

## CHAPTER 3

### CONTROL AND ERADICATION OF FMD

The major factors influencing eradication of a FMD outbreak are:

- Prompt identification and elimination of affected herds, which depend on the effectiveness of surveillance programs, and the timely availability of enough physical, human and financial resources to enforce quarantines and depopulation.
- The ability to identify and quantify the risks by using modern aids to decision-making such as computer models.
- Close cooperation between local/national/international teams and the livestock industry, particularly producers.

Evaluation of the risk period and the area at risk are important because they determine the manpower and other resources needed for surveillance and eradication. For eradication campaigns in areas containing large numbers of large livestock units, the ultimate constraint is manpower. Efficient use of manpower is gained by more precisely defining the area at risk, thus targeting the surveillance activity. For example, in the 1993 Italian epidemic, there were 132 livestock units within the protection zone and 897 units within the surveillance zone surrounding the outbreaks.<sup>3</sup> Computer models showed that airborne diffusion was not likely; consequently, surveillance efforts were concentrated near the affected premises. Without the computer results, the resources would have been scattered over an area too large to control effectively.

Cost benefit analysis of different FMD control strategies suggest that the slaughter of infected animals and dangerous contacts can be more efficient than a strategy based solely on the slaughter of the clinically affected herds (Berentsen et al., 1992b). For instance, in the Italian epidemic, contact herds were destroyed because they presented an unacceptable risk, particularly in the case of the pig units. Because pigs can excrete between 1,000 and 3,000 times more virus than a cow or a sheep, infection of the pig units would have resulted in a massive extension of the area at risk. Given the resources available to the authorities, this area would have been too large to control effectively.

#### **The design of animal health policies aimed at exotic diseases**

The most important factors affecting the magnitude of a FMD outbreak are: 1) the time elapsed from the beginning of the outbreak until the disease is diagnosed, 2) the time elapsed until the start of the

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<sup>3</sup> The protection zone extended for 3 km around all infected premises; the surveillance zone was defined by a 25 km radius around infected premises.

eradication campaign, and 3) the quantity of human, financial and physical resources available when the disease is diagnosed. These factors depend crucially on the preparedness of all actors involved with the livestock industry (e.g., producers, animal health officials, private practitioners and processors), which in turn, depends on the resources invested in previous years.

A number of characteristics of exotic disease outbreaks make the determination of the optimal investment level in preparedness extremely difficult (Ekboir, 1997):

- Exotic diseases have a very low probability of occurrence, but can cause catastrophic losses.
- Because exotic diseases have been absent for a long period of time, the true probability of an outbreak is not known either to the livestock industry, animal health officials, or other government agencies. Consequently, policy makers and producers have to make decisions based on subjective probabilities. However, it is well known that in this type of situation the subjective probabilities will be below the true probabilities if a country and its neighbors have been free of the disease for a long period of time. Conversely, the subjective probabilities will be above the true probabilities in the period following eradication of an outbreak in the country or in neighboring countries (Viscusi et al., 1995).
- Each producer decides his/her sanitary practices independently of what his/her neighbors do. Also, effectiveness of the prevention measures taken by a single producer depends crucially on the measures taken by his/her neighbors.<sup>4</sup> However, he/she has no recourse against neighbors who do not take adequate measures. The optimal investment in prevention by an individual producer equates marginal expected loss due to an outbreak with marginal expected cost in prevention. If the producer's subjective expectation of an outbreak is lower than the true probability, then his/her investment will be lower than the objective (social) optimum. In the presence of externalities, the optimal individual investment is lower than the social optimum unless a government takes appropriate measures to induce producers to invest an amount equal to the social optimum.

Usually a large number of producers are affected by an outbreak. Because of the magnitude of the losses in the case of an outbreak and lack of knowledge about the true probability of an outbreak, private insurance companies cannot provide insurance against an exotic disease (Ekboir, 1997).

Due to these market failures (i.e., externalities, magnitude of the potential losses and ignorance of the true probability of an outbreak), governments have a crucial role to play in the implementation of surveillance policies, and—in the case of an outbreak—in control and eradication, and in compensation of industries affected by the outbreak.

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<sup>4</sup> In economic theory this is known as an externality.

Because of these difficulties and their interaction, no methodologies have yet been created to estimate either the private or social optimal investment levels.

### **The producer's crucial role**

Modern dairy and pork technologies involve high animal densities. Under these conditions, strict sanitary practices and preventive measures are necessary. Economic considerations, however, dictate that veterinary services are used mainly for reproductive checks and design of preventive plans. Only in extreme cases are veterinarians called to treat clinical symptoms, and it is common to cull animals at the early signs of disease. This practice could favor spread of an exotic disease.

