MASTITIS IS AN ECONOMIC PROBLEM

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SUMMARY

Mastitis is an economic problem. As with many other cattle diseases, the economic damage of mastitis, either clinical or sub-clinical, can be brought down to a few categories: milk production losses, drugs, discarded milk, veterinarian, labour, milk quality, culling, clinical mastitis, sub-clinical mastitis and other diseases. Management decisions can be taken at various levels: the quarter level (e.g. drying off a single quarter), the quarter/cow level (e.g. treating clinical or sub-clinical mastitis), the cow level (e.g. culling a cow with clinical or sub-clinical mastitis), the herd level (e.g. changes in management such as barn and milking hygiene) and the national or regional level (e.g. improving extension services). Using the basic cost elements around mastitis and mastitis management, costs and benefits can be calculated for different circumstances. The average costs under Dutch circumstances of a case of clinical mastitis are estimated to be €277 and €168 for cows in early and late lactation respectively. For UK circumstances the average costs are estimated to be £203. On average, treatment of chronic sub-clinical mastitis caused by *Streptococcus uberis* is €15 more expensive than not treating. The outcome of this calculation is very dependent on assumptions regarding transmission of infection. Blanket dry cow therapy, as a strategy is economically preferred over selective dry cow therapy. Factors affecting this decision are the level of intramammary infections during the dry period, the cost of antibiotics and the (spontaneous) cure rate. However, it is difficult to translate this type of generic advice to individual farmers. Many times generic economic calculations are not specific enough. Each cow, farm and region differs for production circumstances and price levels. Therefore, economic calculations should be as specific as possible.

INTRODUCTION

Mastitis is an animal welfare problem. Also, mastitis might be a food safety problem, but mastitis is clearly an economic problem. Being an endemic disease on dairy farms all over the world, mastitis is an important cause of a less efficient milk production. Moreover, mastitis affects milk quality directly through changes in technical and hygienic milk quality and indirectly through the intrinsic milk quality. This makes mastitis a concern for the dairy industry. Mastitis management, therefore, should have the goal of improving milk quality and the efficiency of milk production and thus make the production of milk more sustainable. Given the multi-factorial nature of

mastitis, management consists of a wide range of activities, amongst others the treatment of diseased cows (clinical or sub-clinical), dry cow therapy, prevention of transmission of infections (either from cow to cow, or through the environment) and improvement of the immune system. There is much scientific literature on mastitis management. However, there is less scientific literature on the economics of mastitis and often this literature is a calculation of economic damage of mastitis, or the benefits of one or two management factors. Most studies are normative (using simulation modelling to estimate economic effects). Only a few studies are positive (using collected data to estimate economic effects).

Economic calculations for costs and benefits of mastitis and mastitis management depend very much on the specific situation of a country or region. Therefore, clear economic statements are very hard to give. Recently, IDF published an extensive review on economic consequences of mastitis (16). The aim here is to present a comprehensive overview of economic considerations around mastitis management. First the economic damage caused by mastitis is described in general. In the second part of the paper economic concepts are illustrated at the cow level, herd level and regional level.

ECONOMIC DAMAGE OF MASTITIS

As with many other cattle diseases, the economic damage of mastitis, either clinical or sub-clinical, can be brought down to a few categories: milk production losses, drugs, discarded milk, veterinarian, labour, milk quality, culling, new cases of clinical mastitis, new cases of sub-clinical mastitis, other diseases. Although costs for these factors might differ between countries and regions, the economic principles behind these factors are the same and will be explained below.

Milk production losses

In both clinical and sub-clinical mastitis, there is a loss in milk production. There is a large amount of published research on these changes in milk production (8, 9, 19). Moreover, the loss in milk production does not only occur during the case itself, even after the mastitis case is cured, the milk production level of the cow stays lower. Milk production loss is not obvious to the producer, because this is milk never produced, and therefore never seen. It is a hidden cost or lost income opportunity. The economic damage of a lower milk production per cow depends on the structure of the farming business. First of all, milk payment systems may differ (payment based on amount of fluid milk or based on milk constituents such as fat and protein). Secondly, the calculation of the economic damage of decreased milk production differs between a quota system (e.g. such as in place in the EU, Norway or Canada) or a non-quota system.

