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GUIDELINES FOR THE DEVELOPMENT OF HEALTH MANAGEMENT PLANS TO PREVENT AVIAN INFLUENZA (H5N1) IN WILD ANIMAL COLLECTIONS IN ASIA

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ABSTRACT

Since December 2003 numerous severe avian influenza outbreaks have been reported in South East Asia. In 2004 the epidemic continued to spread in Asia and in 2005 outbreaks were recorded in a number of countries in Europe. The disease is caused by a highly pathogenic strain of the avian influenza A virus (H5N1). Over 150 million domestic poultry have died or been culled as a result of the disease. Humans and other animals including wildlife have also been affected with a number of deaths reported. The effects of this epidemic are unprecedented. The combined severe economic losses, human health, animal welfare and conservation implications mean the potential continued spread of the virus is of global concern. In this paper guidelines for implementing a health management plan to prevent avian influenza in wild animal collections are described. Use is made of a biosecure boundary system and controlled crossing of boundaries. The paper also outlines techniques to, assess risks by hazard analysis, establish controlled crossings and apply and enforce appropriate security measures.

INTRODUCTION

Fowl plague, a lethal viral disease of poultry, has been recognised since the late nineteenth/early twentieth century. In 1955, a specific type of influenza virus was identified as the causal agent of fowl plague. Since then, avian influenza viruses have been found to cause a wide range of disease syndromes in domestic poultry.

Since December 2003 numerous severe avian influenza outbreaks have been reported in South East Asia. More recently the disease has spread to Russia and a number of countries in Europe. The disease is caused by a highly pathogenic strain of the avian influenza A virus (H5N1) which has principally affected the domestic chicken population. The UN Food and Agricultural Organisation (FAO) estimates that over 150 million domestic poultry have died or been culled as a result of the disease with economic losses to the poultry sector of around US$10 billion. Despite control efforts the disease continues to spread.

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Table 1. List of animals affected by avian influenza A (H5N1) in the epidemic across S.E. Asia 2003–2004 *

Captive animals	**Wild animals**
Brown fish owl	Black drongo
Buffy fish owl	Crow
Cat	Dove
Clouded leopard	Grey heron
Crane	Hornbill
Crested hawk eagle	Little cormorant
Crow	Magpie
Egret	Open billed stork
Grey headed fish eagle	Peregrine falcon
Hawk eagle	Pigeon
Heron	Red collared dove
Ostrich	Scaly breasted munia
Psittacines	
Serpent eagle	**Domestic Poultry**
Spot bellied eagle owl	Chicken
Spotted wood owl	Duck
Tiger	Pheasant
	Quail
Status not specified	Turkey
Black swan	Goose
Stork	Guinea fowl

*Sourced from FAO Avian Influenza Disease Emergency News 1–26

Table 2. Some examples of documentation required in a health management plan

1. Introduction and basic outline
2. List of roles and responsibilities
3. Boundary maps with controlled crossings identified
4. Various protocols for each boundary crossing including
    a. Cleaning and disinfecting
    b. Servicing of cleaning and disinfection points
    c. Protective workwear requirements
    d. Animal housing (1) Feed
        (2) Water
        (3) Cleaning
5. Multi-lingual education posters and leaflets
6. Multi-lingual signs. (Do not enter. Please wipe your feet. Please dip your feet. Do not feed wild birds. Do not litter ...etc.)
7. Pest control

Some people have also been infected with serious consequences. As of 29th Nov 2005 there have been 133 confirmed human cases of avian influenza A (H5N1) resulting in 68 deaths. This case mortality rate (51%) has created worries as to the consequences if this avian influenza virus should further mutate into a disease with capability of spreading by human to human contact.

Avian influenza viruses are ubiquitous in wild water birds. Historically, avian influenza viruses have rarely caused disease in wild birds. Previously the only reported die-off was in common terns in South Africa in 1961 (BECKER, 1966; FRIEND, 1999). As this epidemic continues there are an increasing number of reports of infections in a variety of wild birds and other animals (Table 1) that suggest that the virus is sufficiently pathogenic to cause concern for conservationists in an area of the world that is rich in biodiversity.

