

Background Paper

3.2a ii Achievements, issues and options on strategies for HPAI control and prevention

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Summary

Much has been achieved in controlling H5N1 highly pathogenic avian influenza, although some of the achievements have been masked by the continuing occurrence of disease in countries where infection remains entrenched. The main achievement has been the eradication of these viruses from poultry in many countries and reductions in the prevalence of infection in most other countries in which the viruses have been found.

A major achievement is the acknowledgement that H5N1 HPAI viruses will not be eradicated globally in the medium term., This allows a shift in the emphasis away from emergency measures to a longer term approach in places with entrenched infection and long-established, high risk rearing and marketing practices. This allows socially and economically equitable restructuring of the production and marketing system to reduce these risks. This shift is already occurring in places such as Vietnam and China. Other countries, such as Indonesia, are establishing response systems that, over time are expected to reduce levels of infection, although the gains from these, in terms of reductions in new human and avian cases are yet to be seen. These will also need to be accompanied by restructuring to maximize long term benefits.

The strengthening of laboratory diagnostic capacity is perhaps the most visible change in countries supported by donors. The range of appropriate tests available in these laboratories has increased and turnaround time for results has decreased through provision of equipment, reagents and training. These laboratories also have nascent quality management systems on which they can further improve the consistency of their performance. This improved laboratory capacity has supported increased targeted and scanning surveillance in infected and at-risk countries.

Despite these gains, veterinary capacity remains a major constraint. Specific capacity issues are being documented through the PVS process to allow remedial measures to be developed.

However, some of the institutional problems such as devolution of authority to provincial or district level, low wages and allowances and inadequate staffing levels will be difficult to overcome given these are not easily addressed using donor funds. There is still insufficient veterinary capacity to perform all required active and passive surveillance.

Disease reporting has improved considerably during the course of the outbreak with a number of countries that rarely reported disease providing comprehensive summaries of reported cases to international agencies. This was facilitated by the contacts made through regional networks developed through emergency funding. However, these regional networks are proving difficult to sustain.

International organizations and donors have provided considerable support to national governments in controlling this disease, including provision of technical material and development of standards and guidelines, and specific technical advice to individual countries or regional groups.

Many lessons have been learned about the control of this disease and the need to adopt different approaches, depending on the state of infection or risk. Those countries with entrenched infection will adopt different measures to those with outbreaks that have recently occurred. In the former case, widespread stamping out is likely to be of limited benefit and may even be counterproductive unless a very high proportion of infected flocks are detected and changes are implemented after stamping out to prevent recurrence. Vaccination will be required as a control measure in the foreseeable future especially in places where for technical, social, economic or environmental reasons changes cannot be made to high risk production and marketing practices.

Farm biosecurity remains an important disease reduction measure but some farming systems cannot be made biosecure without drastically changing the way that the birds are reared.

Introduction

This paper explores the many achievements in control and prevention of Asian lineage H5N1 HPAI viruses since multi-country outbreaks of disease caused by these viruses were first reported in 2004. It also examines the constraints faced in controlling these viruses and the lessons learned (and re-learned) during this period.

From the 1950s to 2003 all outbreaks of highly pathogenic avian influenza, apart from one in Pakistan, were contained rapidly. This probably led to false expectations that similar success would be achieved with Asian lineage H5N1 HPAI when it first emerged as a multi-country problem. However, these expectations failed to take account of the difficulties of control resulting from the well entrenched infection in a number of countries. These countries generally had large poultry populations, poorly regulated trade and movement in these and other birds, and limited veterinary capacity. This was compounded by the apparent adaptation of these viruses to domestic ducks, which are reared outdoors in large numbers in some of these countries in Asia.

Infection with H5N1 HPAI viruses is still entrenched in a number of countries in Asia and Africa and transboundary spread and human cases of disease have continued. These events have obscured the significant progress made in the control and prevention of this disease.