In a quota situation, the production potential of a farm is in most situations the quota and not the herd size, therefore, the returns of milk sales are for a large part defined by the quota and the goal of the farmer is to produce the milk within the quota as efficiently as possible. With a decreased milk production a farmer has several options (depending on the legislation associated with the quota system):

- Milk more cows to fill the quota. In this case, economic damage is calculated as the additional costs to milk more cows. These costs are not easy to estimate and consist amongst others of additional feed costs, additional veterinary costs, additional labour and additional costs for use of the barn. Many times additional costs for the barn are nil. However, with a crowded barn, costs might be associated with a lower level of animal welfare. When the farmer uses the full capacity of a barn for additional earnings (for instance to raise heifers for sale), the costs associated with higher barn use are the decrease in earnings for these additional activities.
- Increase the production of the cows (e.g. by feeding more concentrates) to fill the quota. In some situations, milk production of the cows can be increased by application of a better (more expensive) feeding regime. Additional costs are associated with the higher amount of (more expensive) feedstuffs to do this. In some cases, depending on the management capabilities of the farmer, a higher milk production per cow can lead to more health disorders.
- Lease out quota to other farmers when the quota will not be filled by own production. In some quota systems, farmers can lease or lease out milk relatively easy. This makes the quota system much more flexible. When this is done due to mastitis because milk production has decreased, the returns from milk sales will be decreased and some savings might occur because of less feeding.

Drugs

This is a straightforward economic damage. Drugs, necessary to treat a cow with mastitis, cost money. Depending on the legislation and the infrastructure in a country, costs of drugs may vary between countries.

Discarded milk

Economic damage due to discarded milk is comparable with the damage of a decreased milk production. However, there is one difference; the discarded milk is actually produced by the cows, which means that feeding costs for that amount of milk has to be taken into account with the calculations. The economic damage of 100 kg discarded milk is therefore larger than for 100 kg decreased production. Although not advisable from a veterinary point of view (e.g. there is an increased risk of developing resistant bacteria in the calves), discarded milk is often fed to calves instead of milk replacer. This will save costs of milk replacer.

Veterinarian

Besides delivering drugs (in many countries), the veterinarian might have to spend time on diagnosis of a (clinical) mastitis case or supportive therapy.

Labour

Costs for labour are, from an economical point of view, difficult to interpret. Opportunity costs for labour, e.g. to treat an animal, may differ from farm to farm. When the number of hours of external labour can be decreased by preventing mastitis, the opportunity costs are easy to calculate: hours x hourly wage. When it is the labour of the farmer himself, opportunity costs are much more difficult to estimate. If the labour comes from his own free time, it is the value that the farmer himself gives this free time. If the farmer, because of mastitis, spends less time on other tasks, opportunity costs are the decreased income because less effective management. Finally, perception of the value of labour might be important. Treating mastitic cows, while other cows are waiting in the milking parlour, is work that a farmer does not like to do. So (s)he is willing to spend money to prevent that. Labour costs are not only made at the farm level. When there are national programmes or programmes by a dairy company to decrease the level of mastitis, these costs can be associated with mastitis.

Milk quality

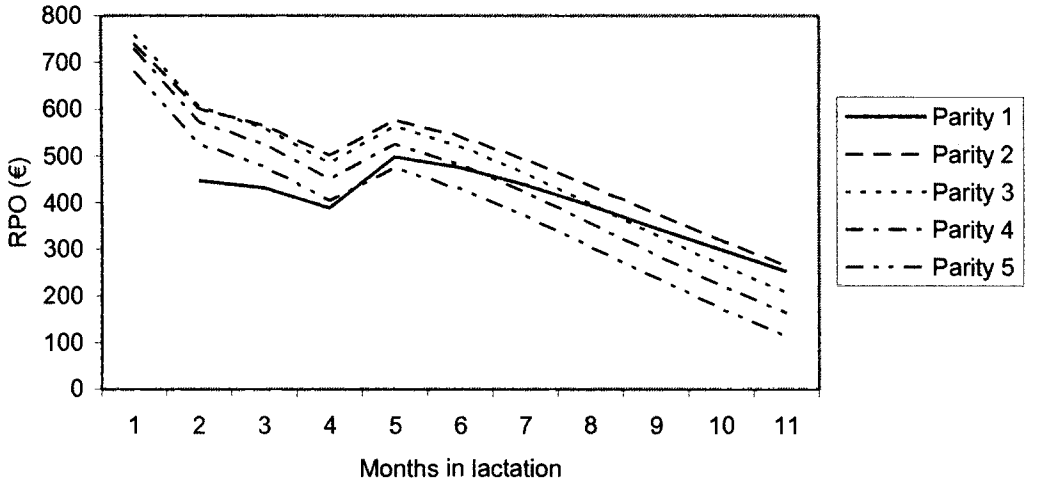
Mastitis influences the quality of milk. Some of these changes cause a less efficient processing of milk and might result in products with less favourable properties. Examples are an unstable and rancid taste of milk, a lower cheese yield and a decreased shelf life (14, 20). The associated economic damage is difficult to calculate and moreover, the direct effect of this economic damage for the individual dairy farmer is even more difficult to estimate. The only changes in milk quality that have a direct effect are the ones influencing factors that are part of the milk payment system, for instance bacterial count and somatic cell count. In most countries there is a regulatory limit for bulk milk bacterial count and bulk milk somatic cell count (BMSCC). In relation to mastitis, BMSCC is an especially important milk quality factor.

