Mastitis management in an economic framework

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Being an endemic disease on dairy farms all over the world, mastitis is an important cause of less efficient milk production. Moreover, mastitis directly affects milk quality through a change in technical and hygienic milk quality and indirectly through the intrinsic milk quality.

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.

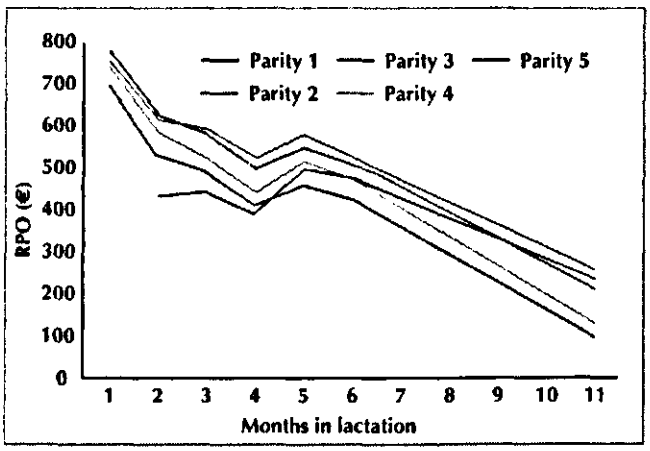

Fig. 1. Costs of involuntary culling for a cow under Dutch circumstances with a calving interval of 13 months and an average production level (Van der Walle, 2004, based upon the model of Houben et al, 1994).

Given the multi-factorial nature of mastitis, management consists of a wide range of activities, amongst others the treatment of diseased cows (clinical or subclinical), 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 economics of mastitis and often, this literature is regarding 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). Less 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.

The aim of this article is to give a comprehensive overview of economic considerations around mastitis management. First the economic damage caused by mastitis is described in general.

Secondly, aspects of management at the cow, farm and national level are described in an economic framework.

Economic damage of mastitis

As with many other cattle diseases, the economic damage of mastitis, either clinical or subclinical, can be brought down to a few categories:

- Milk production losses.
- Drugs.
- Discarded milk.
- Veterinarian.
- Labour.
- Milk quality.
- Culling.
- Clinical mastitis.
- Subclinical 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 subclinical mastitis, there is a loss in milk production. There is an large amount of published research on these changes in milk production.

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 kgs 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 (for example such as in place in the EU, Norway or Canada) or a non-quota system.

In a dairy system where farmers do not face a milk quota, the production potential of the farm is the number of dairy cows present on the farm.

The number of dairy cows might be restrained because of size of the barn, available labour, available foodstuffs or available capital, but the milk that cows produce can be delivered to the factory and will be paid for with the customary milk price.

When milk production per cow is decreased by mastitis, less milk will be delivered to the factory and the net return of the farm will decrease.

There might be some savings because, when cows are fed relative to milk production, the farmer might save on feed (concentrates) which will result in decreased costs.

Suppose that the milk price is €30/100kg milk and that the additional feeding costs is €8/100kg milk, a milk production decrease of 100kg will result in an economic damage of €22.

In a quota situation calculation of economic damage for a decrease in milk production becomes much more complicated.

The production potential of a farm is in most situations the quota and not the number of animals, therefore, the returns of milk sales are more or less determined and the goal of the farmer is to produce the milk within the quota, not more and not less, 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 0.

However, with a crowded barn, costs might be associated with a lower level of animal welfare.

When the farmer used the over 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.

The additional costs for milking more cows are, therefore, very dependent on the specific farm situation.

- Increase the production of the cows (for example by more concentrates) to fill the quota. In some farm situations, milk production of the cows can be increased by application of a bet-

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ter (more expensive) feeding regime.

Additional costs are associated with the higher amount of (more expensive) feedstuffs which are necessary to do this. In some cases (depending on the management capacities of the farmer), a higher milk production per cow can lead to more health disorders.

- Lease out milk to other farmers when the quota is not 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 farmers do not fill their quota, the additional quota can be leased out to other farmers.

