Veterinaria Italiana, **43** (2), 333-348

Disease control options for emergency animal diseases – necessary yet sensitive elimination of disease

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Summary

In the event of any emergency animal disease (EAD) outbreak, the overall aim should be the swift containment and subsequent elimination of the causal agent, whilst maintaining optimal welfare of the affected animal population and protection of public health. The control measures utilised must be acceptable to the general community and, in particular, the affected animal industries. The author reviews the disease control measures currently available. However, where possible, the aim should be the prevention of EADs to minimise their associated social, environmental, welfare and economic costs. This is only possible if the animal industries and the relevant authorities are committed to work together to develop feasible contingency plans that are regularly tested. In controlling an EAD, every effort should be made to minimise animal destruction. Where animal destruction is required, then efforts should be made to minimise wastage through utilisation of resulting carcasses where possible.

Keywords

Animal diseases, Animal disposal, Control, Emergencies, Elimination, Options.

Opzioni di controllo per emergenze legate a malattie animali – eliminazione della malattia: una necessità governata dal buon senso

Riassunto

Di fronte a un qualunque focolaio di malattia identificabile come emergenza epidemica (EAD), lo scopo principale dovrebbe essere il rapido contenimento e conseguente eliminazione dell'agente causale, mantenendo nel contempo condizioni ottimali di benessere animale nelle popolazioni colpite e di protezione della sanità pubblica. Le misure di controllo utilizzate devono essere accettate dalla società ed in particolare dalle industrie di trasformazione dei prodotti di origine animale principalmente colpite. L'autore passa in rassegna le misure di controllo attualmente disponibili. Comunque, ovunque possibile, lo scopo dovrebbe essere la prevenzione delle EADs per minimizzare i costi sociali, ambientali, di benessere animale ed economici ad esse associate. Questo è possibile solo se le industrie del settore e le principali autorità coinvolte si impegnano a lavorare insieme per sviluppare piani di emergenza fattibili e regolarmente controllati. Nella gestione di una emergenza epidemica dovrebbe essere fatto ogni sforzo per minimizzare la distruzione degli animali. Ove questa si rendesse comunque necessaria, si dovrebbe compiere ogni sforzo al fine di

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minimizzare lo spreco mediante il riutilizzo delle carcasse, ogni volta che ciò sia possibile.

Parole chiave
Controllo, Eliminazione, Emergenze, Malattie animali, Opzioni, Smaltimento animale.

Introduction

The basic principles of controlling transmissible diseases of animals by the identification of affected and at-risk animals, isolation, treatment or slaughter and then disposal and disinfection, have been known and practised for centuries.

In the first century, Columella advised 'sick animals should in all cases be separated from others to avoid their becoming contaminated through contact', as recorded by Blancou (10). On 7 September 1499 the *Mesta general de Castilla y León* promulgated a law requiring shepherds to report any places where they knew there were animals suffering from sheep pox or anthrax (13). In recording controls for contagious bovine pleuropneumonia, Blancou (11) notes that Haller in 1773 advised 'in a severe case, all the cattle in an infected cattle house shall be slaughtered for safety reasons, including those that appear healthy and those which show signs of the disease…. Such apparent cruelty is the only way of preventing the contagion from reaching other cattle houses'. Similarly, when dealing with anthrax in France, the Royal Decree of 1784 provided for the slaughter of infected animals 'where the disease has been recognised as incurable by the experts' (10).

The destruction of virulent material and the deep burial of cadavers were recommended in the writings of Vegetius (AD 380-410). In 1713, Bates in England recommended the incineration of cadavers followed by the disinfection of premises and destocking for three months. In 1715, Lancisi recommended the decontamination of anyone who had been in contact with sick animals and of clothing, premises, cadavers, litter, milk etc. (12).

Disease control programmes reduce the prevalence of disease and have often also improved animal management, resulting in improved animal welfare and productivity. A good example has been the bovine brucellosis and tuberculosis eradication campaign (BTEC) in Australia conducted between 1970 and 1997 and the subsequent monitoring campaign to demonstrate freedom. This campaign successfully eliminated both of these important zoonotic diseases from the Australian cattle and buffalo populations. In addition, the improved management required to implement the programme, such as animal identification, fencing of properties, installation of yards and watering points to control cattle movement has resulted in improved breeding and nutrition, as well as increased productivity. Animal welfare has improved due to the elimination of disease and improved livestock management.

Recent scientific advances, such as the development of vaccines and antibiotics, have contributed to the prevention and control of many diseases. New techniques have aided the accurate and timely diagnosis of emergency animal diseases (EADs). However the initial detection of disease still relies on the human factor. Those caring for the animals must be able to recognise abnormal signs and report that observation to the appropriate authority, be that a veterinarian or government official.

Unfortunately many of the scourges of animal production still remain. Foot and mouth disease (FMD), highly pathogenic avian influenza (HPAI), bluetongue, anthrax, rabies and contagious bovine pleuropneumonia are still prevalent in many areas of the globe. The driving forces for control of these diseases are market access, the threat to public health and growing community expectations for improved animal welfare.