Despite national, regional and international efforts, using recommended slaughter policy to eradicate the disease, it is recognised that the condition is now endemic in some areas of SE Asia (OIE and FAO web sites). The effects of this disease epidemic are unprecedented. The combined severe economic losses, human health, animal welfare and conservation implications mean the potential continued spread of the virus is not only of local but of national and global concern. Local concerns for zoos include threats to the health and safety of staff and visitors and the welfare of animals including endangered species in the zoo and possible closure restricting vital income from local visitors and foreign tourists. A number of zoos in Asia have already witnessed the devastating effects of the disease in their animal collections and in September 2005 avian influenza was reported in zoo birds in Jakarta, Indonesia. Some zoo employees and visitors were hospitalised with signs of influenza and the zoo was closed to the public. On a global scale these types of threats are being taken very seriously (SCULLION & SCULLION, 2005) and the American Zoo and Aquarium Association has recently drafted guidelines for the prevention of avian influenza in North American zoos (ANON, 2005). Zoo and wildlife veterinarians and zoo directors in countries where the disease is now endemic or a possible threat need to consider the potential for transmission of avian influenza and to implement control strategies that can curtail its spread.

In this paper guidelines for implementing a health management plan to prevent avian influenza in wild animal collections are described. Use is made of a biosecure boundary system and controlled crossing of boundaries. The paper also outlines techniques to, assess risks by hazard analysis, establish controlled crossings and apply and enforce appropriate security measures.

IMPLEMENTING A HEALTH MANAGEMENT PLAN

For the proper implementation of a health management plan the full co-operation of all staff and support, both financially and in manpower, from the top management level is needed. Quite a lot of the required changes are simple and will incur little extra financial cost. The plan will involve a number of changes to work practices and will need to be in force for some time. It is important to assure people that positive steps can be taken to significantly decrease the chances of a disease outbreak even when the surrounding situation seems desperate.

No matter how good the plan, it will be doomed to failure if all parties involved do not adhere to the various steps required. A series of meetings and instructional courses should be planned to get the necessary support from the people around you. Involve members of staff in their areas of expertise in the early stages to get better acceptance of the overall plan. It is necessary to document the various aspects of the health management plan (Table 2).

UNDERSTANDING DISEASE

Veterinary principles of disease control require a basic knowledge of disease pathogenesis, epidemiology and clinical presentation.

Although the immediate source of infection for domestic poultry can seldom be ascertained, it is thought that most outbreaks probably start with direct or indirect contact of domestic poultry with waterbirds. Many of the strains that circulate in wild birds are either non-pathogenic or mildly pathogenic for poultry but genetic mutations can result in the emergence of highly pathogenic strains. There is evidence to show that domestic ducks have played a central role in the generation and maintenance of highly pathogenic virus in SE Asia in recent outbreaks (LI *ET AL.*, 2004). Although some ducks have died it has been found that the disease is less severe and takes longer to clear from an affected duck population and therefore asymptomatic ducks could spread the disease. Similar situations may occur in other bird and animal species. Thus in areas where avian influenza is endemic, disease prevention measures will be necessary where no obvious immediate threat from sick and dying animals may be apparent.

Pathogenic strains can emerge and cause disease in domestic poultry in any country, at any time, without warning. In fact, outbreaks have occurred at irregular intervals on all continents. The most serious epidemics in recent times were in Hong Kong during 1997–1998 and 2003, The Netherlands in 2003 and South-Korea in 2003 (OIE web site).
Avian influenza is highly contagious in domestic poultry. Infected poultry excrete virus in high concentration in their faeces and in nasal and ocular discharges. The disease generally spreads rapidly in a flock by direct contact, but on occasions spread is erratic. The virus is spread from flock to flock by movement of infected birds, contaminated equipment and people in contact with infected birds.

Airborne transmission may occur if birds are in close proximity. The possibility of vertical transmission is unresolved; however, it is unlikely that infected embryos could survive and hatch.

In highly pathogenic avian influenza the disease appears suddenly in a flock and many birds die either without any signs or with minimal signs of dullness, inappetence, ruffled feathers and fever. Other birds show weakness and a staggering gait. Hens may at first lay soft-shelled eggs, but soon stop laying. Sick birds often sit or stand in a semi-comatose state with their heads touching the ground. Combs and wattles are cyanotic and oedematous, and may have pinpoint or larger haemorrhages at their tips. Profuse watery diarrhoea is frequently present and birds are excessively thirsty. Respiration may be laboured. Haemorrhages may occur on unfeathered areas of skin. The mortality rate varies from 50 to 100%.