When this is done due to mastitis and the associated milk production decrease, the returns from milk sales will be decreased, some savings might occur because of less needed feedstuffs (just as in the non-quota situation), but there are new returns from leasing out milk.

So suppose that the milk price is €30/100kg milk, the savings in feeding costs are €8/100kg milk and the returns from leasing out milk are €15/100kg milk the total economic damage of a decrease in milk production is €7/100kg milk

In general, economic losses due to a lower milk production per cow (and consequently economic gains due to a higher milk production per cow) are lower for a quota situation than for a non-quota situation.

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 100kg discarded milk is, therefore, larger than for 100kg decreased production. Although not advisable from a veterinary point of view (there is an increased risk of developing resistant microbes in the calves), discarded milk is often fed to calves on the farm instead of milk replacer. This will save costs for milk replacer.

Veterinarian

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

Depending on legislation, in some countries this is mandatory for each mastitis case or only for severe mastitis cases upon request of the farmer.

Labour

Costs for labour are, from an economical point of view, difficult to interpret. Opportunity costs for labour, for example to treat an animal, may differ from farm to farm.

In other words, is there an alternative use for the labour involved? 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 in other controlling tasks, opportunity costs are the decreased income due to less control.

Finally perception of the value of labour might be important. Treating mastitis cows, while other cows are waiting in the milking parlour is work that a farmer does not like to do.

So 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 does influence 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.

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 important milk quality aspect. The SCC of a cow or quarter might be strongly increased without visible changes in the milk.

There are, in experimental studies, examples of quarter milk with 13,000,000 SCC per ml without clinical symptoms.

Therefore, due to a (subclinical) mastitis case BMSCC can strongly increase which might have financial consequences.

In some milk payment systems, penalties are given after exceeding the threshold in one bulk delivery, and in some systems, the geometric average of BMSCC should exceed the threshold level during several (mostly three) measurements.

There are many dairy companies that give a bonus on the milk price, when the BMSCC is lower than a certain threshold.

Besides BMSCC and bacterial count, most milk payment schemes test 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 finan-

Table 1. Overview of mastitis management at various levels (based on a more extensive description by Østerås et al, 2005).

Level	Type of decision	Costs	Benefits
Quarter	Drying off quarter	Labour Milk production Culling	Milk quality Clinical mastitis' Culling
Quarter/cow	Treating subclinical case	Labour Veterinarian Drugs Discarded milk Milk quality	Milk quality Milk production Clinical mastitis' Culling
Quarter/cow	Treating clinical case	Labour Veterinarian Drugs Discarded milk Milk quality	Milk quality Milk production Clinical mastitis' Culling
Cow	Culling cow with (sub)clinical mastitis	Labour Culling	Milk quality Clinical mastitis'
Farm	Management change	Labour Material Investments	Milk quality Subclinical mastitis' Clinical mastitis'
Region/country	Extension/service/research	Labour Material Investments	Milk quality Subclinical mastitis' Clinical mastitis'

'Representing subsequent costs

cial 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.

Basically, economic damage of premature culling is caused by increased costs for replacement animals and decreased production efficiency.

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 returns of culling a cow, mostly the price of meat.

The costs of involuntary culling differ over time, depending on milk production, parity, lactation stage and reproductive status.

This is partly illustrated in Fig. 1, where costs of involuntary culling are given for different parities and lactation stages. Also it can be noticed that the RPO increases when the cow is pregnant (around five months in lactation).

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.

Mastitis management at the cow level can 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.

There are only few publications on the spread of mastitis pathogens through the herd. The costs of these new mastitis cases may be attributed to the original mastitis case. Also mastitis management at the herd level does prevent clinical mastitis.

