Mastitis in the Vital 90™ Days…What's the Real Cost?

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INTRODUCTION

Mastitis is a condition characterized by inflammation of the mammary gland, and it remains one of the most costly diseases affecting dairy cattle worldwide. Mastitis is a complex disease most commonly caused by a wide range of bacteria. The economic consequence of these infections can be difficult to estimate due to differences in clinical presentation of mastitis, timing of disease onset, value and age of the cow affected, level and value of milk production loss, treatment approach taken, culling or mortality risk due to mastitis, and the likelihood of additional cases occurring in the same cow or quarter within the same lactation.

Commonly cited studies over the years have estimated the cost of mastitis at approximately $200 per average case, but this is likely a gross underestimation of the true cost of mastitis, especially for cases occurring early in lactation (Bar et al., 2008; Hoblet et al., 1991; Kossaibati and Esslemont, 1997; Miller and Dorn, 1990). One of the most commonly referenced articles for the cost of mastitis is a publication by the National Mastitis Council that references a Dairy Field Day presentation from Georgia in 1994 (Bramley et al., 1996). This article is often used to support the idea that a *case* of mastitis costs $184.40 - but in reality, this reference is describing the reported loss per *cow*. However, the assumptions used to derive this estimate were based on an average of 1.5 quarters infected in 33 % of the cows. Consequently, using these numbers, the actual cost estimate is $373 per average *case* of mastitis (based on 1994 figures with a milk price of $12/cwt. Making adjustments for the impact of inflation from 1994 to 2013, the resulting cost per case is approximately $586 (http://www.usinflationcalculator.com/).

There are other reasons why one cannot simply accept the old estimates of $200 per case as the cost of mastitis. In most cases, the price of milk is substantially higher now than in the mid-90s. Since milk loss typically accounts for 40-60 % of the estimated economic loss due to mastitis, modern market conditions must be considered in order to derive a more accurate cost estimate. Feed prices have also increased, and this impacts the marginal milk value. For example, if we assume that in the early 90s, milk was $12/cwt and feed was $120/t for a TMR, the net value of one additional pound of marginal milk was $0.09. For comparison, consider today's $20/cwt milk and $240/t feed. In this case, the net value of one additional pound of marginal milk is $0.15 -- more than a 65 % increase in value per pound of marginal milk. This does not suggest that average profitability is 65 % higher overall, but rather that the profit potential of incremental milk production is 65 % higher since feed price is the only source of additional cost in this calculation. In the case of mastitis economics, future milk loss value is derived by estimating the pounds of milk that will be lost and multiplying that by the marginal milk value.

Although mastitis can appear at any time in a cow's life, new infection risk is highest just after cessation of lactation and during the periparturient period (Bradley and Green, 2004). The period of time that begins at the time of dry off (60 d prior to calving) and continues through the first 30 d of lactation has been coined *"The Vital 90™ Days"* by Elanco Animal Health. During this 90 d period of time, dairy cows experience major biological and physiological transitions that include mammary development and initiation of lactation (heifers), cessation of lactation and mammary gland involution followed by re-initiation of lactation (cows), and major fetal growth and parturition (both cows and heifers). Accompanying these various changes are large fluctuations in feed intake, dramatic shifts in hormonal profiles, depression of immune status, and major fluxes in hepatic demands and function. The resulting negative energy, negative protein balance, and immune suppression often results in a multitude of metabolic and infectious problems including, but not limited to, retained fetal membranes, ketosis, metritis, displaced abomasum, and mastitis among others. As a consequence, the period of highest recorded incidence of mastitis is typically the first 30 d of lactation with a disproportionate percentage of severe cases also occurring in this first month (Ruegg, 2011).

The importance of establishing the true economic cost of mastitis is increasingly essential for dairy producers as profit margins become tighter and the flow of dairy management information quickens. In order to consistently make the correct decisions, producers and their advisors need a model that provides solid economic information which takes into account their individual farm parameters. This allows them to see the economic impact of small decisions regarding mastitis control – not just the total cost of all mastitis (and thus the value of eradicating all udder disease). This type of model can be used to evaluate management interventions and their potential impact on the economics of mastitis using farm specific parameters.

As previously mentioned, most of the economic estimates commonly used are older references, and using these numbers is problematic for a number of reasons. One is simply the age of the references used. Often, the references are 15 - 20 yr old or more. The impact of inflation alone can shift the cost estimate dramatically. For example, consider the numbers shown in Table 1 for the estimate published by Miller and Dorn (1990). The actual published estimate was \$108 per case, but adjusting for the cost of inflation since 1987 (when the numbers were originally collected via survey) raises the estimate to \$222. Other major factors that have changed include milk price, feed costs, and replacement costs.

ISSUES IMPACTING MASTITIS

There are a number of other issues that must also be addressed to more accurately estimate the financial impact of mastitis in today's dairy herds, and each of these will be discussed further.