Disease control, prevention and eradication

Achievements

Major achievements since 2004 include eradication of H5N1 HPAI from most newly infected countries (e.g. Japan, Republic of Korea, Malaysia, England, Denmark, France and other European countries); increased awareness and preparedness in at-risk countries; and reductions in the virus load in countries with entrenched infection¹ through a range of control measures, including, but not limited to, vaccination.

Up to June 2007, some 59 countries have reported disease due to H5N1 viruses in poultry or wild birds. Many of these have eradicated infection, but remain at risk of re-incursion².

Based on a history of repeat cases over the past 2 to 4 years in poultry and humans, infection remains entrenched in China, Indonesia, the lower Mekong area, in Egypt and Nigeria and, possibly, in Pakistan and Afghanistan. Spillover infection to other countries has occurred. Infection has recurred in wild birds in the Palearctic in 2005 and 2006. Thailand and Viet Nam have both markedly reduced the number of reported human cases using different but locally appropriate responses to the disease. China has also reduced the impact of the disease through a range of measures including mass vaccination of much of its domestic poultry population – a gargantuan task given the country's standing population of almost 5 billion domestic poultry (including ducks and geese). Other changes to market hygiene and marketing practices have been introduced in major cities in China that have also aided in reducing the risk of infection.

In Russia a risk-based approach to control was implemented with vaccination introduced to highly susceptible smallholder flocks in areas frequented by wild birds. Individual outbreaks of disease in Egypt, Indonesia and Nigeria are being contained through application of emergency control measures but new cases continue to emerge. Indonesia is establishing response systems that, over time are expected to reduce levels of infection, although the gains from these, in terms of reductions in new human and avian cases are yet to be seen. For example, the participatory disease detection methods appear to have improved case detection but are yet to have a significant impact on disease prevalence. In addition, the large commercial sectors in Indonesia and Egypt have reduced to some extent the impact of the disease in commercial farms through vaccination (largely because of the commercial imperatives to do so) but this has not proven to be a panacea in the case of Indonesia where disease in commercial broilers remains a major concern.

Considerable donor support is rightly being directed to these countries where the disease is more difficult to manage. However, the immediate benefits of investments in these countries may be less apparent than those in countries where, for a range of reasons (including lower poultry density and climate), the disease is more readily controlled.

¹ Those with recurrent cases over the past 2 to 3 years in poultry and/or humans). The word entrenched is used in preference to endemically infected as in many of these countries the prevalence of infection in poultry varies considerably over time and at any one time most flocks of poultry (with the exception of live poultry in large, poorly managed markets and grazing ducks) are probably free from infection.

² In some countries the extent of gains and validity of claims of freedom are obscured by limited surveillance capacity.

A major achievement has been the acknowledgement that H5N1 HPAI viruses will not be eradicated globally in the medium term (Sims 2007). This allows modification of the approach to control in places with entrenched infection away from an emergency response, as required in newly infected countries. This also allows better assessment of the changes needed to local poultry rearing and marketing practices that will lead to sustained gains in control and prevention.

It also provides an opportunity to ensure the measures implemented are feasible and implemented in a manner that minimizes social, economic and environmental harm. International guidance notes on control and prevention of H5N1 HPAI were released by FAO in September 2004 (FAO 2004b) and much of this information remains relevant. These notes stressed the need for the use of an iterative approach to control based around the most appropriate combination of measures for the local situation and the need to consider and, as necessary, utilize all available tools for control of this disease. These notes were followed by other technical documents on aspects of control, including guidance for newly infected countries (FAO 2006), studies on compensation, the global strategy (FAO 2007) and a range of documents and standards from OIE.

A range of affordable vaccines have been introduced to control this disease and although vaccination remains labour intensive, vaccines have been utilized in large scale publicly funded campaigns in Viet Nam and China to reduce viral loads. Vaccines have also been used as an additional preventive measure in a number of places where the risk of incursion of virus was demonstrably too great to be contained by other measures (e.g. Hong Kong SAR). Lists of vaccine manufacturers have been prepared by FAO/OIE and assessments of some vaccine manufacturing plants have been performed to ensure compliance with OIE requirements for production.