Australia has been fortunate in that the absence of many mammalian species prior to European settlement, combined with geographic isolation, has resulted in freedom from many of the important livestock diseases. When faced by an incursion by one of these agents, Australian policy has been based on control and elimination. This has always been a planned approach. First the disease was, where possible, contained by the imposition of movement restrictions; then prevalence was reduced by management and/or vaccination in the target population and, finally, elimination was achieved by test and slaughter on an area basis.

Past experience teaches us that there is no magic solution. Successful disease control/ eradication programmes rely on the implementation of the best available control options in a planned and co-ordinated manner. It is becoming increasingly important to consider more efficient and humane strategies that ensure minimal wastage of animals and their products as an integral component of disease control.

Current risk factors

In the past, diseases spread to adjacent regions and countries through movements of animals by road or ship but now, with expanding global trade and movement of animals and goods by air, disease has an increased potential to jump large distances to infect animals remote from endemic areas. This can result in rapid escalation from a local problem to an international epidemic (29). The potential for extensive animal movements can be illustrated by the movements of one thoroughbred horse which, between February and October 2002, travelled to seven locations in six countries on three continents. More than 700 sheep can be transported in one aircraft from the southern to the northern hemisphere in less than 24 hours. Disease transmission over long distances has also been associated with the illegal movements of animals and biological products, such as vaccines and serum. Recently reported cases of equine infectious anaemia in Ireland have potentially arisen in this fashion (27).

Emerging diseases have assumed increasing importance in public and animal health, with a steady stream of new diseases appearing over recent years. Examples include Nipah virus, monkey pox, severe acute respiratory syndrome (SARS) and West Nile virus. This trend has been attributed to many factors, including the expansion of the human population, resulting in ecological disruption and globalisation of trade, including trade in exotic and endangered animals. It is likely that this rate of emergence of animal diseases will not only continue, but increase (14).

The intensification of animal industries has resulted in many changes to disease management. The first of these is that fewer people care for many more animals. In some cases, detection of disease is now dependent on indirect measures, such as reduced feed consumption or reduced quantity and/or quality of products. Detection can also rely on recording increased levels of mortality in age groups or other cohorts. These factors may delay early detection and result in failure to notice important early clinical signs, before secondary infections occur.

The second effect of intensification has been the creation of large populations of naive animals held in close proximity. Hence, when a virus such as HPAI enters domestic poultry, it can quickly passage many times, resulting in adaptation and possibly increased pathogenicity. Biosecurity programmes at the farm level become very important in minimising the risk of disease agents entering these populations.

The third change associated with intensification has been the development of specialisation. Animals rarely remain on the premises of birth throughout their productive life. There are specialist breeders, growers, finishers and abattoirs. This results in enormous populations of animals without a shared disease status being moved over large distances and co-mingling. Tracing animal movements and maintaining biosecurity become increasingly difficult as was seen in the outbreak of classical swine fever (CSF) (hog cholera) in the Netherlands in 1997-1998 (18).

The fourth effect is the scale and prominence of EAD control measures if disease does enter these large intensive populations. The decision to slaughter millions of apparently healthy animals to control disease is never taken lightly and, as was seen in the United Kingdom (UK) with the FMD outbreak in 2001, it may no longer enjoy broad community support. Yet, where the disease has a zoonotic potential, communities may accept such measures, as in Hong Kong in 1997, when the entire poultry population was depopulated to control HPAI after six people had died.

Finally, the degree of intensification affects the livestock owner's attitude towards disease (29). Highly infectious diseases such as FMD or Newcastle disease are a potential disaster for the intensive farmer, whereas extensive producers at the village level may be indifferent to the presence of such diseases and see them as part of the natural cycle. This difference in attitude will, amongst other effects, have an impact on the reporting of these diseases.

Historically, agricultural industries tended to be evenly spread across a region. With intensification and the resulting formation of larger production units, there has been a tendency for industries to congregate in areas. For example, all the poultry may be located in one valley, or the feedlots in one region; there are often sound industrial, economic or environmental reasons for this concentration. It may be close to the market, to the source of feed or to the processing plants and hence reduce transportation costs. However, if large populations are in close proximity and disease enters, then it is easier for the disease to spread rapidly. Therefore, those responsible for planning need to consider the disease risks within such production systems.

Where previously livestock industries had relied on governments to prevent the entry of disease to regions or countries by the application of strict quarantine measures, current trade agreements (World Trade Organization, Agreement on the Application of Sanitary and Phytosanitary Measures) require countries to ensure that any sanitary or phytosanitary measure is:

- applied only to the extent necessary to protect human, animal or plant life or health,
- based on scientific principles
- not maintained without sufficient scientific evidence (34).

Whilst quarantine measures are enforced by governments, they are not a form of total sanitary protection for the livestock industries. Other strategies must be adopted.

