

## Animal Health Economics: an Introduction

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### Introduction

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Animal health economics is a discipline, which does not belong to the core of veterinary science but is becoming more and more important as an aid to decision making on animal health interventions at various levels. The levels of decision making range from the individual animal to the national herd and finally to international disease control efforts. The growing importance of animal health economics can be explained by the dramatic changes, which have occurred in the global socio-economic environment over the past 20 years. Key changes affecting decisions on animal health measures have been the following:

- (1) the major epidemic diseases have been brought under control in the majority of the developed countries (the benefits of their control was so evident that formal economic assessment was not required), leaving diseases with less evident economic impact and more complex epidemiology to be tackled by the veterinary profession;
- (2) with wider market integration, self-sufficiency for livestock products receives lower priority as national policy goal and hence political commitment for national disease control efforts has weakened;
- (3) the importance of agriculture in the national economy declines as countries develop, resulting in stronger competition for funds by different sectors of the economy, and;
- (4) more and more responsibilities are being transferred from the public to the private sector, which is more concerned with visible returns on investment.

As a result of these developments, it has become increasingly important to provide sound economic justification for any proposed action to improve or safeguard animal health to those expected to finance the proposed intervention.

Economics is often qualified as the discipline that measures things in monetary units, while other disciplines use physical units. This view is too simplistic and even inappropriate; economics is not concerned principally with money but with *making rational choices/decisions in the allocation of scarce resources vis-a-vis competing alternatives*. Monetary units are simply used as a yardstick to compare the different resources and goals involved in the decision.

The conceptual models underlying economic analyses include three major components: people, products and resources (McInerney, 1987). It is people who want certain products and make decisions, products are goods and services that satisfy people's wants, and resources are the physical factors and services that are the basis for generating the products, and as such the starting point of economic activity. Disease represents a negative input in the process of converting resources or production factors into products, goods and services available to people. Disease

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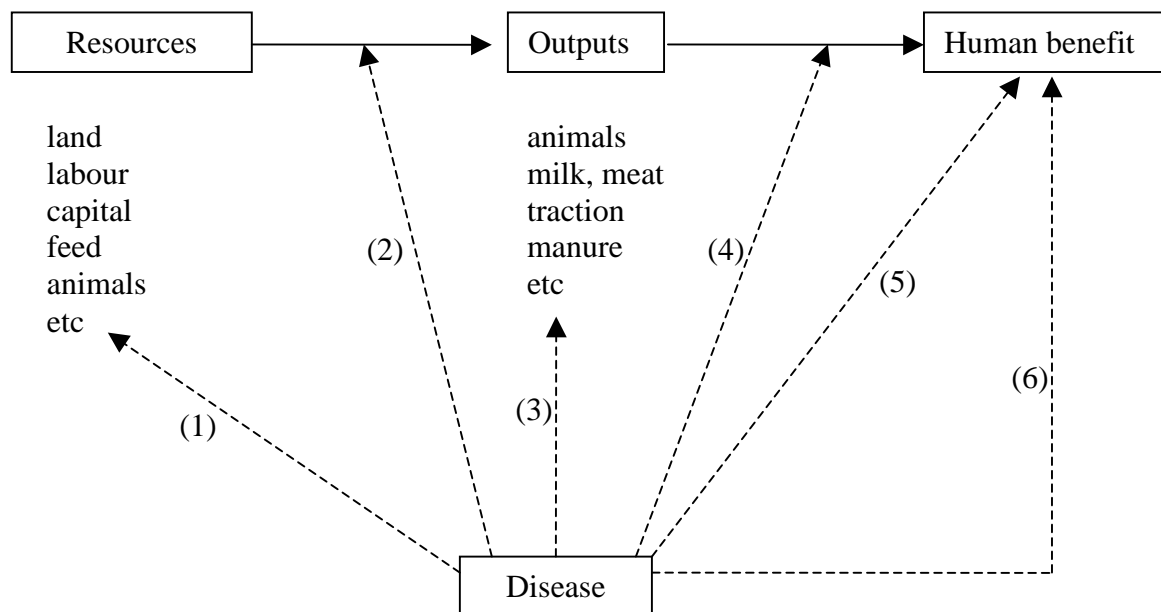
causes direct economic losses for the producer and a potential loss of value in the view of the consumer.