In broilers, neurological signs such as a twisted neck and ataxia may also be seen. The disease in turkeys is similar to that seen in layers, but it lasts 2 or 3 days longer and is occasionally accompanied by swollen sinuses. In domestic ducks and geese the signs of depression, inappetence and diarrhoea are similar to those in layers, though frequently with swollen sinuses. Younger birds may exhibit neurological signs (OIE web site).

BIOSECURE BOUNDARIES

A key feature of the health management plan for avian influenza is the establishment of a biosecure boundary system with controlled crossings where appropriate hygiene security measures can be enforced.

The basis of disease prevention using boundaries is to block the introduction of the pathogen to the host (bioexclusion). Use and reinforce established physical boundaries and create new temporary boundaries if necessary.

Although bioexclusion is the target it is often difficult to achieve this by means of a single boundary. Multiple levels of boundary defence are required to minimize the risk that the pathogen will gain access to the host (biocontainment). Understanding the principles of biocontainment as opposed to bioexclusion should encourage proper adherence to security measures. Education material should be made available to the staff that reinforces these principles.

Access to certain areas in any facility can be either restricted or free. The facility should be inspected to map out the areas where there is no need for free access for both staff and members of the public. Personnel that are allowed access in certain areas are thus fewer in number and it is then easier to apply and enforce further security measures.

Table 3 lists some security measures and enforcement procedures. Variable useage allows flexibility within the health management plan and also increases overall disease prevention as the system is less reliant on one particular method.

Enforcement may involve lock and key, dedicated security personnel, routine surveillance and spot checks. Educational leaflets or signs throughout the facility and especially at hygiene points, that explain their necessity, ensure continued compliance by members of the public.

Three types of boundary defences are relevant within a zoo and wildlife park:

(1) Perimeter
(2) Central facilities
(3) Animal enclosure

Access across the perimeter is required by both staff and public visitors; in certain times of particularly high risk it may be compulsory to close the facility with only limited access for essential animal management. The decision to close the zoo will be enforced by government regulations. Access for external services personnel may not be essential but if so it should be strictly limited. Staff, public and external service personnel should have dedicated entrances that are well separated and well marked as such. The exits for service personnel should be as close to their entrance as possible.

Appropriate facilities for cleaning and disinfection should be maintained at each entrance. Separate staff dedicated to servicing the cleaning and disinfection facilities at these positions

Table 3. Examples of security measures and enforcement techniques

Security measure	Enforcement Technique
Restricted access	Padlock Security guard Multi-lingual signs Surveillance and spot checks
Wash and disinfectant spray	Applied by dedicated personnel Surveillance and spot checks
Foot bath	Placed so that its use is compulsory Multi-lingual educational posters Surveillance and spot checks
Foot mat (Sponge backed mat soaked in disinfectant)	Placed so that its use is compulsory Multi-lingual sign instructs please wipe feet Surveillance and spot checks
Protective clothing	Recognisable uniform Workwear provided, laundered or disposed of by zoo Staff training Surveillance and spot checks
Personal hygiene	Job description and standard operating procedures Surveillance and spot checks

should be identified. A protocol detailing the procedures and frequency of servicing and waste disposal should be available.

The risk of disease entry may not be fully eliminated at the zoo entrances. Public traffic within the zoo increases the risk of pathogens being inadvertently carried in and around central facilities (restaurants, foot paths, gardens etc.). Therefore inside the perimeter a number of secondary boundaries should be defined that will further reduce the risk of pathogen spread.

Zoo housing is the last line of defence between the host animal and the pathogen and each individual animal enclosure acts as a separate bioexclusion unit. Public access should be prohibited and staff access should be strictly limited to necessary staff by lock and key.

Once established these boundary defences will remain in force while the threat remains.

HAZARD ANALYSIS AND RISK ASSESSMENT

The main hazards by which avian influenza could be introduced to captive animals are:

(a) Movement of infected domestic poultry, contaminated equipment and people
(b) Food and water supplies
(c) Wildlife

The risk associated with each hazard can be assessed during a full inspection of the facility (Table 4).

Hazard (a), Movement of Infected Domestic Poultry, Contaminated Equipment and People

Poultry infected with avian influenza become virus pumps producing and shedding large quantities of infectious virus that contaminate the local environment, transmitting the virus within the population and spreading the virus to sites beyond the location of the original outbreak.

The primary means of transmission of avian influenza during an outbreak is related to unregulated movement of poultry (dead or alive, legal and illegal), and the mechanical spread of infected materials by people from infected premises.

Fighting cocks and birds in the pet trade (legal and illegal) and live animal markets are also potential sources of continued transmission of the virus between localities during outbreaks.