This bias against the use of veterinary services creates problems for the design of animal health policies. The actions taken by producers depend on their judgement about the seriousness of the symptoms. Only if they are aware of the possibility of an exotic disease will they report the symptoms. In fact, prompt reporting depends crucially on the farmers' observations and actions. This allows early diagnosis and intervention. Early detection was the main factor that determined the difference in magnitude of the 1924 and the 1929 California outbreaks (Table 1).

It must be stressed that from the individual farmer's point of view, infected animals need not be eliminated from the herd, because they usually become productive again after the acute period. If other producers do not take measures to control the disease, it makes no sense to the farmer to depopulate a farm and repopulate it with non-exposed animals. Thus, it is only the societal decision to eradicate (stamp-out) the disease that justifies depopulation. This point is of crucial importance in considering the government's role in controlling an outbreak, particularly the need for prompt compensation for depopulation.

The solution to this problem is to establish a system that involves all producers in a particular area. The appropriate mechanism varies with local conditions, existing political and legal institutions, capability of government (in particular animal health services), strength of farmers' organizations, and past experiences with animal health programs. In almost all cases, the coordinating mechanism should be set up by the government with significant participation by the livestock industry. Without strong support of producers and producers' organizations, it is impossible to maintain proper surveillance and to conduct a successful eradication campaign.

### **Alternative control and eradication policies**

Alternative control strategies are possible. Each is optimal for particular production and environmental conditions. In some cases, these alternative policies could be a more economical way of dealing with an epidemic (Garner and Lack, 1995):

- Partial stamping-out (slaughter of only clinically infected animals). This requires elimination of a smaller number of animals; however, the risk that carriers will remain increases.

- Total stamping-out with vaccination. In areas with high animal densities, vaccination can be used to limit the spread of the outbreak, followed by depopulation of all vaccinated animals.
- Partial stamping-out with early or late ring vaccination.
- Eradication through vaccination only.

The latest version of the federal action plan to deal with a FMD outbreak (APHIS, 1991) considers the possibility of using vaccination when the outbreak reaches epidemic dimensions. The essential goal of ring vaccination is to reduce the volume of virus circulating in the affected region by lowering the number of receptive animals and, consequently, the quantity of excreted virus. If this policy is successful, the logistics of the eradication campaign are greatly simplified by slowing the speed of depopulation. Additionally, the environmental impact in the infected area could be significantly reduced because the number of carcasses to be burned or buried is reduced and more animals can be used for protein utilization.

Major drawbacks of the use of vaccination are (1) the persistence of quarantines and trade restrictions for a longer period, (2) the need to ensure that vaccinated animals do not leave the quarantine area, (3) the increased risk of extending the outbreak due to the increased contacts between animals and humans conducting the vaccination, (4) animal welfare complications resulting from the continued production while movements are restricted, (5) longer disruption of processing industries inside and outside the quarantine areas, and (6) a possible meat surplus in the quarantine area (Donaldson and Doel, 1994).

There have been a few examples of successful control and eradication through vaccination. Zimbabwe suffered an epidemic in its non-vaccinated area in 1991.<sup>5</sup> By a policy of mainly movement control and ring vaccination, supplemented in some cases by stamping-out, zonal freedom from FMD has been re-established and the export trade resumed. Argentina and Uruguay succeeded in eradicating the disease through high vaccination coverage of the cattle population and restrictions on movement. Although sheep outnumbered cattle by 2.6 to 1 it was not necessary to continue vaccinating the sheep, and vaccination was abandoned several years before complete eradication was achieved (Donaldson, 1994a). Three southern Brazilian states have eradicated FMD through sustained vaccination campaigns.

### **The question of incentives**

The proven method of eliminating an outbreak of a highly contagious exotic disease such as FMD is total stamping-out, i.e., the slaughter and disposal of all susceptible animals that could have been

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<sup>5</sup> FMD is endemic in Zimbabwe's wild animal population in national parks. Authorities vaccinate all susceptible animals in a buffer zone around the park. Animals in the rest of the country are not vaccinated.

exposed to the virus, whether they are clinically affected or not—followed by decontamination of the infected and exposed premises.

Stamping-out requires total cooperation by farmers, and a basic condition to secure their cooperation is that they receive prompt and adequate compensation. Determination of adequate compensation is crucial. If compensation is set too low, producers have no incentive to report sick animals and may sell them at the first sign of sickness, thus favoring the spread of an outbreak; and if compensation is set too high, producers conceivably could have an incentive to introduce healthy animals into infected premises to claim compensation for their destruction.

In any case, since the cost of stamping-out depends on the number of affected animals, it can only be implemented when the expected number of outbreaks and/or animals infected is relatively small (Donaldson, 1994a). For the production conditions prevailing in California and the U.S., however, the threshold above which stamping out is no longer the best policy is not known. Cost benefit analyses could identify the optimal policies for outbreaks of different magnitudes.