The analysis of the effect of animal diseases on a regional or national economy is quite complex. This paper will only provide a broad overview of the issues involved in estimating the 'cost' of animal diseases and the benefits of their control. A list of references and suggested reading is provided for those interested in technical detail and application of economic assessment techniques to specific disease problems.

### **Livestock productivity and the effects of disease**

The efficiency of the conversion of inputs into outputs is commonly referred to as productivity, which is defined as the rate of output divided by the rate of input. Because a livestock production system uses many different kinds of input and produces several kinds of output a common unit of productivity would be desirable. In commercial livestock systems this is usually the economic value of each type of input and output expressed in monetary units.

**Figure 1 Animal diseases in the livestock production system**



Source: McInerney (1996)

Figures 1 and 2 show the economic implication of livestock disease on livestock production. The effect of animal diseases in a given production system is a reduction of the efficiency with which inputs/resources are converted into outputs/products, i.e. they decrease productivity. The effects of disease can be classified as direct or indirect. Direct losses through diseases may occur as follows:

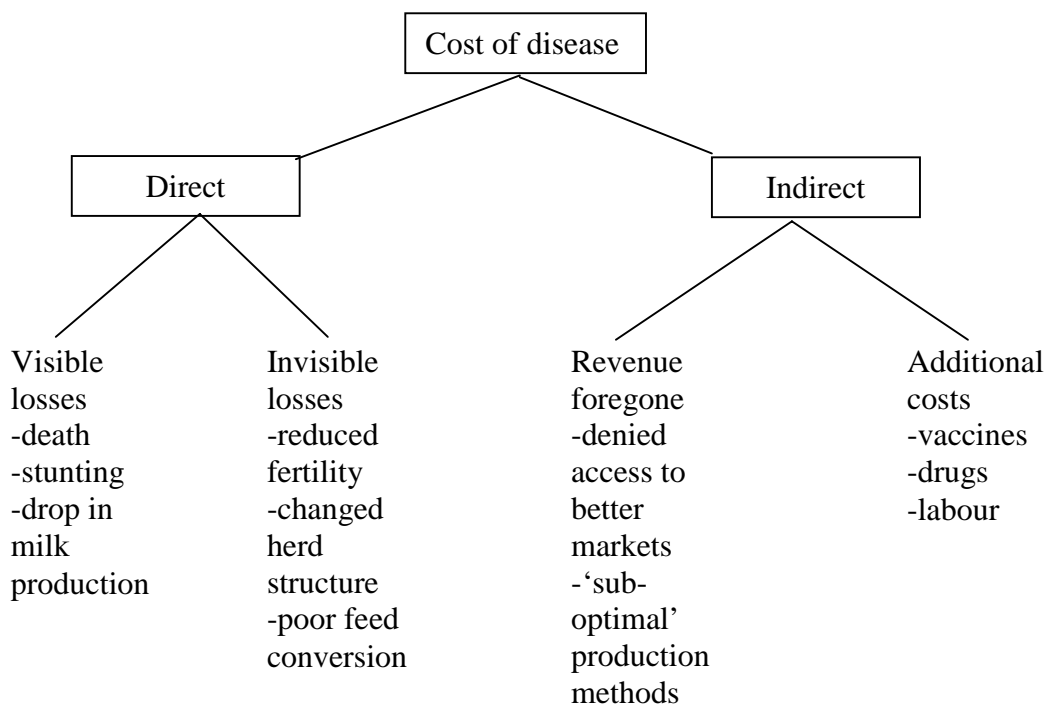
- 1) at input level, disease destroys the basic resource of the livestock production process e.g. through mortality of breeding or productive animals;
- 2) disease lowers the efficiency of the production process and the productivity of resources employed e.g. through reduced feed conversion, and;

- 3) at output level, disease may either reduce the quantity of output e.g. drop in egg production, lowered milk yield or reduce the quality of output or the unit value of the product e.g. poor hides because of tick damage, reduced milk quality due to mastitis, etc.

The indirect losses due to disease include the following:

- 4) losses through additional costs incurred to avoid or reduce the incidence of disease (e.g. vaccination, quarantine) or to treat cases, etc.;
- 5) detriment of human well-being directly through zoonoses such as salmonellosis, brucellosis, etc., and;
- 6) sub-optimal exploitation of otherwise available resources through forced adoption of production methods, which do not allow the full exploitation of the available resources (e.g. the use of trypanotolerant cattle of low milk production potential in tsetse infested areas), and/or through revenue forgone as a result of denied access to (better) markets (e.g. foot and mouth disease), etc.