Since the 1980s there has been a marked reduction in veterinarians servicing the livestock industries and government agencies in many countries. This decline has been due to a wide range of factors, including the end of major disease control programmes, impact of user-pays policies for government services and benefit-cost considerations of the animal owner. The corollary has been privatisation of government veterinary facilities, the trend for intensive industries to provide their own veterinary services rather than rely on government services and more recent graduates preferring to work with companion animals. There are also government budgetary aspects where animal health programmes are usually given a lower priority than human health, education and defence.

A recent paper noted that in the United States of America (USA) in 2002, 90% of all veterinarians were in clinical practice and 70% of total veterinary activity was devoted to companion animals (22). The figures provided by the American Veterinary Medical Association (2) for March 2007 indicate that of the 56 092 veterinarians in clinical practice only 9.2% are involved predominantly in food animal practice, whilst only 3.4% of the 81 468 veterinarians are employed in federal, state or local government services (excluding uniformed services). Whilst targeted surveillance and monitoring programmes can make more efficient use of veterinary resources, any reduction in veterinary services can have serious implications for disease detection, notification and control in livestock. They have even larger potential implications when faced with the recent emergence of many zoonotic diseases.

The result of a reduced presence of regulatory authorities and livestock practitioners has been to shift the responsibility for the detection of EADs to the producer. Poor producer knowledge of the signs of an EAD is a considerable risk factor in reducing the opportunity for early detection of EADs (30) and subsequent ability to promptly eradicate the agent (1, 24).

Since 2001, bioterrorism has received a higher priority. The series of anthrax contaminated letters mailed in the USA in September and October 2001 that resulted in 23 human infections and 5 deaths (15), forced governments to pay more attention to the potential of such an act involving the livestock industries. Whether an EAD results from trade, emergence of a new disease or bioterrorism, the key disease control factors to consider are the ability of the jurisdiction to detect the incursion quickly, to reduce spread and to efficiently eliminate the agent.

Prevention

The old adage 'prevention is better than cure' is now even more applicable to the livestock industries. The current wisdom in modern industry is to minimise potential losses through the prior identification of hazards, followed by implementation of appropriate management strategies to avoid those losses.

The more serious epizootic diseases are generally found to be endemic in developing countries and exotic to developed countries. In the developed countries, the strategies are likely to be dominated by biosecurity and other preventative measures, whilst in the developing countries, the strategies are likely to focus on progressive control, driven by a vision of trade access. However, to be successful, such control programmes must be resourced and maintained until the sources of infection are eliminated. The global rinderpest and contagious bovine pleuropneumonia control programmes were very successful in controlling these diseases in areas where they caused epizootics, but have thus far failed to eliminate the diseases at source in remote areas of some countries (28).

Australia has invested heavily in building the capacity of neighbouring countries to combat diseases. Australia has a policy to assist in the control of diseases at source and, by doing so, substantially reduce the risk of these diseases entering the Australian livestock industries. A good example is the Australian support for the South-East Asia FMD campaign (9). Similar projects to develop livestock disease diagnostic and control methodologies relevant to the domestic and international trade of Australia and partner countries are supported through the Australian Agency for International Development (AusAID) and the Australian Centre for International Agricultural Research (ACIAR) (6).

A systematic approach to the identification, evaluation, and control of hazards is encompassed in the hazard analysis and critical control point (HACCP) method (33), which has been adopted by many different industries. A similar approach is being implemented by the livestock industries with respect to the prevention of disease. This approach has been the basis for the development of many quality assurance and biosecurity programmes for livestock industries across the globe.

Australia's Emergency Animal Disease Response Agreement (EADRA) is unique and significantly increases Australia's capacity to prepare for and respond to EAD incursions. The Agreement brings together the national, state and territory governments and livestock industry groups (3). All parties commit to taking all reasonable steps to minimise the risk of the occurrence of an EAD through the development and implementation of biosecurity plans. Biosecurity programmes at the industry and farm level can aim to either exclude disease, as do national quarantine measures, or to contain the disease to segments of the industry or production units at the farm level. These programmes are developed at industry level, implemented at farm level and are auditable. The programmes are reviewed on a regular basis to ensure all risks are addressed.

Vaccination is a valuable tool for the control of animal diseases. It acts by raising the resistance of the individual animal to a specific disease. However vaccination alone has seldom resulted in the prevention or complete elimination of a disease on an entire population basis. This is because mass vaccination programmes rarely result in all animals developing a protective level of immunity. Vaccination is most successful when used as part of a balanced programme, which includes biosecurity and appropriate management of the livestock. A good example has been the use of vaccines to control HPAI. In Hong Kong, the control measures utilised have been refined since the initial outbreak in 1997. Whilst vaccination was demonstrated to prevent infection in most birds and to reduce the amount of virus excreted by infected birds, biosecurity measures to exclude the entry of virus were still important in the prevention of further outbreaks and monitoring to detect possible incursions (19). Due to costs, potential trade barriers associated with vaccinated animals and their products and the need for the vaccine to be formulated against all strains of the targeted disease, vaccination is a tool usually utilised in an endemic situation.