Besides BMSCC and bacterial count, most milk payment schemes test and apply penalties for antibiotic residues. Although the mastitis in itself does not affect growth inhibition, the use of antibiotics in treatment of mastitis does increase the risk of penalties. Different countries and milk processors use different rules for antibiotic residues, but the financial consequences of antibiotic residues in the milk can be considerable.

Culling

Cows with mastitis have a higher risk of being culled. The cost due to premature replacement of animals due to mastitis is probably one of the largest areas of economic loss. However, it is also a hidden cost. It is very difficult to calculate in a correct way (cf. 5, 10, 13). When a cow is culled, direct costs are the costs of rearing or buying a replacement animal (mostly heifers). Indirect costs are a decreased efficiency of milk production by the replacement animal, since the milk yield of multiparous cows is higher than that of primiparous cows. Moreover, the milk production of a heifer might be disappointing (heifers have a relatively high culling rate). On the other hand, there are also possible returns from culling a cow, mostly the price of meat. The costs of involuntary culling of a cow differ over time, depending on milk production, parity, lactation stage and reproductive status. This is illustrated in Figure 1, where costs of involuntary culling are given for different parities and lactation stages.

Figure 1 Costs (€) of involuntary culling as represented by the retention pay-off (RPO) for a cow under Dutch circumstances with a calving interval of 13 months and an average production level (source: Van der Walle (26), based upon the model of Houben *et al.* (10)



Clinical mastitis

For some management decisions, prevention of clinical mastitis can be an important benefit. Clinical mastitis in itself is not an economic factor. The factors as described above (milk production, drugs, discarded milk, labour, veterinarian, culling and milk quality) are the economic consequences of clinical mastitis. Much mastitis management aims at prevention of clinical mastitis. Specific management at the cow level can also prevent clinical mastitis in the same cow or can prevent spread of mastitis pathogens. Because of the contagious nature of mastitis, a cow with mastitis increases

the risk that other cows get mastitis. The costs of these new mastitis cases may be attributed to the original mastitis case.

Sub-clinical mastitis

By the same reasoning as for clinical mastitis, prevention of sub-clinical mastitis can be an important benefit of mastitis management at various levels.

Other diseases

An association exists between mastitis and other cattle diseases. The causal relation however, is difficult to determine. When the risk of other diseases is increased by mastitis, economic damage of other disease cases attributable to mastitis can be seen as economic damage of mastitis. However, this damage is very hard to establish because the interactions between various diseases are hard to establish and will not be further discussed in this paper.