Perimeter

The zoo or wildlife park should be mapped in relation to local domestic poultry facilities to assess traffic in and around the zoo. Control depends on the stringent implementation of biosecurity measures within the domestic poultry sector. It may be warranted to lobby for the interim closure of local animal markets and controls of independent food vendors in and around zoo premises.

Educational information should be made available regarding the risk posed by visitors acting as vectors of disease. This would involve multilingual displays at the zoo entrance and in press releases which give guidance on minimising disease spread when considering visiting the zoo and when entering the zoo premises. Since avian influenza is a serious zoonosis it is in everyone's interest that the disease is properly controlled and the co-operation of the public can be more readily achieved if they feel that they are protecting themselves by adhering to disease management procedures as well as protecting the animals in the facility.

The risk of attending local poultry facilities including markets needs to be explained to all zoo personnel. Staff should be encouraged to make the zoo veterinarian aware of any potential contact with poultry without fear of recrimination.

For example,

- Do they live on a farm?
- Do they have direct or regular contact with family members or friends that work in poultry farms, abattoirs or rendering plants?
- Do they travel from or through an area of high disease risk?

If so, steps may be taken to temporarily redeploy high risk individuals while the crisis continues although, preferably, contact with poultry should be discouraged in the interim.

Central facilities

Despite best efforts, public access to the zoo remains an unquantifiable disease risk and breach of the zoo perimeter boundary via this route is still a possibility. Further

Table 4. The risk associated with each hazard can be assessed during the zoo inspection and boundary defences can be constructed to address the identified risks

Boundaries Hazards	Outside zoo	Perimeter	Central facilities	Animal enclosures
Movement of infected domestic poultry, contaminated equipment and people	Map poultry farms/markets Where possible ensure outside biosecurity measures are implemented Check staff travel routes Restrict staff access to poultry farms and markets Public education	Stop entrance of poultry, poultry products and any vehicles or equipment in contact with poultry Public education Cleaning and disinfection No new animal acquisitions Dedicated work wear	Minimal entrances Cleaning and disinfection Education Monitor	House animals most at risk Cleaning and disinfection Disposable gloves No public access Dedicated work wear Minimise personnel changes Report disease
Food / Water supplies	Check water reservoir List feed suppliers and origins Analyse feed suppliers' health plan	Treat drinking water Prohibit wildlife access to untreated water Cleaning and disinfection Dedicated work wear	Wash food and clean and disinfect utensils	Wildlife exclusion barriers around feed and watering areas Prohibit exhibit animals' access to untreated water
Wildlife	Map flyways, roost sites and assess risks	Exclude wildbirds Do not feed wild birds	Prohibit wildlife access Careful disposal of waste	Solid fencing and roofing or close down part of enclosure Physical clean up

pathogen introduction and spread by wildlife and vermin may also occur within the zoo perimeter. Therefore areas of public access require a virtual boundary in the minds of staff. Staff access cannot be prohibited in these areas but staff (especially those who ultimately will have access to animal enclosures) should be aware of the risks, should consider the benefits of scheduling their work to take account of these risks and take appropriate actions in regard to personal hygiene (foot baths, foot mats, hand washes etc.) when crossing these boundaries.

Inspect each central facility bearing in mind the list of potential threats. Treat each area with the same respect, planning and implementation. Although there may be many discrete central facilities with similar risk status it is beneficial to contain potential pathogen movement by isolating as many of these facilities as possible with biosecure boundaries. Such facilities will therefore have the number of entrances and exits restricted with strategically positioned cleaning and disinfection points. Staff dedicated to servicing these positions in central areas should be identified and servicing protocols provided. Remember that limiting or prohibiting access may be simpler to control and manage than policing proper useage of hygiene points.

Animal enclosure

Zoo staff are in close contact with the animals on a repetitive basis, moving in and around animal enclosures as they perform daily tasks of feeding and husbandry. This regular traffic flow deserves special attention to prevent disease introduction because of the proximity to susceptible animals.

If possible, staff should be maintained in the same animal sections with minimal changes. Specifically, avian species should be cared for by assigned individuals. These staff should not have contact with birds outside their work. Programmes that involve birds being handled or free flying on public display should be banned for the foreseeable future.

Staff should be familiar with the animals under their care and therefore likely to spot any changes that may be important for follow up. They should report any health problems in the animals to the zoo veterinarian immediately for investigation. Sick individuals should be isolated and the staff involved should remain in charge of the sick animal and not deal with other animals until instructed by the zoo veterinarian.