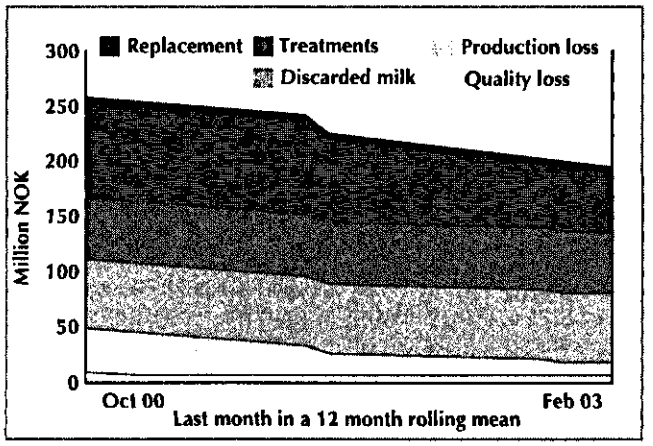

Fig. 2. Distribution of the total mastitis loss to quality, production loss, treatment cost and replacement during 2000 through 2003 for the Norwegian dairy farmers.

Subclinical mastitis

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

Other diseases

There is an association 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.

An economic framework

In this section, mastitis management is positioned in an economic framework. The basis of economic foundation of mastitis management lies in insight in the costs of clinical and subclinical mastitis.

Since the mastitis situation differs from cow to cow and thus from farm to farm, these costs should be differentiated for various pathogens. In the past various calculations have been published on the costs of mastitis.

However, many of these calculations are general, giving an average economic damage per cow with clinical mastitis, which makes it difficult to calculate the farm specific damage of mastitis.

Moreover, not much effort has been carried out in the calculation of damage of subclinical mastitis. Information published so far, is directed at the consequences of production losses due to an increased SCC.

However, subclinical mastitis does imply the risk of a cow becoming clinical and the spread of mastitis pathogens due to a cow with subclinical mastitis in a herd. Knowing a current mastitis situation, different management options can be considered.

Mastitis management is carried out at various levels, and at all of these levels economic costs and benefits may be calculated. An overview of some types of decisions (without trying to be complete) is given in Table 1.

This is based on the more detailed description of costs and benefits of interventions by Østerås et al (2005).

Drying off udder quarters as a management tool, is carried in some smaller herds. Benefits of this management are an increase in milk quality and thus a increase in the probability of higher milk payments, reduction in the risk of clinical mastitis, either in the same cow or in other cows, due to a reduction in the spread of pathogens and a reduction in the risk of culling.

The costs are additional labour to dry the udder quarter, losses in milk production (although there is compensatory milk production in the other quarters) and a increased risk of culling because of a lower milk production.

Treatment of a cow, can be regarded as quarter level management (when intramammary antibiotics are used, the antibiotics are applied at the quarter level) but also as cow level management.

Consequences of treatment are partly at the cow level (for example discarded milk).

Recently, results are published on the effectiveness of treatment of subclinical mastitis. Benefits of this treatment might be an improved milk quality, higher milk production (although St Rose et al (2004) found no improvement of milk production following cure), a lower risk of clinical mastitis in the treated cow, less spreading of mastitis throughout the herd and a lower risk of culling.

Costs of treatment of subclinical mastitis is the treatment itself (consisting of labour, drugs, veterinarian, discarded milk and a risk on antibiotic residues).

Recently some studies are published on the economic efficiency of treatment of chronic subclinical mastitis caused by S. uberis or S. dysgalactiae, S. uberis and S. aureus. These analyses show that the economic efficiency is very dependent on cure rates and specific farm circumstances.

In most farming systems, the treatment of a case of clinical mastitis is hardly a question. It is rather a decision between treatment and culling. Because of animal welfare considerations, almost all cows with a moderate or severe case of clinical mastitis are treated. The costs of treatment are comparable with the treatment of subclinical mastitis cases described above. The benefits are also the same, with the only difference in prevention of clinical mastitis in the same cow.

Therefore, publications were scarce and only on a comparison of different treatments.

For both clinical and subclinical mastitis, an alternative to treatment is the culling of a cow. Because of mastitis, the productivity of a cow decreases and this affects the expected income of a cow. The costs of culling a cow are the costs for culling as described elsewhere in this article and a little additional labour.