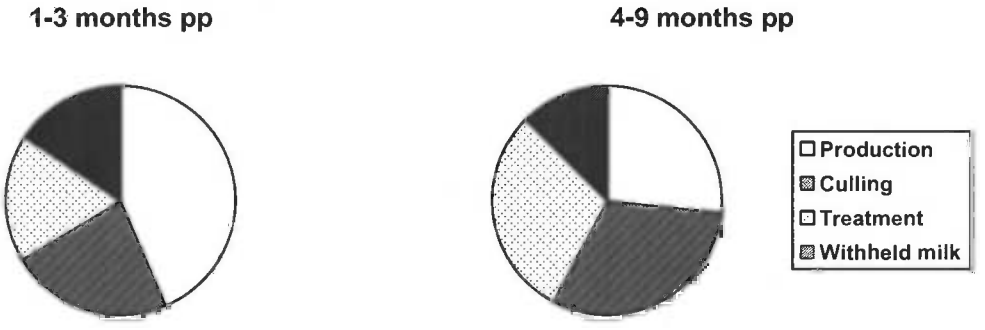
EXAMPLES OF ECONOMIC DECISION SUPPORT AT VARIOUS LEVELS

Economic calculations serve only one goal: to support decisions. As such, calculations should take two situations into account, for instance: doing nothing (*laissez faire*) and treatment. However, as a starting point (before comparing management alternatives) it is a good habit to get insight in the economic magnitude of a situation: how much does mastitis cost at this farm? A starting point for this is a calculation of the cost of a single case of mastitis. When there is room for improvement, decisions at various levels can be supported by economic calculations. This can be done at the cow level (e.g. instance treatment of sub-clinical mastitis), or at the herd level (e.g. selective dry cow therapy versus blanket dry cow therapy). Economic calculations can also be carried out at the regional level (e.g. investments in a mastitis control programme). Examples of various economic calculations are given later.

Economic damage of clinical mastitis

For the Dutch situation, the most recent cost estimations of clinical mastitis were made in 1997 (3). Factors taken into account for this estimation were: decreased production, culling, treatment (including labour) and withdrawal of milk. The economic damage of clinical mastitis depends, amongst others, on parity, lactation stage and causing pathogen. The economic damage of an average mastitis case was calculated as €277 and €168 respectively for a cow 1-3 months after calving and 4-9 months after calving. The distribution of the damage is given in Figure 2. The most important difference in the two lactation stages for the economic damage of clinical mastitis, is the difference in milk yield. Both production losses and kilograms of withheld milk are lower for a cow later in lactation.

Figure 2 Distribution of average economic damage of clinical mastitis for cows in the beginning (1-3 months *post-partum*) and the end of lactation (4-9 months *post-partum*)



Losses from clinical mastitis differ according to causative pathogen. Based upon the literature, de Vos and Dijkhuizen (3) estimated the economic damage of clinical mastitis for a cow early in lactation as begin €263 for *Escherichia coli,* €270 for streptococcal, €293 for staphylococcal and €272 for bacteriologically negative mastitis cases. Using this type of calculation (costs per clinical mastitis case) combined with incidence data from a specific farm, an estimate can be made of the total economic damage of clinical mastitis on that farm. However, one should not forget that assumptions underlying the factors used to calculate the economic damage of an average mastitis case may differ between farms as described earlier.

For the UK situation, estimates of direct costs of endemic animal diseases have been made by Bennett (1). The results of these calculations were at country level and existed both of direct costs and control costs. Based upon a spreadsheet available on-line (www.rdg.ac.uk/livestockdisea/), the economic damage of an average clinical mastitis case for UK circumstances was estimated to be £203. This is higher than the Dutch estimate. Partly this can be explained by different price levels. It is the author's opinion however, that the UK calculations are overestimated given the handling of costs of lower milk production.

Treatment of sub-clinical S. *uberis* mastitis

Traditionally, sub-clinical mastitis cases were not treated with antibiotics except during the dry period. However, recently this practice has been changing with some veterinarians regarding treatment of some types of sub-clinical mastitis to be effective. Various factors play a role in the cost-effectiveness of treatment, amongst others probability of spontaneous cure, probability of the cow becoming clinically diseased, spread of infection to other cows, cure rate under treatment and physiological effects of the infection. Since the decision on antibiotic treatment of sub-clinical mastitis involves much uncertainty and variability, the economic calculations were carried out with a stochastic Monte Carlo model (22). This model is based

upon an earlier described deterministic simulation model (7, 23) and simulates the dynamics of an infection for a cow known to have sub-clinical mastitis caused by *S. uberis*. Besides the effect of treatment on the infection status and economic damage of the cow, possible infections in other cows are also taken into account. The average economic damage (with basic input parameters) when a cow with chronic sub-clinical *S. uberis* mastitis (diagnosed after 2 subsequent cow somatic cell count measures above 250,000 cells/ml) is not treated is €88.47 (Table 1). With a short (3 day) treatment, the average economic damage was higher. With a long (8 days) treatment, the average economic damage was even greater. For the average cow, treatment is not economically efficient. Sensitivity analysis showed that this might depend on some specific cow and farm factors. Moreover, the spread of economic damage (Table 1) indicates that the risk of higher damage is much greater when a cow with chronic sub-clinical mastitis caused by *S. uberis* is not treated. This indicates that, for the (Dutch) average situation treating a sub-clinically infected cow with *S. uberis* is not cost-efficient. However, when for instance the costs of clinical mastitis are estimated to be higher, or when the risk of mastitis spreading is higher than in the average situation, or when the costs of culling a cow are higher, the optimal decision might change. Therefore a general answer cannot be given.