It has long been recognised that certain animals are resistant, or at least tolerant, to disease. An example is the comparative resistance of *Bos indicus* cattle to tick infestation in comparison with *Bos taurus* cattle. Breeding programmes have exploited this advantage. However, for many diseases, it has only recently been possible to begin to identify the markers of genetic resistance. New technologies are being developed that will enable selective breeding for innate resistance to disease. The National Scrapie Plan is being used in the UK, as are similar plans elsewhere in Europe, to breed sheep resistant to scrapie (17). Such programmes require long-term commitment for success. This approach is economically attractive, as it is self replicating with each generation. However, care needs to be exercised so that the resistance trait is not linked to other undesirable characteristics, such as lower productivity.

Minimisation of impacts

Despite the best intentions and plans, EADs can pass undetected due to the relatively low pathogenic nature of a disease. A good example is CSF, which has frequently been misdiagnosed when a low virulent strain is first introduced to a previously free area. In 1960-1961, an outbreak of CSF occurred in Australia which only came to official attention as a result of a higher than normal condemnation rate for 'septicaemia' in pig carcasses at abattoirs and increased mortality in poorly run piggeries, where there was a high prevalence of secondary bacterial infections (20). However here, as with FMD in the UK in 2001, by the time the disease was detected in the abattoirs, it was widespread and required a long and extensive control programme to eradicate the disease.

Early detection and reporting

The minimisation of the impact of an EAD relies upon the early detection of the disease and its effective containment. The interval between the entry of the agent into a susceptible population and the implementation of control strategies has the largest impact on both the duration and extent of the outbreak (1, 24). Early detection is dependent on awareness, reporting of suspect cases, rapid diagnosis, rapid tracing of animal movements and effective surveillance programmes.

Early reporting of suspect cases is dependent on an 'educated' producer who is aware of the clinical signs of an EAD and who is willing to report the suspicion. Animal Health Australia (AHA) is a non-profit public company established by the Australian state and territory governments and major national livestock industry organisations that manages national animal health programmes (www.animalhealthaustralia.com.au/corporate/company-profile.cfm). AHA manages the Protect Australian Livestock Campaign (PALC) in Australia to promote EAD preparedness, on-farm biosecurity, the EAD watch hotline and to encourage livestock producers to 'look, check, ask a vet' if they see unusual clinical signs or unexpected deaths in their livestock (5). PALC is an important means of ensuring producer awareness and commitment to the importance of early reporting.

Willingness to report is in a large part dependent on the potential losses that the producer may suffer. The losses may not only be economic, but also social. It is important that the initial reporter is not seen by his peers as the cause of the problem, unless the incursion of the disease was caused by illegal activity, but rather as a person to be admired for having the knowledge to identify the problem and the sense to report early. Fair compensation is very important to encourage early reporting. 'Fair compensation' refers not only to the value received but also to the timeliness of payments. If the owner is not confident of receiving adequate compensation, then there is the temptation to try treatments and/or delay reporting.

The second part of early reporting relies on the availability of someone in authority to receive the report. This may be a local veterinary surgeon, a government official or a laboratory. Again the person receiving the report must be adequately motivated and trained to assess the report and take the next step.

Rapid containment

The availability of accurate and cheap pen-side tests would allow for rapid confirmation and subsequent action once a suspect case is notified. It can reduce the effect that long distances and poor cold chain facilities can have on sending specimens to a central laboratory and on the results obtained. Whilst laboratory confirmation may be required at least initially, pen-side tests allow early containment measures to be undertaken with more confidence and possibly thoroughness. New developments in communications, such as mobile phones with photographic capabilities, further improve the speed of reporting and decision-making.

Diagnosis must be followed by the implementation of movement controls. On infected premises this is achieved by quarantine. Restricted areas and control areas need to be designated around the infected premises. Movement of animals within and out of these areas needs to be carefully controlled under a permit system governed by strict protocols. The imposition of measures, such as road blocks to prevent/detect unauthorised movements of animals and to minimise spread of disease through checking for animal products and potentially infected fomites, is also critical.

The movement restrictions imposed to control an EAD will result in interference with normal trading patterns. As was seen in 2001 in the FMD outbreak in the UK and the Netherlands, after a period of time these restrictions resulted in the subsequent need to slaughter healthy animals on welfare grounds, where the animals were not permitted to move from their properties and accommodation and/or feed was limited. In the UK in 2001, 2.5 million animals were killed on welfare grounds (31). To minimise such losses, care needs to be taken to allow such animals to be processed where possible. A key factor is the maintenance of markets, particularly domestic, for the products. In addition, animals should not be introduced to the areas where movement controls apply and, in the case of long-term control programmes, consideration should be given to ceasing breeding activities.

A widespread pre-emptive ban on livestock movements (a livestock standstill) has proved effective in many countries in limiting the spread of highly infectious EADs, as was the case with FMD in Europe in 2001 (26, 31). A national livestock standstill minimises the risk of further spread of disease while the nature and extent of an outbreak is being identified, but must be implemented rapidly to be effective. To be effective, the elements of a national livestock standstill must be simple, clear and able to be readily communicated.

