

# The economics of foot and mouth disease

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## Summary

The economic effects of foot and mouth disease (FMD) are summarised. Losses arise from the direct effects of the disease on production, costs of disease control and restriction of trade. Direct effects are of greatest importance in dairy and pig production systems. Costs of disease control, whether by stamping-out or vaccination are high. Even countries that are free of the disease incur prevention and emergency preparedness costs. The published studies indicate that where FMD eradication is feasible, this is the least-cost policy option, even allowing for the costs of prevention, emergency preparedness and the risk of outbreaks. Where eradication is not feasible, it is economically beneficial to protect high-producing livestock by vaccination. Vaccination of lower-producing animals may also be justified, especially where these animals produce milk or traction power, or where this would serve to protect high-producing livestock from disease challenge.

## Keywords

Control – Economics – Eradication – Foot and mouth disease – Trade – Vaccination.

## Introduction

Foot and mouth disease (FMD) is probably the most important livestock disease in the world in terms of economic impact. The reasons for this are not only due to the ability of the disease to cause losses of production, but are also related to the reaction of Veterinary Services to the presence of the disease and to restrictions on the trade of animals both locally and internationally.

Foot and mouth disease is capable of infecting cattle, sheep, goats and pigs. The disease has high morbidity, but low mortality and is highly contagious.

The main impacts of FMD in terms of animal production are the following:

- reduced milk yields and increased probability of mastitis due to damaged teats in dairy animals
- abortions and delayed conception in breeding stock
- perinatal mortality, as a direct result of the disease in young animals, and aggravated by reduced milk production and unwillingness to allow suckling in the dam
- lameness in draught animals, which reduces their ability to work in terms of cultivation and transporting goods

– loss of weight in growing animals due to reduced feed intake resulting from foot and mouth lesions

– animals in intensive production systems that recover from FMD frequently have to be culled prematurely as a result of permanent foot, udder or thyroid damage.

The severity of FMD varies considerably, depending on the virus strain and the type of animal affected. High-producing animals are usually more severely affected, both in terms of immediate effects on production and long-term damage leading to premature culling. In general, disease effects are more pronounced in cattle and pig systems; the impact in goat and sheep systems tends to be low. However, some strains of FMD do cause severe disease in sheep and goats. The direct production effects in extensive cattle systems are normally small, but restrictions on animal movement and international trade can cause much more serious losses.

Oleksiewicz *et al.* report that pigs are difficult to immunise against FMD and that their response to the disease is variable, but they stress the need for rapid and effective control of this disease in areas with high pig densities (29). One of the important issues with pigs and pork products is that these animals are rapid multipliers of virus and pork products have been shown to be a potential risk of disease in countries with

free status (15). Free-range pigs, and those fed waste human food, are at high risk of contracting FMD from meat products.

Intensive dairy and pig production systems are generally considered impossible to operate in the face of endemic FMD; the disease must be prevented either by eradication or vaccination for such systems to be sustainable. Where intensive dairy production is practised in areas at risk of FMD, animals must be vaccinated four or more times each year to maintain an adequate degree of protection. Even then, there remains a risk of outbreaks caused by virus strains different from those used in the vaccine. Effective protection of pigs by vaccination is problematic because of the rapid turnover of populations. High rates of immunity are difficult to achieve in fattening animals that have maternal antibody at first and live for only six months, but which account for the vast majority of the total pig population.

Given that Europe, the United States of America (USA) and other developed countries have concentrated areas of intensive animal production, there is a great need to protect these areas from this disease. The impact of FMD is much more significant when the following considerations are taken into account:

- live animal trade cannot take place between an FMD-infected country and an FMD-free country
- there are heavy restrictions on trade in livestock products from FMD-infected countries to FMD-free countries. In the worst scenario, only meat that has been heat-treated can be exported, which would be the case for a country regularly reporting outbreaks of the disease. In the best situation, while a country is free of disease but continues to vaccinate, meat can be exported deboned, but there are stringent requirements relating to the conditions under which such meat is processed and inspected
- the presence of FMD can affect the export of other products, such as fresh fruit and vegetables, to FMD-free countries
- in countries with active veterinary services, local trade is affected when outbreaks occur. Animal movement restrictions are implemented, making the purchase and sale of animals difficult. This can result in loss of value or increased costs for mature animals that cannot be marketed, as well as overstocking and consequential losses in areas with seasonal rainfall where production systems rely on removal of mature animals before the dry season. In some countries, there are also restrictions on the movement of people. The latter is particularly important in countries where the rural economy is based on tourism rather than animal production.