Constraints

Veterinary capacity remains a key constraint to effective H5N1 HPAI control. The specific constraints are well recognised and are being documented and measured through the PVS process as an important first step towards addressing these issues. Long term support will be required to enhance veterinary capacity but short donor funding horizons can inhibit implementation of the long term changes needed to deal with this and other emerging animal health and public health issues. In addition, structural and political impediments to strengthening veterinary services identified in PVS assessments, including poor public sector wages, allowances and conditions, limited budget allocations for animal health activities and provincial autonomy, will be difficult to overcome using donor funds and will require active engagement at high levels in government.

Cooperation and communication between the large scale poultry industry and government remains weak in a number of countries. Devolution of veterinary services to provincial or lower authorities compounds problems of poor lines of communication in multi-layered veterinary services, which already suffer from filtering of information at each step between the field and central authorities.

Measurement of successes remains difficult especially in countries with entrenched infection. Human cases represent one imperfect but useful independent indicator (imperfect because not all cases of infection are detected). Globally these appear to have stabilized in 2007 with Thailand and Vietnam in particular experiencing far fewer cases in 2006-07 than in the previous 3 years.

The overall effectiveness of combined control measures implemented is evident in these countries but as various elements were used concurrently it was not possible to ascribe the gains to any one particular measure.

Surveillance, disease diagnosis and laboratory capacity

Achievements

A major advance in the past 3 years and one of the most visible areas of activity of the donor community is the enhanced capacity, capability and quality of activities in veterinary laboratories.

In a number of countries, including China and Viet Nam, RT-PCR and/or real time RT-PCR have been introduced to veterinary laboratories and are backed by nascent quality management programs, including external quality assurance testing.

This improved laboratory capacity has supported increased targeted and scanning surveillance in infected and at-risk countries. As with disease control, various methods have been used that are appropriate to the local situation (e.g. X-ray surveillance in Thailand, participatory approaches in Indonesia).

The result has been an increase in the number of reports of disease and virus isolates (which can lead to an apparent increase in disease prevalence due to better case detection). The gene sequences of many of these have been made available to the international community to assist in pandemic planning and in understanding virus evolution and epidemiology. Primers and probes have been redesigned to cope with changes in genetic codes, allowing emerging genetic variants to be detected in routine tests. International guidance on surveillance was provided by FAO in 2004 (FAO 2004a) and stressed the need to develop trigger points for investigations that differ depending on the production system and whether other measures such as vaccination are in place (vaccination should result in lowering of trigger points). Additional guidance on surveillance for avian influenza is provided in the OIE Terrestrial Code (OIE 2006).

Hong Kong SAR, which controlled infection in the commercial poultry sector after a number of incursions of H5N1 viruses from 1997 to 2003 in poultry typifies the changes that have occurred in surveillance and also the levels of testing needed to demonstrate successes in control programs. The intensive surveillance system developed there is based on testing of dead birds in markets and farms, pre-market serology to ensure vaccine-induced immunity in chickens, placement of unvaccinated sentinel poultry in all flocks, cage/faecal swabs from markets by two unrelated organizations and dead wild bird monitoring. This demonstrates the intensity of surveillance required to detect low levels of infection in high risk places. However, this model, also highlights the large gap between this system and the surveillance systems that can be implemented in most Asian countries given resource constraints and the much larger farm and poultry numbers compared to Hong Kong SAR. Without this system, Hong Kong SAR would not have been possible to demonstrate the gains made from the range of control measures implemented, including apparent freedom from infection in live poultry markets and farms for the past 3.5 years. The dead 'wild' bird monitoring system has also demonstrated the on-going threat posed by infection in free flying birds, especially in the winter.