**Figure 2 Direct and indirect losses due to animal diseases**



**The 'cost' of disease and the principle of marginal returns**

The total cost (C) of a disease is the sum of the production losses (L) (direct and indirect) and the control expenditures (E), in mathematical notation:  $C = L + E$ . The cost of a particular disease will vary between production systems, e.g. foot and mouth disease will cause higher production losses in dairy herds than in beef herds. Also, the control costs will differ between production systems. However, within a given production system there will be an inverse relationship between production losses and control expenditure, i.e. higher treatment and prevention expenditures should result in lower losses. In most cases this relationship between losses and expenditure will be

non-linear reflecting the non-linear nature of the typical production function. Table 1 illustrates the relationship between production losses, disease control expenditure and the total cost of disease based on a hypothetical response to anthelmintic treatment in calves.

**Table 1 Hypothetical response of calves to anthelmintic treatment**

Doses (@\$4)	Weight (kg@\$1)	Marginal cost (\$)	Marginal product value (\$)	Marg. return (\$)	Total revenue (\$)	Prod. losses (\$)	Control costs (\$)	Disease cost (\$)
0	110				110	40	0	40
1	122	4	12	8	118	28	4	32
2	132	4	10	6	124	18	8	26
3	141	4	9	5	129	9	12	21
4	147	4	6	2	131	3	16	19
5	150	4	3	-1	130	0	20	20
6	150	4	0	-4	126	0	24	24

Source: adapted from Dijkhuizen *et al* (1997).

In the example, the lowest disease cost is incurred at 4 anthelmintic treatments despite the remaining production losses of 3kg. Although a fifth treatment would still improve the weights of the calves by these 3kg, this additional weight increase does not cover the costs of achieving it as can be seen in the column “Marginal return”. According to the law of diminishing marginal returns, the additional return per additional unit of input will decrease as the amount of inputs increases. Therefore, the maximum use of inputs will not lead to the maximum revenue. For any variable input, the optimum level of its use occurs when the extra return just equals the extra cost per unit. Thus, there is an “economic optimum” amount of helminth infestation for the above circumstances while from an animal welfare point of view the total elimination of helminths would probably be desirable. The economic optimum amount of disease is greatly influenced by the prices of the products and the control inputs. For example, an increase in the price of meat by \$0.5 would make a fifth treatment worthwhile. Consequently, the ‘economic optimum level of disease’ requires regular reassessment in the light of advances in control methods and changes in consumer demand translated into product prices.

Assuming the use of anthelmintics were the only possible means of controlling helminths in the above hypothetical example, what is the cost of helminthiasis to a farmer dosing his calves twice? Although the value of \$26 appears in the column “Disease cost” this figure is misleading because it implies that there is a situation, which is helminth-free without intervention, i.e. at no cost at all. This is obviously not the case and it is the *avoidable* cost that needs to be considered. The avoidable cost of helminthiasis under the assumed circumstances is the difference between the adopted strategy and the currently “optimal” strategy, i.e. \$7 (\$26 - \$19). In the assumed circumstances, investing an additional \$8 in anthelmintics would give an extra return of \$15, which can be considered a very high return on investment.

For decision making on animal disease control measures it is the avoidable disease cost, which is relevant, i.e. the cost of a disease beyond a realistically achievable ‘optimum’. The figures for the “cost of diseases” which are commonly found in the literature offer little help in deciding whether or not anything should be done to change the situation, because they normally ignore the expenditure required to achieve the desired level of control and the residual production losses. Sound economic analysis will involve the

identification and *comparison* of different disease control options in terms of their expected benefits and costs as well as the distribution of costs and benefits over time and social groupings. One of the options, the one against which the others will be compared, is usually the 'do nothing' or 'leave things as they are' option'.

### **Level and type of analysis**

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People form groups, which have access to different resources, produce different goods and have different goals. Thus, when conducting an economic analysis to assist in deciding on the "best" allocation of resources, the first clarification that must be made is: *Whose point of view will be considered?* With respect to animal health problems, the alternatives include the farmer, the veterinarian, the processor who buys the farmer's product, the farming community and finally society as a whole. For example, a single farmer might be best off by simply "riding out" an outbreak of foot and mouth disease in his beef cattle while government officials, in the interest of the other farmers and society as a whole might insist instead on depopulation of the farm to avoid further disease spread (Erb, 1988).