Countries with the highest prices for livestock products such as Japan, the USA and the European Union (EU) are the strictest in terms of applying trade restrictions for livestock and livestock products. The incentives to achieve FMD-free status for countries with the potential to export animal products are therefore high.

Finally, FMD gives rise to a range of costs related to the control of the disease, which vary depending on the disease status of the countries concerned, as follows:

- countries with the disease usually implement vaccination policies to control outbreaks, protect high-value production systems and, in some cases, in a plan to eradicate the disease
- countries close to the eradication of FMD usually adopt a slaughter policy for infected and in-contact animals; the carcasses of these animals are destroyed
- countries that are free of FMD dedicate resources to emergency preparedness, surveillance, border controls and inspecting the veterinary services and meat processing establishments of exporting countries with FMD.

The list of impacts of FMD is long and complicated, but varies between countries. For example, countries that present one or more of the following characteristics:

- do not have the capacity to export livestock and livestock products
- are unable to prevent FMD virus introduction from neighbouring countries
- import livestock and livestock products from countries with FMD and
- have a majority of extensive production systems

are unlikely to have much incentive to run eradication campaigns. The reasons for this are that the returns from a change in disease status would be small and possibly, negative. However, countries that present the following characteristics:

- potential to export livestock and livestock products
- ability to prevent FMD virus introduction from neighbouring countries and
- a majority of intensive production systems

have strong incentives to control and eradicate FMD, and in the case of countries free of FMD, to invest resources to maintain this status.

The pattern of eradication of FMD follows these characteristics closely, with countries such as the USA being one of the first to eliminate the disease, followed by countries in Europe and more recently, some countries in South America, such as Uruguay.

Given the importance of FMD at farm, national and international levels, it is not surprising that there are many references on the economic impact of the control of the disease. However, the estimates for losses in production are generally based on expert opinion and not on direct observation. The reasons for this are that in countries seeking to control or eradicate FMD, affected herds may be destroyed immediately.

Where stamping-out is not practised, infected holdings are quarantined and obtaining access to observe production impacts is difficult. In countries where FMD is endemic, there is less interest in impact assessment and more animals tend to be kept in low-input/low-output systems where the disease impact is less severe.

The following section provides a summary of available literature.

## Information on the economics of foot and mouth disease

### General

Table I provides a brief summary of publications on FMD economics that are considered to be important in the economic assessment of this disease.

### Europe

Europe was considered to be an endemic zone for FMD until the late 1980s. In Italy, where regular outbreaks occurred, the benefits from FMD control were estimated at 42,855 million Italian lire (7) while the costs of this programme were estimated at 5,316 million Italian lire (17). Stougaard estimated the costs of different strategies of controlling FMD in Denmark (35). The author found that an annual vaccination policy was the most expensive compared to policies of ring vaccination and

slaughter and control with no vaccination. However, Stougaard states clearly that prevention is better than cure and that a livestock-exporting country such as Denmark should not take the risk of losing valuable export markets by discontinuing vaccination. However during the late 1980s and early 1990s, much research was conducted with regard to the change in policy on control of FMD in Europe due to a change in the FMD status of the continent.

Mainland Europe practised FMD control by annual vaccination until 1991; this was then changed to increased surveillance and stamping-out in the case of outbreaks. Dufour and Moutou estimated that the new policy cost thirteen times less than the vaccination policy and the burden of costs had shifted from the farmer to the State (12). They comment that their analysis did not include any estimation of the risks of re-infection under the two policies. In the Netherlands, Dijkhuizen showed that a change in policy would be economically beneficial (11), and an analysis by Berentsen *et al.* calculated that there would have to be four outbreaks every ten years to make the annual vaccination policy more attractive than the surveillance and slaughter policy (3). The latter authors also reported that the change in European policy was positive for the Netherlands, even taking into account the increased risks of re-infection and the impact of export bans, provided that outbreaks were controlled with a ring vaccination and slaughter policy (4, 5). In Italy, the change in policy was also found to be positive, even taking into account risks of outbreaks in the Po Valley, which is a zone with intensive livestock production (1). In Germany,