Australia will implement a risk-based national livestock standstill if FMD is diagnosed or strongly suspected. The standstill will be enacted for an initial minimum period of 72 hours. Any extension or lifting of the standstill will be based on an assessment of the risks, the outcomes of initial tracing and surveillance information and the epidemiology of the outbreak. The standstill will apply only to FMD-susceptible species of live animals (cattle, buffalo, sheep, goats, pigs, deer, camelids and other cloven-hooved animals). Standard operating procedures are being developed to handle stock in transit or in saleyards at the time the standstill is applied.

Tracing

The process that begins with an infected animal, herd or flock and traces all possible locational and interactive exposures in both directions, back towards the source and forward to contacts, is the backbone of EAD management (18). Rapid and complete tracing is critical to the early containment of the disease. Not only animals, but movements of personnel, fomites and products also need to be investigated.

In the past, tracing has relied on knowledge of the traditional and annual patterns of such movements. These movements can be influenced by seasonal and economic factors, such as trade access and product values. The accurate and rapid identification of specific animals and their movements will, if fully functional, reduce reliance on knowledge of the patterns of animal movements.

In the 1960s, Australia introduced a cattle-tracing system as an essential part of the BTEC programme. The system was based on a unique identification number that was assigned to each farm (parcel of land). The identification number, known as the property identification code (PIC), was eight digits in length, with the number accommodating a state identifier, a region prefix and an individual property number. All Australian states introduced legislation that underpinned the use of the PIC. The result was that the application of a cattle tail tag or transaction ear tag bearing the PIC of the property of origin became a mandatory requirement for all cattle sales and transfers of ownership. Over time, this system became the instrument that enabled surveillance of residues of agricultural and veterinary chemicals, in addition to disease surveillance and monitoring.

In Australia, the National Livestock Identification System (NLIS) (23) is being implemented to allow tracking of animals from birth until slaughter. Calves are identified with a radio frequency identification device (ear tag or bolus). The unique number of the device is linked to the PIC and an online database allows subsequent movements of the animal to be traced. Where possible, the NLIS relies on automated systems to reduce recording errors and workload.

The NLIS programme was extended to the sheep and goat industries. Lambs and farmed goats are now required to be identified with an ear tag printed with the PIC of the property prior to moving off the property of birth. The pig industry is using a property identifying slap brand tattoo to allow the tracing of pigs.

Once full transaction recording is in place, a life record of an animal's residency and other animals it has interacted with will be established. It is this centrally stored electronic history of an individual animal's residency that will enable rapid and accurate traceability.

Surveillance

Surveillance programmes are becoming more important as fewer veterinarians are regularly involved with livestock production and producers have less contact with individual animals. Governments have recently implemented targeted syndromic surveillance programmes which aim to monitor specific diseases, such as bovine spongiform encephalopathy, rather than rely on the general range of diagnostic samples routinely submitted to veterinary laboratories. The aim is to make more efficient use of limited field and laboratory resources. However, such targeted surveillance programmes will not detect new or emerging diseases, the majority of which have recently been associated with wildlife.

The Australian Wildlife Health Network (7) was established recently to provide information relating to diseases of wildlife. Its mission is to promote and facilitate collaborative links in the investigation and management of wildlife health in support of human and animal health, biodiversity and trade. This role has become more urgent given the recent discovery of a number of viral diseases, such as SARS, Nipah virus, Hendra virus and HPAI viruses, which have spread from wildlife to domestic animals and then to humans. Unfortunately, as these diseases are subclinical in wildlife, disease in livestock and humans is often the first indication of their presence.

Options for emergency animal disease control

The key to minimising the impacts associated with an EAD is rapid action – rapid detection, rapid reporting, rapid diagnosis, rapid containment and rapid tracing of infected and in-contact animals. These in turn rely on adequate resources provided by a whole-of-government approach, the implementation of existing tested plans and prior education of all stakeholders for success.

Planning

Under current trade agreements, national quarantine restrictions must be scientifically based and limited to that which is necessary to prevent the introduction of animal diseases. Nevertheless, new diseases are emerging. More than ever before, authorities need to develop integrated emergency responses to address disease incursions. These plans need to be efficient and minimise animal wastage and the impacts on both the livestock industries and the community at large. As a result of the FMD outbreak in the UK in 2001, there has been a move to comprehensive, generic preparedness plans linked to specific disease control strategies. The emphasis has to be placed on pre-existing plans, which have been trialled. The legal basis of the plans and jurisdictional responsibilities must be clearly understood to avoid duplication and challenges that may delay a response (24).

The Australian Veterinary Emergency Plan (AUSVETPLAN) (4) is a co-ordinated national response plan for the control and eradication of exotic diseases and certain emerging or endemic animal diseases. The purpose of AUSVETPLAN is to:

- provide policy and guidelines for the consistent management of an animal disease emergency by appropriately trained personnel
- provide coherence of emergency disease plans
- provide compatibility of operation and procedures between the jurisdictions, authorities, emergency management organisations and the community
- improve the technical validity of the underlying assumptions in the development of strategies to combat disease emergencies
- identify deficiencies in technical knowledge required to combat a disease emergency and establish research priorities
- provide a focus for the training of people in appropriate operational responses and procedures
- provide guidelines for the development of standard operating procedures for response personnel in combat agencies.