There is a distinction in economics between "economic" and "financial" analysis as one moves from the individual farm to the national level, relating broadly to the division between "private" and "social". Financial analysis deals purely with money and market prices, while economic analysis deals with everything that has a value but not necessarily a (fair) market price. With respect to disease, the individual farmer is concerned with its impact or the impact of control measures on the profitability of his enterprise - the prices, which matter to him are the market prices which he actually pays and receives. However, these prices may not reflect the real costs or values to society as a whole, for example because of taxes, subsidies or price controls. In addition, actions on his farm are likely to have 'external' effects, e.g. disease control on one farm may also improve the disease environment for neighbouring farms at no cost to them. Thus, for any economic analysis it is important to state whose point of view will be considered, i.e. the boundaries of the analysis.

An assessment of the economic effects of disease control on an individual farm is relatively straightforward. Economic analysis becomes more and more complex as one moves from the individual farm to larger sectors of society and different analytical techniques have been developed (Table 2). For detailed reviews of the methods that have been used see Ngategize and Kaneene (1985), Dijkhuizen *et al* (1991), Bennett (1992), Mlangwa and Samui (1996) and Rushton *et al* (1999). Methods of economic analysis employed include partial analysis, enterprise budget, decision analysis, optimising mathematical models, simulation, cost-benefit analysis and cost-effectiveness. The choice of the economic methods for a particular analysis will be influenced by a number of factors (Bennett, 1992; Dijkhuizen 1992), namely;

- (1) the nature of the problem (including the economic level involved);
- (2) the complexity of the system involved (e.g. of the disease and its effects);
- (3) the availability of data on the problem;
- (4) the use to which the model will be put and the preference of the model builder and/or decision maker, and;
- (5) the resources available (considering time, money and analytical tools).

**Table 2 Economic methods commonly used for disease control decision support**

Method	Level of analysis	Basic concept	Choice indicators	Examples
Partial budget analysis	Farm/herd level	Partial budget set up over period of one year	Marginal benefit	Rugoor <i>et al</i> (1994) Mukhebi <i>et al</i> (1989)
Enterprise budget	Farm/herd level	Gross margin analysis to compare profitability of different enterprises	Gross margin	Okello-Onen <i>et al</i> (1998)
Decision tree analysis	Farm level/higher level of aggregation	Purpose is to compute the value of different courses of action by incorporating risk (probabilities) and attitude towards risk into the analysis	Optimal choice based on criteria e.g. expected monetary value, minimax, maximax, etc	Ngategize <i>et al</i> (1986) Parsons <i>et al</i> (1986) Rodrigues <i>et al</i> (1990) Carpenter <i>et al</i> (1987)
-Linear programming and variants	Farm level	The goal is to find the best solution for competing activities when constraints exists	“optimal” solution	Christiansen and Carpenter (1983) Habtemarian <i>et al</i> (1983) Jalvingh (1993)
-Dynamic programming	Farm level	Searches for optimal solution	“optimal” solution	Van Arendock (1985)
Simulation	Farm level/higher level of aggregation	The goal is to simulate the dynamic and risk aspects of livestock disease within production systems	Variable	James (1977) Van der Kamp <i>et al</i> (1991) Houben <i>et al</i> (1994) Dijkhuizen <i>et al</i> (1987)
Cost-benefit analysis	Industry / national level	Comparison of benefits and costs covering more than one year	Net present value (NPV), Internal rate of return (IRR), Benefit Cost ratio (BCR)	Power and Harris (1973) Berensten <i>et al</i> (1993)
Cost-effectiveness analysis	All levels	Goal is to produce a desired output at least cost	Cost-effectiveness (e.g. number of animals vaccinated per \$ spent)	Tambi <i>et al</i> (1999)

When attempting to evaluate the costs and benefits of animal disease control for society as a whole, careful consideration must be given to 1) the prices used to value inputs and outputs, 2) effects of the control program on other sectors of society, i.e. externalities; and 3) intangibles.

The prices used must reflect the ‘true’ costs and ‘true’ benefits cost to society. To do this, economists use:

- (1) shadow prices e.g. family labour valued at best alternative use in society.
- (2) shadow exchange rates e.g. when a currency is overvalued, such as many African currencies prior to structural adjustment programs. In such cases black market exchange rates might give a more realistic picture of the ‘true’ value of a currency.

