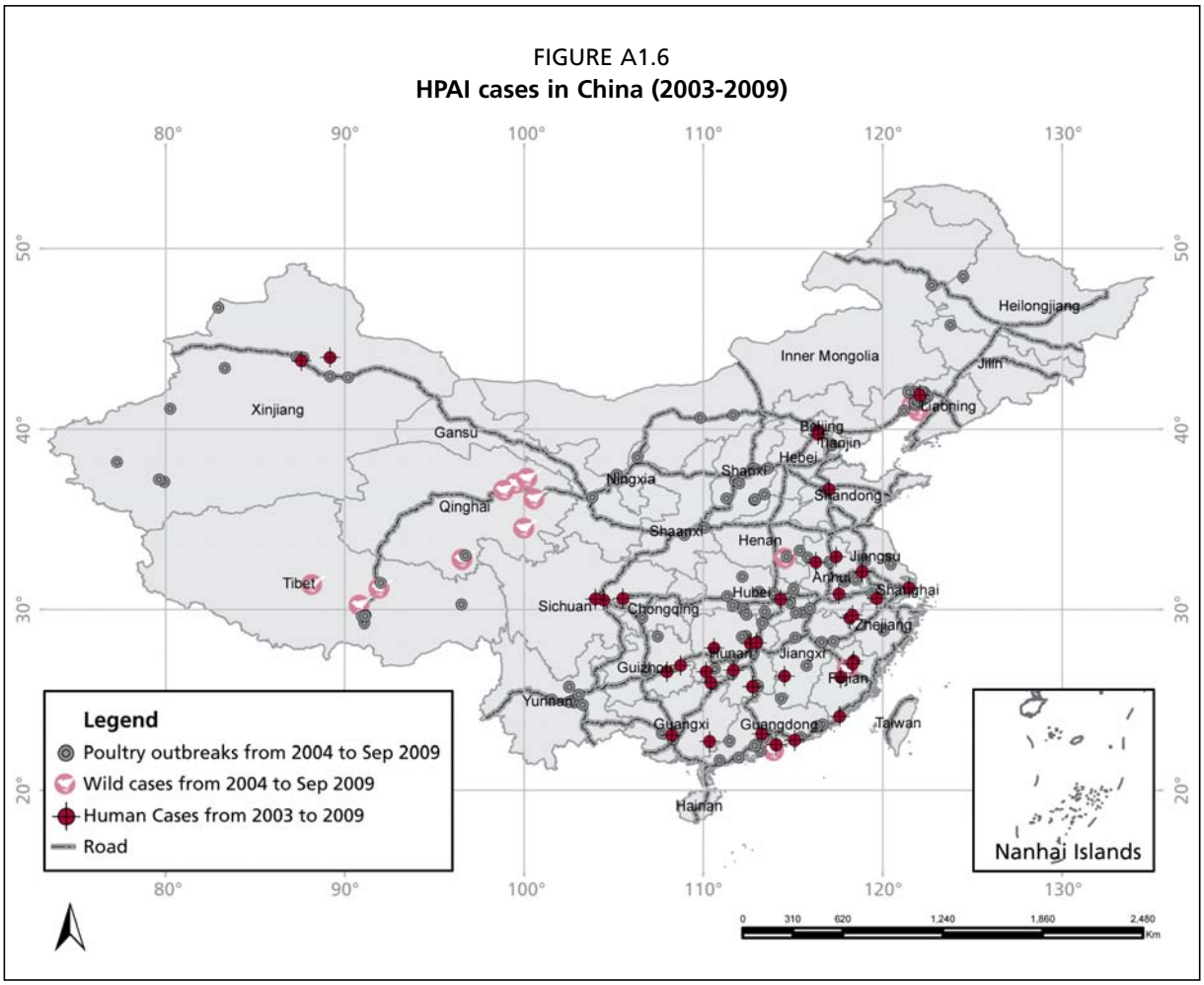
BRIEF HISTORY OF THE DISEASE

The first known Asian-lineage H5N1 HPAI virus was detected in geese in Guangdong province in 1996. The next year, a severe outbreak affecting humans and poultry occurred in Hong Kong SAR. H5N1 HPAI viruses similar to the ones first found in 1996 continued to circulate and evolve but it was not until 2004 that reports of disease due to this virus were officially recorded from across the country. Further outbreaks occurred over the following years but none have been reported since May 2009. Human cases also occurred in 2003, 2005-2009 and 2010, with only one case in May 2010 (see Table 1 in main document).