A noteworthy development associated with this panzootic is the increased transparency typified by reports on outbreaks of avian influenza from countries such as North Korea and Myanmar, and the marked increase in the amount of timely information from China covering not only disease outbreaks, but also surveillance data and developments in vaccine production and research. This increased openness also resulted in sharing of a number of viruses from these countries. Globally, there is still room for additional reporting of information, greater coordination of animal health and human health information, and sharing of genetic data on viruses. However the trend noted so far is extremely encouraging. Some of this increase in reporting resulted from increased engagement with international organizations through national and regional support programs.

Considerable resources have been expended on surveillance of wild birds and tracing of their movements. These studies have demonstrated the very low rate of carriage of H5N1 viruses by healthy birds and the importance of testing of dead 'wild' birds as an early warning system for presence of infection. These studies have also provided insights into the complex movement patterns of migratory birds.

Constraints

The size of the poultry industry in many infected countries does not allow performance of sufficient surveillance and diagnostic testing to allow detection of all cases of infection, especially in silently infected domestic ducks and large live poultry markets. This is complicated by the dispersal of poultry into millions of small flocks.

In addition, the 5 to 7 day period between initial infection of a flock of chickens and detection of disease could result in the inadvertent sale of some poultry incubating disease. With the exception of Hong Kong SAR, surveillance programs in most countries, including post-vaccination surveillance, only cover only a small proportion of the flocks of poultry.

As this disease is seasonal, and the composition of flocks alters rapidly, repeated surveillance is required to reconfirm infection status in any given area. Resources are not available to conduct the quantity of testing needed to provide animal health authorities with sufficient data on which to base decisions on control programs.

Companion serological tests to detect infection in vaccinated flocks (DIVA tests) have been developed and used effectively in Europe in monitoring infection with low pathogenicity viruses in vaccinated poultry. However, for a number of valid reasons (including the early stage and objectives of the control program in some countries and the circulation of other low pathogenicity avian influenza viruses that can interfere with test interpretation) these have been used infrequently in the field in most endemically infected countries. Sentinel poultry have been used in caged flocks (e.g. Hong Kong SAR) but can be difficult to manage under other management systems and are not always welcomed by producers, especially if this is not a universal requirement. Other approaches to detection of recent infection in vaccinated flocks, such as testing of routine mortalities should be considered but are difficult to apply in the millions of small flocks of poultry present in currently infected countries.

There are few veterinary pathologists working in many of the countries with entrenched infection and therefore cases of HPAI are being diagnosed on the basis of positive PCR and or culture results and clinical signs without determining, through pathological studies, whether other diseases are also occurring.

WHO recommends that H5N1 HPAI viruses should only be cultured in laboratories meeting BSL-3 conditions. In many countries there is limited capacity to do diagnostic work under these conditions and limited budgets to service and maintain these facilities once installed in order to meet WHO requirements³.

Public sector, private sector international organizations and donors

Achievements

Ultimately, control of H5N1 HPAI within individual countries rests with national governments operating through national and provincial veterinary services. This has been strongly supported by regional and international organizations that provided support, both directly and indirectly, to achieve their objectives. Major regional and sub-regional organizations, including ASEAN, ASEAN+3, SAARC, ECO and AU/IBAR, have provided leadership in addressing the regional dimension of the H5N1 HPAI control. Globally, the strategic alliances among FAO, OIE, WHO and other UN agencies under UNSIC has been underpinned by multilateral and bilateral donors, including development banks such as the World Bank and the Asian Development Bank. Without this support from international agencies and donors many of the achievements in emergency preparedness, emergency disease control and, increasingly, longer term control and preventive strategies built around strengthened veterinary capacity and capability would not have occurred and will not be possible to sustain in the future.

The initial outbreaks of avian influenza led to development of a number of emergency programs that provided essential emergency equipment and advice to countries facing outbreaks of this disease or the threat of viral incursion. Funds were also directed to develop regional groups, given the transboundary nature of this disease and the need for a consistent (but not necessarily uniform) approach to disease control within and across regions.