Similar calculations have been carried out for *Staphylococcus aureus* (24). In this study it was concluded that in general treatment of chronic sub-clinical mastitis caused by *S. aureus,* is also not cost effective. Cow factors and transmission of infection are important variables in this case.

Table 1 Total economic damage (€/cow with chronic *S. uberis*) for different treatment methods. Given are the average and the spread (extremes and percentiles)

Treatment	Average	Minimum	Maximum	5%	95%
None	88.47	0	1,149.26	7.52	416.12
Short	103.47	0	1,019.38	9.13	294.78
Long	142.85	0	1,240.14	8.90	234.33

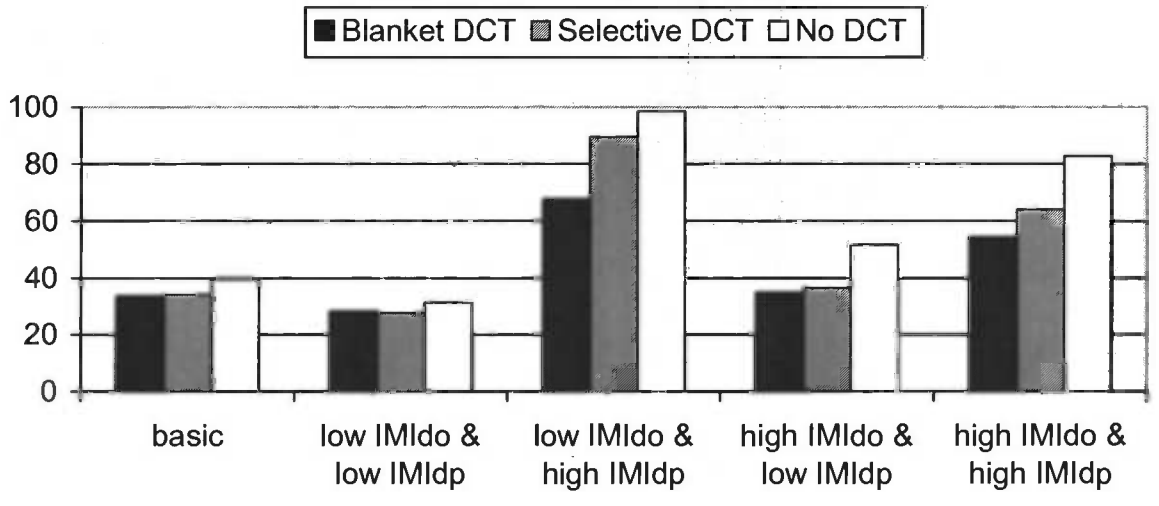
Optimal dry cow therapy

In many countries (including the Netherlands and the UK) blanket dry cow therapy (DCT) is the standard way to dry-off cows. However, due to concerns on antibiotic resistance, selective DCT is proposed as an alternative. An economic benefit may occur from using selective dry cow therapy, since not all cows have to be treated with antibiotics, which saves on the costs of antibiotics. An initial economic model on DCT indicated that for most circumstances blanket DCT was more cost-efficient that selective DCT (6). In order to account for variation and different types of pathogens, a new model was developed (11). This stochastic Monte Carlo model simulates the

dynamics of intramammary infections (IMI) around the dry period in order to predict the economic consequences of DCT for various types of pathogens (*Streptococcus agalactiae*, *Streptococcus dysgalactae*, *S. uberis*, *S. aureus* and *E. coli*). The parameters milk production, distribution of pathogens, risk of IMI during the dry period, prevalence of IMI at the moment of drying off, effectiveness of cow selection for selective DCT and probabilities of cure, prevention of new infections and economic values of these factors can be varied within the model. The probabilities for the basic situation were gathered by interviewing experts. The expert opinions are translated into a minimum, most expected and maximum value (Pert distribution) of the different probabilities.

For Dutch circumstances, the average costs associated with mastitis and mastitis control around the dry period were €39.62, €33.59 and €34.25 per cow for respectively no DCT, blanket DCT and selective DCT (basic situation in Figure 3). The largest proportion of these costs was caused by the costs of clinical mastitis after calving (92%, 65% and 85% respectively). However, the mastitis situation at a farm is an important factor when deciding on a DCT strategy (Figure 3). Moreover, costs of antibiotics and cure rates (spontaneous as well as after treatment) showed a large influence on the optimal strategy.