Active surveillance in live poultry markets has established that viruses continue to circulate, with the most recent positive results reported in January 2010.

A wide range of H5N1 HA clades, including all first and second order H5N1 HA clades, have been detected in China including Hong Kong. Recent information on gene sequences demonstrate that Clade 2.3.2 viruses now appear to be encountered more frequently in

FIGURE A1.6
HPAI cases in China (2003-2009)



poultry than Clade 2.3.4 or Clade 7 viruses. Viruses from other clades (including Clade 2.2) have not been reported in 2009-2010 in poultry (Jiang *et al*. 2010, Li *et al*. 2010).

OTHER KNOWLEDGE GENERATED IN THE PAST FIVE YEARS

Control and prevention of H5N1 HPAI

The structure of the poultry sector and veterinary services has hampered efforts to eliminate H5N1 HPAI from China, especially in areas with large numbers of poultry reared under conditions of minimal biosecurity. However, China has been active in promoting vaccination as a means of prevention and has also improved the biosecurity of large commercial farms and the hygiene of some live poultry markets.

Stamping out

Wide area stamping out was used in China when outbreaks were first reported in 2004 coupled with movement controls and cleaning and disinfection of affected farms. Compensation is paid to farmers who are affected by government control operations.

Understanding and modifying the poultry sector, improving farm and market biosecurity and hygiene

The standing population of poultry in China in 2008 was approximately 5.6 billion with about 4.6 billion chickens, 760 million ducks and 300 million geese. A high proportion of poultry are still reared outdoors. As described elsewhere in this document there is considerable variation in the poultry sector both within and between provinces.

Many birds are sold through live poultry markets and there is considerable interprovincial trade in poultry with birds being moved over long distances. Some market chain studies have provided improved clarity on the complexity of value chains and the extent of poultry movement in some parts of the country.

Vaccination

Vaccination has been used in China for a number of years and was officially sanctioned in 2004 when it was deployed in a 5 km zone around the 3 km stamping out zone that surrounds outbreak sites. Mass vaccination campaigns have been conducted, and the vaccine was made available free of charge since 2005. China has an active programme of vaccine development and has produced effective vaccines that are well matched to circulating strains of virus. Over 15 billion doses of vaccine were used in 2008. Nine modern plants are licensed to produce H5N1 vaccines.

Mass vaccination campaigns are conducted several times a year for small flocks of poultry, with supplementary vaccination in some cases. Commercial farms vaccinate poultry at the appropriate age. As with all vaccination campaigns, the programme is hampered by concurrent diseases in vaccinated flocks, and although it is compulsory there is evidence that not all poultry, especially ducks, are vaccinated (Chen 2009). The Ministry of Agriculture is convinced that vaccination has helped reduce the number of disease outbreaks and the quantity of circulating virus.

Surveillance and disease reporting

China has undertaken considerable active surveillance on H5N1 HPAI. Studies conducted on ducks from 1999 to 2002 showed that H5N1 HPAI was circulating in the southern provinces.

A monthly report on surveillance activities is prepared by the Ministry of Agriculture and published in the Official Veterinary Bulletin. Testing is based on national guidelines that are amended every year, and include post-vaccination monitoring for antibody response, serological testing of unvaccinated poultry in selected provinces and virological samples from a range of species. Surveillance is conducted by different groups within the Ministry of Agriculture and includes work conducted by the National Reference Laboratory.

The veterinary service is multilayered which means that decisions on whether a disease warrants reporting are made by veterinary technicians low down in the chain. Where vaccination is used, H5N1 HPAI is unlikely to appear in its typical form and therefore there is potential for cases with low-level mortality or egg drop not to be reported or investigated further.

LESSONS LEARNED

- China is a large country which requires major efforts to create a pool of competent veterinary epidemiologists. A systematic and long-term approach is needed for training in this area.
- Live poultry markets (with inadequate hygiene measures) and domestic ducks remain major challenges for disease elimination in China (and other countries).
- Considerable movement of poultry occurs across China and could potentially spread disease.
- Wild birds are playing some role in the transmission of H5N1 HPAI, particularly in China's northwest area.
- H5N1 HPAI can be eliminated from poultry in parts of China, as has been demonstrated in Hong Kong SAR and from other disease-free zones in mainland China.
- Relatively quick development and distribution of new vaccines is possible provided programmes are in place to identify antigenic variants among viruses and the research facilities linked to vaccine companies have the capacity and capability to develop and test new antigens.
- Vaccination is likely to play a role in the prevention of H5N1 HPAI as long as the threat of infection persists. Modifying vaccination programmes requires better information on the level of threat posed to individual farms and household poultry within particular areas.
- Risk factors for infection are becoming better understood through studies that assess the links between agro-ecological factors and occurrence of infection.