Staff should be familiar with the biosecurity measures specific to their section. They should have a uniform (or dedicated clothes) and footwear for the facility and washing facilities that allow footwear to be scrubbed free of any visible dirt. Footwear should be immersed in disinfectant before further entering the enclosure. Hygiene points in animal enclosures should only be serviced by the staff who enter the enclosures. A servicing protocol should be available and include details of frequency of servicing and waste disposal. Disposable gloves should be worn while working with animals and hands should be washed frequently throughout the day and especially before entering and leaving an animal facility.

Hazard (b), Food and Water Supplies

Highly pathogenic viruses may remain viable for long periods of time in infected faeces, in tissues and water (Appendix 1). Food supplies originate from farm premises outside the zoo and it is difficult to exert complete controls from the point of origin.

Perimeter

Chicken and chicken products should be banned as a food item and should not be brought into the zoo by anyone during this crisis. A number of avian influenza outbreaks have occurred in zoo premises during the recent epidemic in S.E Asia. In one outbreak in Sri Racha Tiger Zoo, Southeast Thailand, over 100 infected and in-contact tigers either died or were euthanised after avian influenza was spread to the zoo animals by the feeding of chicken carcases (OIE).

Food suppliers should be listed and all items of food traced to their origin. A food supplier may be based in a region where a disease outbreak is occurring or may have a delivery or collection route that takes them in and around sites of potential high disease risk such as markets. The supplier's health management programme needs to be available for your inspection. Some suppliers may have no programmes in place and should not be used until they meet your biosecurity requirements.

Overall, the complete regulation and correct implementation of the biosecurity measures of others is outside your control. For this reason all suppliers should submit to stringent hygiene measures at the zoo boundary.

This may involve limiting access of trucks and personnel. Inspection of vehicles should be carried out to ensure that proper cleaning and disinfection is possible. Wood is almost impossible to adequately clean and disinfect. If suppliers have wooden vehicles they may be asked to use other vehicles or be refused entrance and asked to unload off premises. Exclusion of all vehicles would be the ideal but where this is not practical and a vehicle must cross the zoo boundary it should be adequately cleaned and disinfected with attention paid to wheels and mudguards. Adequate time should be allowed for disinfectant contact. Attention needs to be paid to the siting, safe waste disposal and safe drainage of cleaning and disinfection areas.

Food supplier personnel, if they need to enter at all, should use zoo supplied disposable foot coverings and overalls on entering zoo premises.

Central facilities

Where possible fresh food should be cleaned before use. Feed utensils should not only be washed but also disinfected at each enclosure on a daily basis. If feed utensils are brought from zoo enclosures to a central area for cleaning and disinfection then transport these in a closed container which can be easily cleaned and disinfected. The central clean up area should be managed separately to the food production area and ideally situated in different buildings or at least separated by time.

The zoo water supply should be assessed in terms of its potential to carry infection and appropriate measures put in place to minimise risk. Municipal water supplies should be investigated for placement of appropriate wildlife control measures at the reservoir and if these are inadequate then water supply to the zoo can be treated at its point of entry by using a header tank, biological filters and chemical disinfection (Appendix 2).

Other water supply sources in the zoo such as natural rivers, lakes and ponds and water features including waterfalls and fountains should be identified and unless treated their access should be closed off.

Animal enclosure

Exhibit animals should be fed and watered indoors or else solid barrier fencing should be constructed to cover feed areas. Implement frequent physical cleaning and disinfection of *in situ* feed utensils.

Natural water supplies via a river catchement or natural ponds pose a high risk of contamination and should be fenced off from the zoo stock.

Hazard (c), Wildlife

Generally, once established in domestic poultry, wild birds are no longer essential for the spread of avian influenza, since it is a highly contagious disease. However, it can be assumed that all birds are susceptible to infection and may act as vectors. There are a number of reports that some wild birds and other animals have become sick and died in the recent outbreaks of avian influenza in S.E. Asia (Table 1), so it would be sensible to try and block this potential route of disease transmission to the facility.

Perimeter

Control of the movements of wildlife outside the zoo may be the most difficult area to manage. Mapping of natural flyways and roosting sites near the zoo should be carried out to allow for hazard analysis. Specific risks may be identified such as excrement from wild bird roosting sites contaminating a water-course or foot path that traverses the zoo grounds.