Figure 3 Sensitivity of costs (€ per average cow on a farm) for different strategies of dry cow therapy (DCT). Given are the basic situation and situations with a high level of intramammary infections (IMI) at drying off (IMIdo) and during the dry period (IMIdp)



In a calculation for the UK situation, using decision tree analysis, the use of blanket DCT showed to be highly favourable over selective DCT (2).

Mastitis control at a regional or country level

The type of mastitis control to be applied is usually regarded as something that the individual farmer should decide upon. However, it might be beneficial to establish regional or national programs in order to reduce the level of mastitis. Currently a number of initiatives to improve the udder health of farms in a country are undertaken (4, 17, 21, 27). The Dutch program (27) was initiated by the Dutch dairy industry in order to put extra focus on the production of health milk from healthy cows. A good udder health is regarded as one of the most critical factors of this. Besides that, it was estimated, using the calculations of de Vos and Dijkhuizen (3) that the yearly economic damage of clinical mastitis for Dutch farmers exceeds 100 million Euros, assuming a yearly incidence rate of 25% and 1.6 million dairy cows at risk each year. Investing a few million Euros in a project aiming at a reduction of clinical mastitis with 10% seems to be a good investment. However, figures like these (the 100 million Euros) should be handled with care, especially in a situation without a quota, where the free market regulates milk prices. A decrease of disease costs will result in lower production costs, which changes the supply curve. This change in the supply curve will result in lower prices. So a large part of the benefits of lower diseases costs in a free market system will be for the consumers and not for the producers (consumer surplus). In a quota situation, the shift of the supply curve is also influenced by the quota, so this consumer surplus effect is hardly a problem under quota circumstances.

DISCUSSION

In this paper the basic elements to calculate the economics of mastitis and decisions around mastitis has been described with some examples of the use of economic calculations for decisions at various levels. This paper does not provide a conclusive answer of the costs of mastitis and the benefits of certain mastitis management options. These costs and benefits depend on the specific situations (price levels, production circumstances) of a country region or the farm. Decisions might even differ from cow to cow, given milk production levels, age and reproductive status of that specific cow. Economic calculations should therefore be very specific. Current developments in the use of computers in dairy farming provide opportunities for farm or cow specific economic calculations. The elements described in this paper can be used to calculate costs and benefits of mastitis and mastitis management for different situations.

When economic calculations are used for decision support (which is the primary goal of animal health economics), there are a number of assumptions, such as transparency, perfect information and a clear definition of a utility function. Under these assumptions, the (rational) decision maker follows the most optimal advice. However, in reality, people take other decisions than the most optimal one from an economic point of view. Anecdotal evidence from veterinary practice does support these

observations. Neo-classical economists might argue that the problem and choices were not transparent, that there was no complete information, or that the definition of the used utility function was not correct. However, from the field of behavioural economics, where psychological insights are combined with economic theory, there is an argument that behaviour of people might be irrational from an economic point of view, but is rational from a psychological point of view. In this field many experiments are carried out describing the economic behaviour of, mostly, consumers (12, 15, 18). Since farms are small "family companies", the private household and the business are closely interrelated and the decisions are often taken by one person. Therefore, the economic behaviour of consumers and of farmers might be comparable. Finally, deserving more attention are the gain/loss disparity (consumers regard the value of a loss higher than the value of a gain, which shows some resemblance with cure or prevention) reasoning under uncertainty and the time preference of money (discount rates unconsciously used by consumers are much higher than the "economic" discount rates (25). Insight into this economic behaviour of dairy farmers can explain deviations of economic optimal behaviour. However, to enhance the profit of dairy farms, correct economic calculations for mastitis management remain very important.

CONCLUSIONS

Mastitis is an economic problem. The economic damage of mastitis, either clinical or sub-clinical, can be reduced to a few categories: milk production losses, drugs, discarded milk, veterinarian, labour, milk quality, culling, clinical mastitis, sub-clinical mastitis and other diseases. The costs for these factors might differ from farm to farm. Therefore, it is hard to give conclusive answers on the costs of mastitis and the benefits of mastitis management for individual farms. Management decisions can be taken at various levels: the quarter level (e.g. drying off a single quarter), the quarter/cow level (e.g. treating clinical or sub-clinical mastitis), the cow level (e.g. culling a cow with clinical or sub-clinical mastitis), the herd level (e.g. changes in management such as barn and milking hygiene) and the national or regional level (e.g. improving extension services). Using the basic cost elements around mastitis and mastitis management, costs and benefits can be calculated for specific circumstances.

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