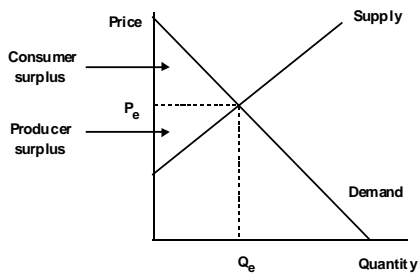
Externalities, defined as beneficial or harmful side effects borne by third parties that arise from disease control need to be considered and examples include:

- (1) effects on the natural resource base (e.g. higher animal numbers and subsequent higher grazing pressure may lead to soil degradation, which would require a value to be placed on the land that would be lost, or pollution by uncontrolled disposal from laboratories, which may affect neighbouring households);
- (2) income of other groups that may be affected (e.g. a government disease control project may affect private practice incomes; diagnostic services provided by a project may affect income from other laboratories, etc.);
- (3) access to new markets for all producers within a sector due to eradication of a trade-limiting disease from some few affected farms or areas;
- (4) increased investment into livestock production as a consequence of reduced risk of failure and increased market opportunities.

Finally, some account should be made of the items that cannot be valued in monetary terms, such as human lives, health and welfare but which may be affected by disease control activities (e.g. reduced rural morbidity and mortality by reduction in the incidence of brucellosis, better relationship with neighbours, improved social equity, etc.)

### **Distribution of benefits of disease control**

As mentioned previously, the ‘economic optimum’ level of the disease and disease control are determined by the prices of required inputs and products. In market economies, these are the result of demand and supply. Demand is the relationship between the market price of a product or service and the quantity people are willing and able to buy while supply is the relationship between the market price and the quantity producers are willing and able to sell. It is common practice to display demand and supply functions in graphical form with prices on the vertical axis and quantity on the other. A hypothetical demand and supply graph is shown below. Demand curves normally slope down from left to right – more of a certain commodity is demanded as its price falls – whereas supply curves slope upwards from left to right – more is supplied as price rises. The two lines cross at the equilibrium price at which the quantities demanded and supplied are in balance.

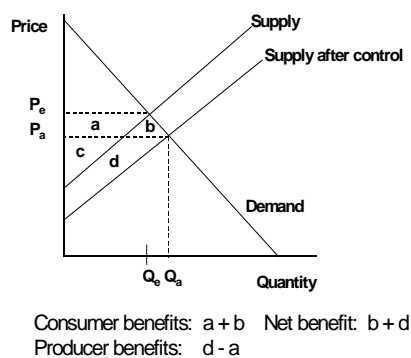


A measure of the responsiveness of the quantity demanded and supplied to changes in market price of a product is referred to as price elasticity of demand or supply respectively. If small percentage changes in price result in larger percentage changes in quantities demanded or supplied the demand/supply curve is called elastic (the curve has a relatively small slope). If a given relative change in price results in a smaller percentage change in quantity the curves are referred to as inelastic

(the slope of the curve is relatively steep). Agricultural products are characterised by relatively inelastic demand and supply curves, i.e. demand changes relatively little as prices changes, which, conversely, results in relatively small changes in quantities potentially having large price effects.

The area between the demand and supply curve to the left of their point of intersection is very important with respect to the distribution of the benefits of disease control. This area provides information on the ‘welfare’ effects for producers, consumers and the society as a whole. For example, the supply curve indicates that some producers would have been willing to supply the market in return for prices below  $P_e$ . On the other hand, some consumers would have been willing to purchase the product at prices above  $P_e$ . Thus, both consumers and producers receive a kind of surplus, some consumers because they obtain the product for a price below the one they would have been willing to pay and some producers because they receive a price above the one they might have been willing to produce for.

The effective control of animal diseases increases the efficiency of resource use in the affected population, and consequently shifts the supply curve for livestock products to



the right, i.e. farmers are willing to produce more at whatever is the current price and a new equilibrium will be reached. This is illustrated in the figure to the left. As can be seen from the figure, as a result of the new equilibrium, consumer and producer surpluses have changed. More of the product is being sold at a lower price. The consumer, who pays less, benefits and the producer, who sells more, also benefits. The areas b and d in the figure represent the net benefit to society as a whole. The

distribution of the benefits of a given shift in the supply curve depends on the elasticity of demand. The more inelastic consumer demand is, the greater the consumer surplus will be, while producers will benefit rather little from the increase in production efficiency. Increases in supply and consequent price shifts will have to be considered when the control of a particular disease is improved on a large proportion of farms, e.g. through national control or eradication programs.