**Table I**  
**Principal studies on the economics of foot and mouth disease (FMD)**

Country	Major findings	Comments	Ref.
United Kingdom	Compares two control strategies, i.e. stamping-out and vaccination, to control FMD. This is based in the 1967/1968 FMD outbreak in the United Kingdom. The study finds that both policies are positive, but the stamping-out policy is favourable if no account is taken of unquantifiable benefits	Thorough study, one of the first to be conducted at country level. The findings are now not so relevant in the United Kingdom where the rural economy has changed and importance of tourism is so high	(31)
General	Lists the major losses caused by FMD	The information is generally based on expert opinion, but the layout is a useful starting point for the economic assessment of FMD	(20)
South-East Asia	Presents a combined epidemiology and economic model to assess the profitability of FMD eradication in South-East Asia. The analysis would suggest that eradication is attractive, but in some countries is dependent on the export of pig products. However, in Thailand eradication gives good returns without exports	The article reviews estimates of returns to FMD control found in consultancy reports and stresses the need for systems analysis in assessing disease control campaigns (Obiaga <i>et al.</i> in South America [28])	(30)

Lorenz estimated that, in the long term, the surveillance and stamping-out policy was less expensive than an annual vaccination and stamping-out policy (23). The research took into account the risks of outbreaks with both policies. In a slightly different analysis, Davies found that the costs of annual vaccination in seven EU countries were equivalent to the direct cost of 200 outbreaks of FMD in these countries (10).

Mahul and Durand suggest that a stamping-out policy is economically optimum for countries with FMD-free status (25). Furthermore, they stress the importance of minimising the period during which a country cannot export livestock and livestock products as being the key to high returns.

### South America

South America has a long history of control and eradication campaigns against FMD, which are based on vaccination. The success of these campaigns has been limited to countries with potential to export agricultural products. Information in the literature on the economics of these control campaigns is scarce, but Carpenter and Thieme developed a model to assess the control of FMD in Brazil, which was part of the programme implemented by the Inter-American Development Bank to review investments in animal health at a time when a number of South American countries were investing in FMD eradication campaigns (9). In addition, some studies have been conducted on the importance of a change in vaccine technology, the importance of livestock systems analysis in FMD campaigns and the economic impact of FMD at farm-level.

Astudillo and Auge de Mello report the advantages of a change in vaccine technology, with the oil-adjuvant vaccine being more cost-effective in a South America scenario than a vaccine with aluminium hydroxide adjuvant (2). They noted difficulties at that time of adopting this technology due to a lack of a commercially available product, but this vaccine technology has since been widely adopted.

Obiaga *et al.* analysed the importance of livestock production systems as determinants of FMD epidemiology and argued that control programmes need to recognise and classify systems before beginning campaigns (28). The methodology outlined was the basis for future FMD campaigns in South America.

In Paraguay, it was reported that farmers were unwilling and hostile to vaccinating all their animals against FMD each year (26). The importance of this campaign for the national economy has been described, but no mention was made of farm-level incentives (26).

In Colombia, returns from farm-level controls of FMD in dairy farms were found to be positive (8). On a dairy farm with 280 cattle that experienced FMD, 74% of the animals were affected leading to a 26% drop in milk production, an increase in mortality (0.7% died) and an average loss in weight per animal

of 23 kg. Losses per sick animal were estimated at 12,900 Colombian pesos (8).

In Bolivia, Bulman and Terrazas reported an outbreak on a dairy farm in Cochabamba where 45% of the cows were affected, even though the herd had been vaccinated two months previously (6). During the outbreak, milk production was reduced by 15%, two cows died and four cows permanently lost milk production from one or more quarters of the udder.

### India

India has nearly 15% of the world cattle population, kept for draught power and milk production. The country also suffers from endemic FMD. Ellis and James found that there were positive returns to a campaign to eradicate the disease (20).