CONSTRAINTS

The major constraints to progress in the control, prevention and elimination of H5N1 HPAI identified in China are listed below:

- The size of the country, its poultry population and the mixture of poultry production and marketing systems.

- Central direction but provincial implementation of policies.
- Incomplete understanding of disease dynamics and transmission cycles at the domestic poultry–human-wildlife interface.
- Incomplete understanding of the dynamic pattern of poultry production systems, value/supply chains and trade in poultry and poultry products within China.
- Limited understanding of disease outbreak dynamics, and few mechanisms for tracing backward and forward, making it difficult to acquire a national and holistic picture of the disease situation.
- Difficult to refine the control strategy (including the vaccination strategy) due to insufficient epidemiological knowledge and lack of understanding of the risks present in various poultry production systems and along market chains.
- Poor understanding of infection and transmission dynamics of the virus in local situations in places where the virus persists.
- Vaccine strategy still based on large-scale blanket campaign.
- Effects of vaccination are not fully documented and understood.
- Absence of an 'exit strategy' for mass vaccination.
- Not all live bird markets have improved biosecurity and hygiene.
- Few skilled veterinary epidemiologists available to conduct effective epidemiological studies, disease outbreak investigations and disease modelling.
- Lack of an early reporting mechanism for results of the active surveillance programme limit its use as an early warning system.
- Emphasis in the past on outbreak reporting rather than infection distribution and epidemiological understanding of infection and disease, although the situation is improving now.
- Data from the active surveillance system is collected in various institutes/agencies and stored in different databases, leading to potentially incomplete analysis.
- Not all sporadic outbreaks or cases of infection are detected or reported.
- National surveillance system at the county level still needs to be strengthened.
- Lack of denominator data (population at risk) at local level.
- Some delays in the past in sharing of information on virus genetic sequences but some improvements recently.
- Variations in quality of veterinary laboratories.
- Limited coordination between the Ministry of Agriculture and other departments and agencies such as the State Forestry Administration, the Ministry of Health.

PROGRESS ON CONSTRAINTS TO VIRUS ELIMINATION

Factor 1: The structure of the poultry sector

Some studies have been undertaken to understand the complex structure of the poultry industry. The government has improved many live bird markets, and banned the sale of live poultry in some cities. A shift in production from backyard to industrial has been promoted, and certification requirements for poultry have been strengthened for large consignments of poultry.

Factor 2: Veterinary and animal production services

Considerable action has been made to strengthen veterinary laboratory and epidemiological knowledge and skills through training. Changes have been made to monitoring and surveillance systems based on recommendations from FAO.

Factor 3: Commitment

Commitment to action against H5N1 HPAI is evident at all levels of government and in the large commercial sector. Disease-free zones and compartments have been established but country-wide virus elimination remains a distant goal.

MEASURES PROPOSED FOR CHINA FOR THE NEXT FIVE YEARS

To provide recommendations to the Chinese government and update the national guideline policy for HPAI control, a list of actions for the next five years (2011-2015) has been proposed with the following objectives:

1. Develop a sustainable poultry sector system not only through a healthier poultry sector but also by increasing production sustainability.
2. Strengthen veterinary services at different levels for the effective control of diseases.
3. Create a transparent HPAI control system by combining efforts from different actors playing roles in the control and prevention of HPAI.

TABLE A1.5
Objectives for China (2011-2015)

Objective	Expected Outcomes
GOOD POULTRY PRODUCTION PRACTICES	
Establish good and sustainable poultry production practices	Define different certification legislation for healthy poultry production according to different sectors and economic background and assign strong working teams to provide technical support and supervision
Develop epidemiological knowledge and improve knowledge of poultry production dynamic pattern	Define poultry population at risk in different ecological and epidemiological systems
Involve enterprises in improving the quality control of poultry	Establish incentive systems for the quality production of one-day-old poultry
LIVE BIRD MARKETS	
Establish a commercially viable strategy for poultry marketing, based on business models	Ensure good veterinary public health practices and consumer protection by harmonizing public and private interests in a sustainable and viable manner
Improve the biosecurity and hygiene of live bird markets by establishing public private partnerships	Identify the relationships between public and private stakeholders and provide technical support on the restructuring of live bird markets
Improve the understanding of risk factors along market chains	Combine the results of market chain studies and surveillance programmes targeted at live bird markets to develop a tracing system of poultry and poultry products

(cont.)