AUSVETPLAN consists of a series of related documents which are regularly reviewed and updated. They are the authoritative reference for the control and/or eradication policies for EADs in Australia and provide a management structure and an information flow system for the handling of an EAD at national, state/territory and district levels.

Agency support plans are sub-plans of individual state or territory disaster plans and are developed and maintained through collaboration between animal health and emergency management agencies and ensure a whole-of-government approach.

Australia has taken positive measures to address the concern about the veterinary resources available in rural areas. Australia is an active member of the International Animal Health Emergency Reserve which, in the case of an EAD occurring, allows it to call on animal health related resources from five overseas countries. Within Australia, the Australian Veterinary Reserve (AVR) has recently been formed. Members of the AVR are experienced veterinary practitioners in rural practice across Australia who have received training to undertake specific duties, such as surveillance, in the event of an EAD.

Detection

Whilst many different technologies are currently under development, the greatest need is for on-the-spot confirmatory tests which allow rapid detection of an EAD and facilitate rapid implementation of biosecurity measures and culling of infected animals. The ability to accurately differentiate infected animals from non-infected animals may result in fewer animals being slaughtered. Recent developments in the various technologies have improved the speed, sensitivity and specificity of laboratory-based tests, but few tests with appropriate sensitivity and specificity in a robust field format have been internationally validated as yet. The small market potential, due to infrequent EAD outbreaks in developed countries, does not provide great economic incentive for the development of such technology (8).

Vaccination

Vaccination may be used to reduce potential spread of infection but, in most cases in naive populations, there is little time to organise the supply and administration of vaccine and for the vaccine to result in a protective level of immunity. Vaccination in the face of an outbreak is also very resource intensive and may divert limited resources from other high priority tasks, such as tracing and surveillance. There is also the risk that vaccinating teams moving from premises to premises may spread the disease, hence strict attention needs to be paid to biosecurity and 'spelling' of teams. Vaccination in the face of an outbreak has been used to buy time to allow the orderly disposal of potentially exposed animals as in the Netherlands in 2001 (16).

A recent review has indicated that emergency suppressive vaccination (vaccination-to-die) may be permitted for the control of FMD in Australia under certain conditions '… provided that all vaccinates are identified, subject to strict movement controls and ultimately slaughtered' (8). This is because 'tests for use in serosurveillance to distinguish vaccinated from infected animals '… are not sufficiently validated for international recognition of their use in individual animals'.

Vaccination in the face of an outbreak may not reduce the number of animals slaughtered, due to trade issues. In the 2001 FMD outbreak in the Netherlands, where vaccination was used to prevent spread and allow the orderly culling of animals, 186 645 vaccinated animals were slaughtered (26). Vaccination may be valid in incidents where the initial cases are not detected and substantial spread has occurred. In this circumstance, vaccinated animals could be culled in an orderly manner over time, possibly for domestic utilisation.

Vaccinate-to-live has been used successfully elsewhere to control diseases, such as HPAI in Hong Kong (19), where inactivated, non-homologous vaccines have been used, which allow infected animals to be differentiated from vaccinated animals. Non-vaccinated, sentinel animals can also be utilised to detect the presence of infection. Vaccination in these cases was usually utilised to assist in the control of infection in 'endemic' situations, where short-term access to export markets was not critical.

Currently, the use of vaccines may delay the subsequent declaration of freedom from disease with substantial economic implications. Vaccination is a useful tool and may be considered where there are delays in detection of an EAD, resulting in widespread infection and the likelihood of a prolonged control programme.

Tracing

This requires allocation of sufficient trained resources to determine the links, prioritise them and to follow them to completion. This process is dependent on accurate identification of animals to their source, databases that contain details of movements of animals and animal products and which allow rapid interrogation, combined with information systems which allow co-ordination of activities. Many systems (ANIMO in Europe and NLIS and the Animal Emergency Information System in Australia) have been developed to allow this process to be undertaken efficiently. However all traces do not just relate to animal movements and information must be obtained from many sources such as interviews, log books, transportation records and sales documents.

Despite the best efforts in any outbreak, there will be secondary cases with no apparent source. It was to overcome this situation that pre-emptive slaughter on an area basis was used in the Netherlands in the 1997-1998 CSF outbreak (18) and in the 2001 FMD outbreak in the UK (29).

Stamping out

The culling of infected and exposed animals is referred to as 'stamping out' the infection. The size of the population which needs to be destroyed can be limited by rapid notification, diagnosis and implementation of control measures. This is dependent on the availability of adequate resources early in the control campaign.