A socio-economic study in the Indian Punjab found that the education level of farmers could be correlated with the likelihood of FMD outbreaks, and it was suggested that this was linked to the fact that educated farmers were more likely to seek professional advice and to vaccinate their animals regularly (32). Saxena used a survey within India to estimate losses caused by FMD in terms of milk production and abortion (33). The author estimated that in India, the losses per year were 3,508 million litres of milk, which is approximately 6.5% of the total annual national milk output. In terms of value at 1990 prices, the annual loss of milk was Rs12,520 million in terms of lost foreign exchange, and between Rs16,500 million and Rs18,730 million in terms of lost domestic economic surplus. In a further study, Saxena estimated the losses due to lost draught power, animal deaths and costs of treatment at Rs18,130 million. On average, annual losses per head of cattle and buffalo in the country were estimated at Rs125 (34).

### Australia and the United States of America

Australia and the USA are countries free from FMD without vaccination and both are exporters of livestock products. Both countries have active surveillance systems for FMD and their interest is to remain free. Garner and Lack estimated the consequences of an outbreak of FMD if the disease were to occur in Australia (16). The study showed that the impact would be greater where the production systems were not diversified, but the authors believed that the impact in terms of trade would be less due to the possibility of zoning a country. In a very early study, McCauley *et al.* evaluated the costs of endemic FMD in the USA (24). The study is of interest in that it examines costs with different control strategies.

### Other countries

A range of additional studies have been conducted in other countries.

Ertan and Nazlioglu estimated that losses due to FMD in Turkey were 141 million Turkish lire (13). The disease infected 57,000 cattle and 76,000 sheep.

In Israel, losses in a non-vaccinated dairy herd were US\$231,000 and in a partially immune herd, US\$65,700 (19). On average, the national annual losses were US\$289,900 with vaccination costs of US\$1.47 million. However the authors indicate that without vaccination, the losses would increase to US\$68.09 million and the returns from the present policy were positive.

Farag *et al.* found that sheep and goats were infected throughout Saudi Arabia, but clinical FMD in these species was not common (14). Controlling FMD in Saudi Arabia is difficult as the country imports large numbers of live animals from endemic countries. These animals have been reported to have been exposed to FMD, but do not appear to be carriers (18).

Leabad reports that the stamping-out of a FMD outbreak in Morocco cost US\$3.3 million (22). This country had been free for twenty years, and it was suspected that the virus was introduced in meat imported from South America.

A study of an outbreak of FMD in Ethiopia indicated that cattle, sheep and goats were affected by the disease. In cattle, the disease caused mortality in calves (6%) and 64% of the farmers reported FMD as a harmful disease. Of these farmers, the majority reported losses in milk production and loss in draught power production of approximately twenty days (27).

Analysis of data from an FMD disease outbreak in Sahiwal cattle indicated that 70% of the herd was affected, even though it had been vaccinated previously. Of the cows affected, 69% had reduced milk yields (74 litres) and 74% lost weight (average 18 kg). This herd reportedly experienced six outbreaks of FMD in a fourteen-year period (21).

## Conclusion

Foot and mouth disease is probably the most important livestock disease in terms of economic impact. The disease causes the greatest production losses in cattle and pigs, and in particular in intensive dairy and pig systems. Foot and mouth disease status is an important determinant of international trade in livestock products, and the existence of FMD is an effective barrier from the markets with the highest prices for these products. Therefore, many resources have been and still are dedicated to surveillance, control and eradication of this disease. These efforts have been successful in that many areas of the world are now either free from FMD or have the disease under control. The incentives of these control activities are dependent on the export potential of countries and the types of livestock systems that are found within the countries.

The published literature indicates that in countries where FMD eradication with stamping-out of outbreaks is feasible, this is

the lowest-cost policy, even taking into account the risk of relatively frequent re-introduction of infection. The costs of annual vaccination would generally be much higher for such countries and would not eliminate the risk of outbreaks. The costs of allowing the disease to become endemic without vaccination would be even higher.

In countries where eradication is not feasible, vaccination of high-producing livestock is clearly economically beneficial. In some circumstances, vaccination of animals kept in low-input/low-output systems may also be justified, especially if the animals produce milk or traction power and the costs of vaccination can be kept low by high volume vaccine production and efficient delivery of vaccination. It may also be justified to vaccinate such livestock to protect high-producing animals from disease challenge.