### **Mobilizing resources for control and eradication**

The U.S. Secretary of Agriculture has the authority to declare an emergency in case of a disease outbreak which constitutes a threat to the livestock or poultry industries of the United States. Some resources for control and eradication can be mobilized only after an emergency declaration. It is expected, though, that additional resources would be required to deal with a large scale event.

Delays in declaring the federal emergency have been commonly experienced. The delays were caused by disagreements on whether eradication was possible, the method to achieve it—use of vaccines was a major issue—and the high expected cost of the eradication campaign. Advanced evaluation of alternative eradication policies could help to accelerate the decision making process in the event of an outbreak.

### **Vaccination considerations**

To be effective, a vaccine must be potent, safe, antigenically matched against the strains of virus likely to pose a threat, and properly administered. To be operative, a vaccine bank should keep a relatively large volume of different types of serotypes to produce the right vaccine on short notice. Additionally, it should invest consistently in the latest developments in vaccine technology. However, because an outbreak has a very low probability of occurrence in FMD-free countries, the resources invested in a vaccine bank are unlikely to be used. The cost of maintaining a vaccine bank can be reduced by sharing it with other countries. Presently the largest bank is located at Pirbright (the world reference laboratory) and is funded by a number of countries. The U.S., however, maintains a separate vaccine bank. The benefits of this should be compared with the cost reductions and potential efficiency gains obtained from joining the vaccine bank at Pirbright.

When vaccine is used in the face of disease as part of an emergency control policy, vaccinated animals are likely to be severely challenged. In this situation it is desirable to ensure that they are isolated before coming into contact with other animals. Therefore, vaccines employed for this purpose must be formulated to contain an especially high antigenic payload (Donaldson, 1994a). Donaldson and Kitching (1989) indicate that during emergency vaccination programs all FMD-susceptible animals within the vaccination zone should be vaccinated, and vaccinated animals should be kept separated from unvaccinated stock at the outer boundary of the zone for at least three weeks. Availability of trained personnel to administer the vaccines may be a constraint. Advance identification of the conditions under which it is convenient to vaccinate would provide important information to support the decision process in case of an epidemic.

Production losses in vaccinated animals are smaller than among fully susceptible animals. However, vaccination will not necessarily prevent immunized animals that are exposed to infection from replicating and excreting the virus (Donaldson, 1994a). Such silently infected animals can be an important and usually unrecognized disseminator of the virus.

### **Other considerations**

Depopulation of areas with large number of animals creates major logistical and legal problems, as evidenced by previous experiences (Donaldson and Doel, 1994). The recent outbreak in Taiwan highlights the difficulties of eradicating an outbreak in a highly dense animal population: 1) a very large amount of human, physical and financial resources have to be mobilized on a very short notice, 2) a large proportion of the personnel in charge of depopulation, C&D and quarantine enforcement will likely require training (delaying the full implementation of the eradication campaign), 3) disposal of carcasses must comply with federal, state and local environmental regulations, and 4) public opinion may object to the massive killing and burial, in particular if it involves a large number of asymptomatic animals.

Eradication of FMD from wildlife populations is extremely difficult. There seem to be two approaches to deal with this problem. The first is to pursue eradication through poisoning and/or hunting of susceptible species to either eliminate the local population or reduce the number of individuals below the threshold density required to maintain the disease, meanwhile attempting to keep the infected group isolated from contiguous populations. This was the approach taken in the 1924 California outbreak. The second approach is to leave the feral animal population undisturbed in the hope that the disease will die out naturally through an eventual lack of susceptibles as happened in the 1985 Israeli outbreak where mountain gazelles were infected.

## COMMENT: THE ROLE OF FARMERS

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The creation of huge data bases and large committees for early detection or tracing of FMD is only one approach, and not necessarily the most important. Farmers and their employees are the ones who must be relied upon for reporting of infected herds. Tracing exposed herds depends on local conditions and the detective acumen of the responsible veterinarian(s). Misdiagnosis is likely, and farmers should be encouraged to report not only suspect lesions. The first thing that happens when an animal gets FMD is that it stops eating and producing milk. This is something the dairy operator will invariably observe, and should be encouraged to report if two or more animals are affected.

During the Pennsylvania avian influenza epidemic in 1983, it was observed retrospectively that the affected flocks showed a significant drop in feed and water consumption two weeks before peak mortality. Early warning systems based on abnormal changes in consumption or production parameters may be applicable to other diseases such as Newcastle disease and FMD. There will be false alarms, but even these will provide opportunity to educate farmers and improve their operations.