Within Australia, the preferred control option is rapid and humane destruction of infected and in-contact animals and the safe disposal of their carcasses and products, particularly if the EAD is a zoonosis or is highly infectious. The culling and disposal of large numbers of animals, especially clinically normal animals, for disease control purposes was questioned during and after the 2001 FMD outbreaks in the UK (31) and the Netherlands (16) on economic, environmental and welfare grounds.

In some cases, treatment and isolation are possible, as with clinical cases of anthrax. However this option is usually not applicable for emergency diseases such as FMD and CSF.

In the 2001 FMD outbreak in the UK, the disease was not detected at the initial farm level, but later at an abattoir (31). This resulted in the infection being widespread. Pre-emptive culling, that is the slaughter of non-clinical animals within a set distance from a source of infection, was utilised to stop the spread. However, before the disease was eradicated, animals on 2 026 infected properties were slaughtered and animals considered to have been exposed on another 8 000 premises were destroyed (31).

The numbers of animals destroyed could be reduced if there were sensitive and specific pen-side tests available which allowed all infected animals to be identified. Until such tests are internationally validated, for highly infectious diseases such as FMD, once an infected herd or flock is identified, all the exposed, susceptible animals are destroyed.

A modified stamping-out policy can be adopted where adequate resources are available to assess potentially exposed animals. This requires rapid collection and assimilation of data from many sources to rapidly identify exposed animals. A targeted culling programme of infected and dangerous contact animals must be based on a veterinary risk assessment (21). The assessment must consider the characteristics of the agent, species of livestock involved, farming systems, biosecurity measures in place, distances of separation of groups of animals and the prevailing climatic conditions. The destruction can then be limited to just the infected and exposed, but care must be exercised that infected animals do not remain. Such a programme was shown to be effective in the UK in the 2001 FMD outbreak (21). Contiguous area-based culling makes no allowance for spread by animals or fomites beyond the area and hence may not control the outbreak. It also results in the culling of many unaffected animals.

Any reduction in the numbers of animals slaughtered can have a significant environmental, economic and social impact. Not only are there less resources required for destruction and disposal, but there are also savings in resources required for cleansing, disinfection, monitoring and restocking (21).

Disposal

One option is to allow uninfected animals within the restricted area to move direct to slaughter under strict controls. This harvesting allows an orderly reduction in the number of susceptible animals in the area at greatest risk. In an EAD response involving major farmed species, it is highly desirable that suitable slaughter facilities are included within the control area to allow the processing of animals from unaffected farms and vaccinated animals and hence minimise the need for welfare slaughter. The resultant product would need to be consumed by the domestic market. However, concerns may be raised that the existence of such product may lead to further export market limitations. Products could be stored for future processing. Milk from vaccinated animals was processed for human consumption in the Netherlands in 2001 under stringent conditions (26).

There is an urgent need for animal health and human health authorities to meet consumer agencies and major food retailers to explain the plans and risks associated with potential outbreaks of EADs. The safety measures applied and the risks associated with control measures, such as vaccination, need to be fully explored in advance, so that when an EAD occurs, the public can be reassured and the impact on domestic markets at least can be limited, in turn reducing the need for destruction of animals on welfare grounds.

Utilisation of the resulting carcasses will depend on the nature of the organism and the existence of plans developed in advance. In the case of infected and exposed animals, the circumstances of the slaughter on-farm make it difficult to perceive the product from these animals as safe for human consumption. However, the carcasses and products could be utilised by composting or rendering rather than be a total waste as is the case if they are burned or buried.

The options for the safe disposal of infected animal carcasses and products are limited to burial, burning, rendering or composting. Other techniques, such as lactic acid fermentation and alkaline hydrolysis, have been evaluated but are limited by capacity (25). Additional aspects, such as biosecure pre-treatment (freezing or maceration), storage and transportation, must also be considered.

The 2001 FMD outbreak in the UK and the Netherlands provided valuable lessons. On-farm burial was limited due to concerns about potential pollution of underground water. On-farm burning raised concerns regarding air pollution and potential impacts on public health, not to mention the visual impact the pyres had on farmers and on local and overseas communities. This resulted in a move to engineered burial sites and rendering.

The logistics of providing such facilities and the required secure transport take time to arrange. A disposal hierarchy reflecting the environmental and public health concerns was developed with rendering and incineration ranked first, followed by burial in licensed landfill sites, then burning with mass burial and on-farm burial ranked last. In the case of burial and burning, monitoring programmes had to be devised to ensure public health and environmental concerns were addressed (32). Vaccination in the Netherlands allowed vaccinated animals to be moved under permit and slaughtered in designated abattoirs when sufficient resources became available. Carcasses were also deep frozen and stored until rendering capacity became available (16).

Composting carcasses has been proposed as a solution. It has been used effectively in large outbreaks of disease in poultry. However, in a large outbreak involving large ruminants, it is difficult to conceive that all destroyed animals could be composted due to the amount of carbon and resources required.

Given the need for rapid destruction of infected animals in a major outbreak, it is unlikely that any one solution will suffice in all circumstances.