(cont.)

Objective	Expected Outcomes
VACCINATION STRATEGY	
Modification of vaccination programmes	Provide decision makers with evidence-based data to review the strategy for mass vaccination and shift to targeted vaccination
Improve the methodology for evaluating vaccination efficacy	Fully document the impact of vaccination
Improve the understanding of the economic impact of the national vaccination programme	Provide decision makers with cost-benefit analysis
Reinforce the supervision of vaccine efficacy	Establish national avian influenza vaccine quality control system and ensure compulsory vaccination
PERFORMANCE OF OFFICIAL VETERINARY SERVICES	
Improve the internal vertical governance of official veterinary services and upgrade the disease flow of information	Establish internal coordination mechanisms and a clear and effective chain of command at the national level for most activities
Improve the coordination mechanism between the Ministry of Agriculture and other departments and agencies such as the State Forestry Administration, and the Ministry of Health.	Provide an information sharing platform between public health, veterinary and wildlife staff
DISEASE SURVEILLANCE AND MONITORING	
Improve the understanding of disease dynamic and transmission cycle at the domestic poultry-human-wildlife interface.	Maximise the use of active surveillance programme results and conduct risk analysis, modelling and communication
Foster coordination mechanisms with clearly described procedures or agreements at the national level for routine surveillance and emergency response Strengthen the disease early warning mechanism	Ensure transparency and disease data sharing
Improve the analysis of data generated by the active surveillance system	Develop risk models for different compartments using surveillance data Further improve disease management by accurately reporting the disease situation and submitting detailed data about the local situation Apply risk modelling or risk mapping to fully predict the risk level by eco-geographic zones
Enhance border region detection	Decrease the illegal movement of poultry to prevent H5N1 HPAI transmission across borders
OUTBREAK REPORT AND NOTIFICATION	
Incentive system to report outbreaks.	Develop a national disease reporting incentive system among different stakeholders.
Improve the understanding of disease outbreak dynamics and mechanisms for tracing backward and forward to provide a national and holistic picture of the disease situation.	Provide more information on infection distribution and epidemiological understanding of infection disease, leading to better disease management.

Objective	Expected Outcomes
LABORATORY CAPACITY BUILDING	
Improve the standardization of the quality of veterinary laboratories.	Provide national guidelines for laboratories at national and provincial levels to ensure standardization of sample collection, diagnostic procedures and data reporting.
Improve the ring test among laboratories.	Increase the accuracy and consistency of diagnostics among different institutes or agencies.
EPIDEMIOLOGY CAPACITY BUILDING	
Increase the number of skilled field veterinary epidemiologists available to conduct effective epidemiological studies and disease outbreak investigations.	Provide local veterinarians with basic knowledge and skills though training.
Improve the epidemiological capability of national and subnational veterinary services.	Organize training of senior and key technical staff in advanced disease analysis and modeling techniques.
Provided sustainable education on veterinary epidemiology.	Establish a national curriculum on veterinary epidemiology.

Annex 2

Possible milestones for Viet Nam 2010-2016

(from FAO submission to Review of Green Book)