Central facilities

By their nature most zoo boundaries are open to a breach by wildlife. Stray domestic cats can be a pest in some zoos. Cats can become infected with avian influenza A (H5N1) and are an unknown risk in spreading the disease (Table 1) (KUIKEN *ET AL.*, 2004). A cat trapping and euthanasia or removal policy may be necessary. Access of free-ranging wildfowl to open ponds or drainages on the zoo property must be prevented where possible by constructing physical boundaries around and over such sites. It might be possible to minimise wild bird access to the zoo by employing strategically positioned visual bird scarers but this might not be an easy task with resident birds to consider. Use education programmes to prevent the public feeding wild birds and improve waste disposal management within the zoo and this will discourage wild birds and other pests from frequenting the zoo premises.

Animal enclosure

Wildlife must be excluded from zoo animal enclosures. Solid fencing and covered enclosures are preferable. If this is impossible use small mesh netting to close off selected high risk areas in the enclosure where zoo animals and wild animals have contact. This may require the closing off of part of an enclosure for the foreseeable future. Physically clean up and disinfect enclosures twice daily. Outdoor enclosures may be restricted to areas that are amenable to this process.

Animal acquisitions for the zoo should be stopped for the foreseeable future. No sick or injured wild birds should be brought on to the zoo premises but should be submitted to the nearest official veterinarian for testing.

Other Disease Prevention Measures

In the past, it has been considered counter-productive to vaccinate against highly pathogenic avian influenza as some vaccinated individuals may become infected and shed virulent virus. Thus, in a national eradication programme, vaccination may not be allowed. However, in previous outbreaks in Pakistan and Mexico, inactivated vaccines have been employed to combat rapidly spreading disease and some countries have made use of vaccines in the recent outbreaks in S.E. Asia, to help slow the spread of the disease in conjunction with a slaughter policy to eradicate the disease. Vaccination of species other than chickens cannot be guaranteed to work. However, it would be advisable to consult with your local official veterinary office in regard to the use of vaccination and perhaps develop a contingency plan with them in relation to individual circumstances.

Surveillance and monitoring

The whole zoo team, through education and familiarity with their roles in the health management plan, should be involved in surveillance and continual monitoring of the measures put in place. Regular veterinary checks need to be carried out to ensure that protocols are adhered to and that standards of implementation are kept high.

Reporting and implementation of official control measures

There is an obligation on everyone to immediately report suspect avian influenza to the authorities. Even if a breakdown does occur, a well run health management plan will help curtail the spread of the problem and allow it to be brought under control quickly.

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Technical data sourced from
http://www.oie.int/
http://www.fao.org/

Appendix 1. Susceptibility of avian influenza virus to physical and chemical action

Temperature:	Inactivation by 56°C/3 hours; 60°C/30 min
pH:	Inactivated by acid pH
Chemicals:	Inactivated by detergents, oxidising agents, sodium dodecyl sulphate, lipid solvents, ß -propriolactone, ammonia, acids
Disinfectants:	Inactivated by formalin, bleach and iodine compounds
Survival:	Remains viable for long periods in tissues, faeces and water

Cleaning and Disinfection:

Influenza viruses are very sensitive to most detergents and disinfectants. They are readily inactivated by heating and drying. However, influenza viruses are well-protected from inactivation by organic material. For instance, infectious avian influenza virus can be recovered from chicken manure for up to 105 days. Complete cleaning and removal of all organic material is part of any effective disinfection procedure.

Avian influenza virus survives well in water with the result that, simple washing may assist transmission of the highly pathogenic virus to previously uninfected areas where it can then infect other birds. For this reason it is important to use a detergent in the initial cleaning phase. Disinfectant can then be applied. As bird droppings are the most important vector of avian influenza transmission, it is essential to thoroughly clean and disinfect all items that have been in contact with faeces: for example cages, shoes, etc.

Care needs to be taken to control drainage and waste in central clean-up areas.

Appendix 2. Prevention of waterborne avian influenza infection

If the water is cloudy or contains organic material then any preventative treatment is of limited use, so before treatment water should be sand filtered. Free chlorine at 5 ppm in clean water for an hour is considered effective. Chlorine dioxide (ClO_2) is considerably more effective than using simple chlorine treatments but is 10 times more expensive. Other methods include ultra-violet and ozone (oxidising) treatments.

Municipal tap water is usually satisfactory, but care needs to be taken if placed in storage or header tanks since these can become contaminated if not effectively sealed.