Technical advice has been provided to at-risk and infected countries on aspects of disease control and prevention. This includes advice to governments in the face of crises and in developing longer term approaches (e.g. advice to Vietnam on vaccination etc) A series of international meetings covering avian influenza control and prevention, the role of wild birds, vaccination and other issues relevant to this disease have provided invaluable information on which national governments developed their control strategies. Regional and national meetings and workshops have also been arranged to discuss similar issues. Meetings with donors have also been organized to ensure on-going support to the program Donors have provided considerable quantities of supplies and equipment, both for emergency and longer term use.

At risk and infected countries have received considerable training for animal health and production staff in disease recognition, epidemiology, and use of animal disease recording databases. Much of this has been through donor supported programs FAO and OIE have provided up to date information on suspected reports and confirmed cases, providing early warning system to countries for this and other

³ Procedures that do not require propagation of H5N1 HPAI viruses, such as PCR, can be conducted in facilities meeting BSL-2 standards using BSL-3 work practices – so-called BSL2+ activities.

diseases. The establishment of the FAO Crisis Management Centre provides a facility to bring rapid-response capacity to transboundary animal and plant diseases and has been activated for recent outbreaks (e.g. Bangladesh).

FAO has also established teams specifically devoted to avian influenza at national and regional level to deal with AI issues and provide support to national governments and regional bodies.

Numerous technical papers have been produced on issues such as surveillance, disease control, biosecurity, and compensation socio-economic effects of the disease and the control measures used.

Constraints

Absorptive capacity of national governments has been challenged by the large amounts of timebound funds provided for AI support. Regional networks have provided benefits but are difficult to sustain without on-going funding and strong political support from the countries involved. There appears to be a shortage of skilled professionals available to work on avian influenza projects.

Lessons learned

Donors have questioned why a uniform approach to this disease has not been developed and why advice from consultants, even within the same organization varies. This arises largely because there are at least four different scenarios for infected countries parts of countries or countries at risk. These are:

- Countries in which infection was rapidly detected after incursion, and which normally have a low risk of virus incursion (e.g. EU 2006)
- Countries that recently detected infection but did not detect early incursions so that
- disease/infection was already widespread before action was taken (most countries in SE Asia in 2003-04)
- Countries with entrenched infection (cases of disease reported in poultry and/or humans in the previous two years (e.g. Egypt, Nigeria, Viet Nam, China, Indonesia)
- Places/countries with high risk of virus incursion (e.g. Hong Kong SAR, large parts of Russia)

The approach to control under each of these scenarios differs. Guidelines for emergency responses promoting early case detection and rapid stamping out are appropriate for the first scenario. However, this approach has failed to eliminate infection in countries with entrenched infection and in fact may not always be the most appropriate response, for such countries.

All control measures reduce but do not eliminate risk (FAO 2004). Each country has to adopt the measures most appropriate to the local situation. Combinations of measures are better than measures used singly and those used should be appropriate for the country concerned. An iterative approach to disease control is required.

It is evident that unless changes are made to the way that poultry are reared or other risk mitigation measures are introduced, this disease will persist in countries where the viruses are entrenched. However, the structure of the poultry industry (production, marketing and other inputs) in endemically infected countries present

huge challenges when implementing appropriate, socially responsible control of this disease.

The presence of H5N1 AI viruses does not automatically lead to human infections, as demonstrated in Hong Kong SAR in 2001-03 when infection occurred in poultry but no human cases were recorded. Reducing the HPAI incidence even without eradication, can reduce and even prevent human cases of disease, as shown in Thailand and Viet Nam. The overall goal should be to minimise the amount of circulating H5N1 HPAI viruses and where conditions allow, eradicating them.