	2010 Milestones	2012 Milestones	2014 Milestones	2016 Milestones
H5N1 status	Less than ten human cases per annum in Viet Nam Develop proposals for designating central provinces as an eradication zone — training and resource needs	Designation of central provinces (regions four and five) as HPAI eradication zones		Demonstrate freedom in selected central provinces in accordance with OIE standards No human cases in Viet Nam for preceding two years Development of proposals for eradication in Mekong Delta (see vaccination)
Veterinary services	Detailed, realistic, costed plan for the redevelopment of veterinary services prepared covering 5, 10 and 20 year time frames	Twinning arrangement established between overseas veterinary school and Viet Nam veterinary school for support in veterinary public health, preventive veterinary medicine, disease investigations, pathology and epidemiology	New veterinary law adopted and enforced	Registration system in operation for veterinarians and para-veterinarians based on standardized qualifications Professional body providing CE programme and professional guidance to profession
Veterinary laboratories	Quality management system implemented in all DAH labs and associated provincial labs (VAHIP)	Designs for new NCVD and Region six laboratory reviewed by international experts and approved	NCVD and Region six laboratory relocated based on internationally 'approved' plans	First two laboratories achieve ISO accreditation
Investigation milestones	Preparation of joint investigation reports of outbreaks that provide appropriate detail on the investigation for 20 percent of reported avian cases and 40 percent of human cases (deemed suitable for publication in MMWR or Eurosurveillance)	Preparation of joint investigations reports on outbreaks that provide appropriate detail on the investigation for 40 percent of reported avian cases and 60 percent of human cases that meet publication standard	Preparation of investigation reports that provide appropriate detail on the investigation for 75 percent of avian cases that meet publication standard	Preparation of investigation reports on 90 percent of outbreaks that meet publication standards
Vaccination	First round of results from GETS programme available and used to modify vaccination and surveillance programme	Cost of vaccination to government reduced with no increase in the number of human cases (better targeting, greater user pays, others) Final results from GETS programme available and used to modify vaccination and surveillance programme	Availability, acceptance and use by farmers of a (single dose) duck vaccine (e.g. vaccine against DVE and HPAI) in grazing ducks that also allows clear differentiation of infected from vaccinated ducks	Decision made on whether vaccination is required in central zone

	2010 Milestones	**2012 Milestones**	**2014 Milestones**	**2016 Milestones**
Market chains	Ha Vi market redevelopment completed	See behaviour change communication (BCC) below	Traceability established for all consignments of poultry to slaughterhouses	Traceability established for all consignments to wholesale markets
Border controls	Describe and understand the drivers of illegal imports and set targets	New penalties introduced for smuggling poultry (perhaps based on cost to country of virus incursions) that strongly discourage the activity backed by BCC (see below)	Joint northern border anti-animal smuggling liaison group operating Possible compartment established for import of DOC from China	
'Commune health'	'Commune health' programme commences	First five pilot communes fully implemented	100 new communes completed	1 000 communes completed
Compart-mentalization		First commercial poultry compartment operating successfully		Second commercial poultry compartment operating successfully
Emergency plans	Emergency plan reviewed and redrafted			
Epidemiology and surveillance	Five percent of provinces produce acceptable surveillance reports meeting standards set by DAH (aim for publishable standard)	30 percent of provinces produce acceptable surveillance reports meeting standards set by DA	Routes of introduction of virus to central provinces understood from disease investigations	90 percent of provinces produce acceptable surveillance reports for the key animal diseases
Restructuring	LIFSAP operational Detailed costed plan for development of livestock services staff prepared		10 provincial poultry development plans implemented fully	LIFSAP completed and lessons learned applied
Farm biosecurity			Biosecurity audits compulsory for all farms >5000 poultry	
Behaviour Change Communication (BCC)		Specific behaviour change communication programme developed and implemented for traders and transporters aimed at reducing risk they pose to farms Intensive BCC campaign for northern border provinces	Demonstrated reduction in the quantity of smuggled poultry	

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Ar – Arabic
C – Chinese
E – English
F – French
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At its peak in 2006, highly pathogenic avian influenza (HPAI) caused by viruses of the H5N1 subtype was reported in over 60 countries. Since then, most affected countries have eliminated the disease. However, in Bangladesh, the People's Republic of China, Egypt, India, Indonesia and Viet Nam, the virus has remained entrenched and these countries continue to be endemic for the disease.

The Food and Agriculture Organization of the United Nations, in association with national authorities, has developed a framework, based on experiences gained so far in endemically infected countries and covering activities that, if adopted, will help to move each country along the path towards virus elimination. Each framework comprises a mix of measures aimed at outbreak control and responses; gathering and analyzing information from surveillance, disease investigations and other epidemiological studies and market chain studies; and disease prevention and risk reduction.

As the virus is unlikely to be eliminated from poultry for some time the risk of emergence of a human pandemic strain from an avian virus will persist and will need management. The extended time frame until the virus can be eliminated provides opportunities for research into new and innovative measures for the control and prevention of H5N1 HPAI and other influenza viruses. This includes better vaccines that can be delivered easily to poultry production sectors; methods of developing virus resistance in poultry through genetic manipulation and selection; and universal influenza vaccines for humans that protect against different influenza virus subtypes, thus minimizing the threat posed by the virus to human health.

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