Where eradication of FMD is not feasible, the reason is usually that re-introduction of infection from neighbouring countries is impossible to prevent. In such cases, a co-ordinated regional programme would be required to achieve the potential economic benefits of freedom from FMD. The literature indicates that the regional programme in Europe has been economically beneficial.

An issue that is not well addressed in the published literature is whether the use of ring vaccination in addition to stamping-out in the event of an outbreak in an FMD-free country would be beneficial. For a country exporting animal products, such a policy would considerably extend the duration of restrictions on exports, unless the vaccinated animals were marked and subsequently slaughtered. It is possible that some vaccinated animals could become infected, possibly without showing signs of the disease, and would thus have the potential to cause recrudescence of FMD. Ring vaccination in the face of an outbreak also carries the risk that the vaccinators themselves could accidentally carry infection between herds.

The progress of an outbreak of FMD is extremely difficult to predict in the early stages of the disease. The course of an outbreak can be critically affected by minor and inherently unpredictable events such as a single livestock movement. For this reason, predictive disease models, which depend on statistical probabilities of transmission, have not met with much success in predicting the spread of FMD from herd to herd, and still less, in predicting the impact of control measures. Given these constraints on predicting the impact of ring vaccination on the progress and extent of an outbreak, it is difficult to envisage an economic analysis that would guide decisions on the possible use of ring vaccination. This leads to the rather unsatisfactory conclusion that, in most cases, the impact of using or not using ring vaccination is essentially unpredictable. By the time that it becomes apparent that ring vaccination would have been justified, it is likely to be too late to use this method of control.

## Aspects économiques de la fièvre aphteuse

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### Résumé

Les auteurs décrivent sommairement les répercussions économiques de la fièvre aphteuse. Les pertes économiques découlent de l'impact direct de la maladie sur la production, du coût des mesures prophylactiques et des restrictions commerciales. Les effets directs sur la production sont particulièrement perceptibles au niveau des systèmes de production laitière et porcine. Les mesures prophylactiques ont un coût élevé, qu'il s'agisse des abattages sanitaires ou de la vaccination. Même les pays indemnes de la maladie n'échappent pas aux coûts de prévention et de mise en place de plans d'urgence. Les études déjà publiées montrent que l'éradication de la fièvre aphteuse constitue l'option politique la moins onéreuse, même si l'on y intègre le coût des mesures préventives et des plans d'urgence, ainsi que les risques d'épizootie. La protection par vaccination des élevages les plus productifs se justifie économiquement quand l'éradication s'avère impraticable. La vaccination des animaux moins productifs peut également s'envisager, notamment lorsque ces derniers sont exploités à des fins de production laitière ou de traction animale, ou lorsqu'il convient de protéger les animaux très productifs contre un risque de fièvre aphteuse.

### Mots-clés

Échanges commerciaux – Économie – Éradication – Fièvre aphteuse – Prophylaxie – Vaccination.



## Aspectos económicos de la fiebre aftosa

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### Resumen

Los autores sintetizan las repercusiones económicas de la fiebre aftosa. Las pérdidas causadas por la enfermedad derivan de sus efectos directos sobre la producción, de los costos que entraña su control y de las restricciones impuestas al comercio. Las consecuencias directas sobre la producción revisten la mayor importancia en los sistemas de producción lechera y porcina. Los costos de las medidas de control, ya se trate de sacrificios sanitarios o de vacunaciones, son también elevados. Incluso en países libres de fiebre aftosa, las medidas de prevención y preparación para emergencias zoonosológicas acarrearán cierto costo. Los estudios publicados ponen de manifiesto que la erradicación de la enfermedad, cuando es factible, es la opción menos onerosa, aun contabilizando los costos ligados a la prevención, la preparación para emergencias y el riesgo de brotes. Allí donde la erradicación no es una posibilidad realista, proteger con vacunaciones al ganado más productivo constituye una alternativa económicamente rentable. La vacunación de los animales menos productivos también puede estar justificada, sobre todo cuando se trate de animales lecheros o de tiro, o cuando tal medida pueda proteger al ganado productivo de la exposición al virus.

### Palabras clave

Comercio – Control – Economía – Erradicación – Fiebre aftosa – Vacunación.



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