Stamping out

Stamping out has been used effectively in control of some outbreaks but did not prevent reincursion of virus in subsequent years (e.g. Japan, Republic of Korea, Malaysia). Incursions of virus to new places or countries justify an emergency response. However not all of the first recognized cases are the true index cases. If disease is already widespread the value of mass culling becomes questionable especially if reported clinical disease represents only a proportion of infected flocks. Stamping out provides only temporary gains unless there are changes in farming and marketing practices in places where the risk of incursion is high. Stamping out leads to loss of livelihood for an extended period, especially for smallholders. Most compensation schemes do not support such payments. Availability of compensation does not guarantee disease reporting (although absence of a compensation scheme also inhibits reporting). Reduced use of culling reduces the need for compensation and associated complications.

Humane destruction remains problematic and therefore the use of mass slaughter as a routine response is a somewhat questionable approach to this disease. Culling should be restricted to the minimum amount required to control infection

Movement management (including cross border controls)

Border controls and internal check points can reduce the risk of illegal movement of poultry. However, it has always been impossible to prevent all smuggling of poultry, with price determining the direction of poultry movements across land borders. In places where there is considerable smuggling of poultry other control measures must be sufficiently robust to withstand these incursions of potentially infected poultry. There are also significant difficulties in preventing illegal movement of poultry within a country especially when there are millions of small farms and many transporters carting small quantities of poultry. The overall effectiveness of movement management needs to be taken into account when designing control programs.

"Restructuring" – changes to management practices in farms and marketing

Certain industry practices pose higher risks than others and unless these are changed the risk of infection and disease will persist. Examples include selling poultry through poorly regulated live poultry markets. Changes to market management (or in some cases a shift in the way that poultry are sold) are required to reduce these risks. The need for such changes has been identified in Indonesia and Egypt because there is considerable uncontrolled sale of broiler chickens through many poorly regulated live poultry markets.

However for social, economic, environmental and/or technical reasons elimination of some practices is not feasible (e.g. grazing ducks in Viet Nam) in which case other interventions are needed (such as vaccination) to reduce the risk of infection. Where

high risk production and marketing practices exist any gains from other control measures will likely be short lived unless these high risk practices are modified.

Biosecurity

Despite enhanced disease control, transboundary spread of disease has not been prevented, with a number of countries experiencing re-incursions of virus after stamping out (this has occurred twice in Malaysia after the initial outbreak in 2004 was stamped out). Some of these incursions were probably the result of wild bird introduction of viruses (e.g. Japan and Republic of Korea) others were probably due to illegal movement of game birds (e.g. Malaysia) and demonstrate that even when biosecurity measures are taken to reduce the risk of incursion of virus onto farms, some failures still occur.

Farm level biosecurity measures reduce but do not eliminate the risk of virus incursion. There are many examples of supposedly biosecure farms breaking down with horizontally transmitted diseases, including avian influenza (e.g. Japan, Republic of Korea 2006-07). Many production systems cannot be made biosecure without radical changes to management (e.g. grazing ducks). While these management practices persist vaccination remains one of the few tools available to reduce the risk of infection in these systems.

The risk of virus incursion to any farm is a complex mix of the level of threat and the measures practiced to prevent incursion or onward transmission of virus. (See Table 1) Any outbreak of H5N1 HPAI avian influenza in a farm is an indication that there is an imbalance between the threat of infection and the biosecurity measures used on that farm to prevent this disease. One difficulty for farmers is that information on the level of threat is not always available.

Table 1. Risk of incursion into and sustained transmission within one or more farms in each FAO production system - without vaccination

FAO System ►	System 1	System 2	System 3	System 4
Level of threat* ▼				
Negligible	Negligible	Negligible	Negligible	Negligible
Low	Very Low	Very Low	Moderate	Moderate
Moderate	Low	Low to Moderate	Moderate to High	Moderate
High	Moderate	Moderate-High	High to Extremely High	High

*Examples of qualitative 'levels of threat' used in this table

- Negligible: Australia New Zealand 2006 (no virus in country and very low risk of incursion)
- Low: Europe in winter 2006 (some wild birds carriage of virus to parts of Europe)
- Moderate: Viet Nam Mekong Delta 2006 (virus still circulating in unvaccinated ducks)
- High: Nigeria, Indonesia, Egypt 2006

Vaccination

Vaccination has been used as a preventive measure in places with moderate to high risk of virus incursion (e.g. Hong Kong SAR 2004-07) It is also a valuable tool for use

in control of AI by reducing the virus load and increasing the resistance of poultry to infection. It can be used as an adjunct to other measures to assist in eradicating infection from poultry.