The benefits are an improved milk quality and a lower risk of clinical mastitis in the future.

Most calculations of the costs of involuntary culling of dairy cattle, do not take the disease status of the cow into account. It can be expected that the expected future income of a cow with mastitis (either clinical or subclinical) is lower than without mastitis.

Therefore, culling a cow with mastitis might be economical beneficial because of this lower expected income for the cow.

This was studied by Houben et al (1994), who concluded that in most cases the optimal decision was to keep and treat rather than to replace a cow.

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For subclinical mastitis an economic analysis showed that in many cases extra culling was justified in order to reduce the level of infection in the herd. Since culling of infectious cows is an important part of many mastitis control systems, the subject of economic efficiency of culling cows with mastitis deservers more attention in the future.

At the farm level, many different management measures are possible. The benefits of these measures lie in a lower incidence of clinical and subclinical mastitis, and depending on the milk payment system a higher milk price due to a better milk quality.

Costs of a change in mastitis management can be a higher need for labour, more materials (such as teat dips) and higher costs for investments.

From an economic point of view, investments should be depreciated and interest should be calculated for the capital used for that investment.

Some studies have been published on specific management activities such as vaccination or dry cow therapy, where specific attention was given to selective dry cow therapy.

At the regional or country level, decisions are not taken by the farmer, but by governments, dairy processors or representatives of the farmers. Types of decisions might be to provide free or cheaper extension on mastitis, provide cheaper service (for example in bacteriological testing) or carry out research.

The costs of these activities are made by governments (paid by the public then), dairy processors (indirectly paid by farmers throughout the milk price) or farmers' collective funds.

Benefits are, on average, a lower incidence of mastitis and a better milk quality. In Norway, for many years the dairy sector is focusing on mastitis. To estimate the effects of this focus, costs associated with clinical and subclinical mastitis are estimated at the national level (Fig. 2).

Before cost calculations at the herd level are extrapolated to the national or regional level it is important to know whether it is a quota or a non-quota situation. In a non-quota situation, costs at the national level cannot be based on individual herds.

When all herds succeed in lowering the costs of mastitis, the cost price of milk will decrease, this means that (in an open market) with a given milk price the supply will increase, followed by a decrease in milk price and a stabilisation on a lower milk price, taking into account the lower cost price of milk due to mastitis prevention. The benefit at the national level will not be for the farmer but for the consumer.

This is referred to as the consumer surplus. In a quota situation, the supply of milk is fixed.

A decrease in cost price because of an improved mastitis situation will then be completely beneficial for the farmer.

Discussion and conclusions

In this article the basic elements to calculate the economics of mastitis and decisions around mastitis are given.

This article 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 article 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.

Since farms are small 'companies' in the private household and the business are closely interrelated and in which the decisions are often taken by one person, economic behaviour of consumers and of farmers might be comparable.

Items in this field that deserve 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, Thaler, 1981). 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.

Concluding, the economic damage of mastitis, either clinical or subclinical, can be brought down to a few categories – milk production losses, drugs, discarded milk, veterinarian, labour, milk quality, culling, clinical mastitis, subclinical mastitis and other diseases. The costs for these factors might differ between countries and regions, therefore, it is hard to give conclusive answers on the costs of mastitis and the benefits of mastitis management.

Management decisions can be taken at various levels – the quarter level (for example drying off a single quarter), the quarter/cow level (for example treating clinical or subclinical mastitis), the cow level (for example culling a cow with clinical or subclinical mastitis), the herd level (for example changes in management such as barn and milking hygiene) and the national or regional level (for example improving extension services). Using the basic cost elements around mastitis and mastitis management, costs and benefits can be calculated for specific circumstances. ■

References are available from the author on request.

This article also appears in "Mastitis in dairy production: current knowledge and future solutions", edited by H. Hogeveen, www.wageningenacademic.com/mastitis

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