Decontamination

Once the animals have been destroyed and disposed of, the agent needs to be eliminated from the environment to prevent subsequent infections. This requires attention to cleansing and disinfection. This process can be resource intensive and, depending on the environment, can take considerable time. Care needs to be taken so that washing and disinfection effluent does not spread infection or pollute the environment. Where possible, the use of physical measures, such as ultraviolet light, heat and the passage of time, can assist in meeting this aim.

Restocking and monitoring for freedom

Following depopulation and decontamination, the premises are usually left vacant for an agreed period of time to ensure that the cycle of infection is broken. The premises are then stocked with a restricted number of uninfected, susceptible animals that serve as sentinels. It can be difficult to source such animals after an extensive outbreak. These animals are maintained under regular surveillance for a period of at least two maximum incubation periods for the agent responsible for the outbreak. At the end of this period, they should test negative before the premises can be fully restocked.

Once the disease has been eliminated from an area, a monitoring programme needs to be devised in accordance with OIE (World Organisation for Animal health: Office

International des Épizooties) guidelines to establish area-freedom and re-establish trade. The restocking and monitoring for freedom can be resource intensive in both the field and laboratory services.

Decision-making in the event of an emergency animal disease

Rapid and effective responses are critical when an EAD is identified. Often the decisions have to be made with incomplete information. The speed of movement, combined with the globalisation of trade in animals and animal products, requires that plans are formulated and tested in advance. No longer can countries simply rely on observation and the lessons learnt from other disease control programmes elsewhere.

Functional responsibilities need to be formally recognised and not be open to challenge. Decisions taken must be flexible and capable of being amended as the outbreak is addressed and more information becomes available. Where possible, major stakeholders should be consulted in advance. Decisions need to be clearly communicated and the reasons for any changes to policy need to be clearly announced. The initial phase of assessment and containment requires swift and effective action as any delay may prove costly and result in permanent repercussions (24).

For zoonotic diseases, the interdependence of human and veterinary public health disciplines needs to be recognised. Whilst strategies and priorities may differ, the interest in zoonoses and emerging diseases results in common ground.

Information systems need to be capable of handling large volumes of data interactively, at high speed and securely. Data is generated not only from the field and laboratories, but also by support systems, such as modelling and geographical information systems. This data needs to be suitable for analysis, storage and retrieval, at the time and in the future. The data also needs to be presented to the decision-makers in a comprehensible format. This is only possible if the systems are developed in advance and used in day-to-day activities (endemic disease control programmes) by those who will be involved in managing any future EAD outbreak.

Above all, there must be a willingness to over commit resources early and scale back later, as it is very difficult to catch up with the outbreak when it has a lead. This requires a pre-agreed funding arrangement which facilitates the initial response.

Recent major outbreaks of animal disease (HPAI, FMD) have demonstrated the importance of ensuring the public is fully informed. This relies on the media in all its forms and credible spokespersons. Unfortunately the media may seek to find dissenting opinions from 'scientists', but it is essential that the public is presented with authoritative, accurate and timely information. Such an activity should be viewed as an important part of the campaign and not as a distraction. Those in authority and their media representatives need prior training to handle these situations.

The livestock industries need to be actively engaged and educated at all levels. In Australia, this is facilitated by EADRA (3). As industry and government are committed in advance to the cost of controlling EADs, industry takes an active role in the planning, training and control activities. There is a sharing of decision-making and accountability. Industry is an integral part of the team at local, state and national levels.

The decline in veterinary and ancillary resources, rural-urban population shifts and other demographic changes, as well as the sheer scale and cost of large-scale outbreaks, point to the need to recognise the key role that communities and local governments play in emergency management response and recovery. Traditional models of emergency management will increasingly need to change. Effective emergency management, including resourcing, will require the partnership to be strengthened between all levels of government and the private sector (business and industry, voluntary organisations and the public). A fundamental challenge for emergency managers is how to effectively engage the community. An 'engaged community' involved in the decision-making processes associated with emergency management activities is more likely to be responsive and self-managing when emergencies do arise. This approach also allows the people affected by, or with an interest in, the emergency to contribute to emergency management efforts.

Rapid detection, response and mobilising resources for assisting in movement control, collection and collation of data, assisting in vaccination and the 'over-commitment' of initial resources, are critical for minimising the social, environmental, welfare and economic costs associated with an EAD. The development of national animal industries and community capabilities and the encouragement of stakeholder commitment to work together will enable this objective to be met more successfully.

Critical factors

In summary, to ensure the effective control of an EAD, the following need to be addressed:

- pre-planning, testing plans and training all stakeholders
- commitment of all stakeholders
- pre-agreed funding mechanisms
- rapid detection and diagnosis
- rapid containment
- rapid implementation of control measures
- informed community
- legislative powers, to enable appropriate actions.

Acknowledgements

Sincere thanks are extended to my fellow officers of the Department of Agriculture, Fisheries and Forestry, Australia, for their encouragement and assistance in the preparation of this paper, in particular Peter Black, Chris Bunn, Iain East, Graeme Garner, Greg Greet and Jill Mortier.

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