### Choosing between investment options

Measures commonly used to quantify the “profitability” of an investment include net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR). Both NPV and IRR require that costs and benefits be measured in the same units. There are instances in medicine where the costs and benefits are not measured in the same units and in these cases a modified BCR must be used as measure of “profitability”, for example the number of human cases of tuberculosis avoided per \$ spent on TB-testing of cattle.

The hypothetical example of helminthiasis control illustrates, that a farmer who doses his calves twice will make extra profit by investing in two additional treatments. However, the analysis does not consider alternative uses for the required capital of \$8, which might yield even better returns nor, whether or not the farmer actually disposes of the required capital. As the marginal return of one course of action diminishes, alternative uses of resources are likely to become more attractive.

Furthermore, farmers having to make decisions about the allocation of the resources at their disposal have a combination of three often conflicting goals in mind: increasing profit, increasing personal welfare (e.g. more prestige or spare time) and avoidance of risk. Of these three goals, personal satisfaction is the most difficult to quantify, but many decisions taken by farmers are to a large degree influenced by the expected gain in personal welfare (Erb, 1988). Personal welfare is difficult to incorporate into formal methods of economic analysis. For example, a number of studies have shown that dairy farmers could increase their income by returning to the barn each night for half an hour to observe their cows for signs of oestrus. However, very few farmers actually do this. These studies have probably failed to consider the “true cost” of half an hour of the farmer’s labour *at this time of night*, which apparently is of higher value *to him* than the additional income he can expect from increased heat detection. On the other hand, a farmer may devote a considerable amount of time to activities such as improving the outer appearance of the farm, although this is unlikely to yield any tangible returns. Subjective “weighting” of different types of benefits does not only occur with individuals making decisions, but also with larger groups. Thus, analysis of EU dairy policies has shown that policy makers weighted one dollar of producer benefit approximately the same as two dollars of consumer benefit.

Finally, the outcome of most disease control measures and other investments cannot be predicted with absolute confidence. However, the results of some investments are more predictable than those of others. Most farmers are risk averse and therefore will not necessarily choose the most ‘profitable’ disease control strategy. They often choose a disease control strategy, such as herd vaccination, even though another strategy might, ‘on average’, be more ‘profitable’. They make this choice because vaccination minimises the risk of a severe disease outbreak, i.e. the additional cost of the selected strategy can be seen as an insurance against an unlikely but catastrophic loss, and they basically buy ‘peace of mind’, a commodity to which it is difficult to apply a monetary value.

### **Data requirements for economic assessment of disease control projects**

As should have become clear by now, a fairly large amount of quantitative information has to be compiled in order to carry out a sound economic evaluation of animal disease control at the national or even regional level. These data requirements can be classified under the following seven headings:

- (1) fundamental knowledge of the disease
- (2) information on disease occurrence
- (3) effects of the disease on the production process
- (4) effects of disease beyond the production process
- (5) potential control measures

- (6) expected benefits of control measures
- (7) cost of control measures

Much of the required information will not be readily available and estimates or 'expert opinion' will have to be used instead. The subsequent economic analysis is therefore only as reliable as the data and technical expertise available. However, the apparent complexity of economic analyses should not discourage from undertaking the task. The focus should be on the comparison of alternatives resulting primarily in the ranking of the options rather than in precise figures of costs and benefits. Risk and uncertainty can and should be built into complex economic analyses, allowing outcomes described in terms of probability distributions. The robustness of the analysis can be assessed through sensitivity analysis, i.e. testing if changes in the basic assumption lead to major changes in the relative merits of the alternatives tested.

The role of veterinarians in the process should be to generate and provide important information for the economic analysis of disease control efforts, such as the probability of disease under various scenarios, the losses caused by the disease at different production stages, the control options available and their respective costs. An economist should oversee the analytical process while the decision-makers, be it individual farmers, producer groups or governments, will be required to bring their preferences, e.g. their degree of risk aversion or their willingness to forego profit in favour of other goals into the decision-making process.

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