The use of vaccination can modify the risk of sustained transmission in poultry flocks as illustrated in Table 2.

Table 2. Risk of incursion into and sustained transmission within one or more farms within each FAO production system with effective vaccination

FAO System ►	System 1	System 2	System 3	System 4
Level of threat* ▼				
Negligible	Negligible	Negligible	Negligible	Negligible
Low	Very Low	Very Low	Low	Low
Moderate	Low	Low	Low to Moderate	Low to Moderate
High	Low	Low to Moderate	Low to Moderate	Low to Moderate

Large scale vaccination programs are the only option available to reduce the likelihood of disease in some places with high risk production practices. However vaccination campaigns require well coordinated and properly resourced animal health services, strong central, provincial and local support for the measures, and sufficient quantities of suitable quality assured vaccine.

The goal of vaccination programs must be clearly defined and will vary depending on the situation in the country. In countries with many high risk production practices the gains from vaccination may only be temporary unless these practices are modified. Parallel activities to remove underlying factors that lead to sustained infection need to be implemented when conducting the vaccination campaign. The effectiveness of these other measures will determine when reliance on vaccination can be reduced.

Post-vaccination monitoring is essential in all vaccination campaigns but the program should be adapted to the stage and purpose of the campaign, the capacity of veterinary services to monitor vaccinated flocks and the extent of monitoring for infection prior to vaccination. As a minimum, when vaccination is used, active surveillance should be conducted to detect and characterize circulating H5N1 viruses to ensure that existing vaccines remain protective.

The logistic challenges of large scale vaccination campaigns, especially those involving village level poultry, are major constraints to effective programs. However, these are probably no less daunting than the challenges faced in determining the exact extent of infection, stamping out all foci of infection, enhancing biosecurity of these premises or implementing effective movement controls.

Scientific information on vaccination is being interpreted in different ways by different countries leading, in some cases, to rejection of its use on non-scientific grounds. In Thailand and Nigeria, where vaccination is not permitted, illegal

importation and use of vaccines has been detected. This complicates control programs, and is potentially dangerous if vaccines purchased are not produced correctly or if vaccine antigens are improperly inactivated.

Most current vaccines require injection of individual birds and therefore vaccine campaigns are very labour intensive. Research is needed to develop appropriate vaccines that can be delivered in hatcheries or by other methods.

Antigens in vaccines should ideally match closely to circulating virus strains even though good cross protection is afforded by a wide range of antigens. Generally speaking the closer the match the better the level of protection. Antigenic variants that resist existing vaccines have been described. There is an urgent need for regulators to consider allowing vaccine manufacturers to incorporate different, appropriate antigens into vaccines in cases where antigenic variants have arisen without having to resubmit full approval dossiers. If some way of streamlining this regulatory process is not established antigenic variants could become widespread complicating control of this disease.

Cleaning and disinfection

Cleaning and disinfection are important measures for reducing residual levels of infection in farms, markets and transport vehicles. However, there is considerable wastage of disinfectants (limited contact time, wrong disinfectant, high loads of organic matter) especially given that the main source of infection is live infected poultry. In many infected and at risk countries, changes to these practices will be difficult to implement but improved guidance on use of disinfectants is required.

Behavioural change campaigns

Behavioural change takes time and for many farmers or villagers, financial realities counter public health concerns when dealing with sick or dead poultry, especially if they perceive the risk of infection to be low.

Despite considerable training and BCC campaigns on 'biosecurity' many high risk practices persist in smallholder flocks.

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