Pathogens

The typical profile of mastitis pathogens has changed over time. Older papers were most likely dealing with the effects of different pathogens than commonly encountered today, or that may be encountered on an individual farm. Fifteen to twenty years ago, the most common pathogens were most likely *Strep* *agalactiae, Staph aureus*, and *Coliforms*. Today, *Strep agalactiae* has largely been eliminated due to the widespread adoption of dry cow therapy and beta-lactam antimicrobials. While coliforms still comprise the most commonly isolated pathogens in clinical cases of mastitis, the proportion of cows that contract the most severe forms of coliform mastitis is greatly reduced due to widespread adoption of J-type common core antigen vaccines (Oliveira et al., 2013). The prevalence of *Staph aureus* is greatly reduced due to changes in management approaches and culling philosophy. Now, while coliforms continue to be the most commonly cultured pathogen in clinical mastitis, environmental streptococci and coagulase-negative staphylococci have become the second and third most common pathogens isolated (Oliveira et al., 2013). These changes in pathogen prevalence have altered the epidemiologic behavior of mastitis, including the severity of disease, the strategy for treatment, the risk of cure, and the production impact of the average case.

Genetics

Older papers are based on a previous generation of dairy cattle genetics with lower associated production. It was common to see average milk production levels (rolling herd average) of 15,000 to 18,000 lb (or less) in the studies on which the common economic estimates are made. Today's higher producing cows are not likely to still have the same level of milk loss as cows from two decades ago. This not only changes the economic impact of lost milk production, but may also change the risk of acquiring intramammary infections, since higher producing cows within a breed and herd are more likely to experience mastitis (Rupp and Boichard, 2000). Furthermore, genetic selection for improved milk quality parameters and lower infection risk may also confound the comparisons between the cattle in older studies and modern dairy cattle.

Timing of Infection

The effect of mastitis on milk production is somewhat time dependent. Many estimates of the cost of mastitis previously reported were based on an average case occurring across a lactation and did not specifically examine the impact of cases occurring in early lactation. Several studies have reported that milk production loss due to mastitis, as well as the total economic impact, is greater for cases of mastitis that occur in early lactation as compared to mid or late lactation (Heikkila et al., 2012; Huijps et al., 2008; Steeneveld et al., 2011). With increased emphasis during the last decade on the management of cattle during the transition period, improvements in housing, nutrition, and overall management have lead to higher levels of milk production and, in some cases, reductions in either the risk or negative impact of periparturient diseases including mastitis. However, cattle that experience early lactation disease, including mastitis, tend to experience greater reductions in milk production. This more negative effect on lactational yield is manifest, at least partially, on changes to the lactation curve via reductions in either the level of peak milk production or the slope of the curve prior to peak production. Additionally, cows experiencing early lactation mastitis have more total lactational time at risk to experience milk loss due to damage to the mammary gland as compared to cows in mid to late lactation.

Treatment

Treatment approaches vary considerably between farms, and the variation is even greater when comparing historical treatments to the commonly used therapeutic regimens of today. Although few novel drugs have been introduced to treat clinical mastitis, the way in which those drugs are being used has changed; including extended therapy and selective treatment based on on-farm culture results (Pinzón-Sánchez et al., 2011). The interaction of changing pathogen prevalence and changing treatment schemes greatly alters the impact of infection both in the short term (treatment costs, discarded milk, and death or culling risk) and the long term (total lactation losses, recurrence risk of additional cases, reproductive consequences, and future culling risk).

Culling

Another factor that is typically difficult to model and understand is the impact of a disease such as mastitis on culling (sold and died) risk. Well-designed models must carefully examine the attributable culling risk due to mastitis, and consider the true value of the animal that is prematurely culled as opposed to simply using a *cash cost* approach. Due to immune dysfunction that is present in early lactation, and the potential association between mastitis and other common transition diseases, there is a need to carefully consider the lactation-specific culling risk changes that are attributable to mastitis. Culling behavior by producers is also highly dependent on farm-specific management factors (stocking density, disease incidence, disease detection, and treatment success) as well as the economic climate at the time (feed costs, availability and cost of replacements, and market cow prices). These interactions combined with the actual calculation challenges complicate the estimation of the true economic impact of a case of mastitis and make it difficult to assign an average cost across different dairies.

Recurrence

When considering the cost of a first case of mastitis, there is usually no accounting for the increased risk of future cases – either new or recurrent. A new case in mid to late lactation is probably less likely to result in a recurrent case simply due to a difference in lactational time at risk. A cow in early lactation that develops a case of mastitis, however, has nearly the whole lactation ahead of her. Future cases may be true recurrences, with the same infecting pathogen, or may be new cases with a different pathogen due to cow-factors that increase her risk of mastitis. In the first of these scenarios, there is economic value in preventing the original case or successfully treating it to prevent the recurrence. This value must be captured in the estimate of the cost of the first case, especially for early lactation mastitis.

Reproduction

Many economic models fail to account for the negative impact of mastitis on reproduction, especially mastitis occurring in early lactation. Previous work has shown clear negative impacts of mastitis or elevated somatic cell counts on time to first service, first service conception risk, time to pregnancy, and risk of pregnancy loss (Ahmadzadeh et al., 2009; Huszenicza et al., 2005; Moore et al., 2005; Santos et al., 2004; Suriyasathaporn et al., 1998). Any economic analysis for early lactation mastitis must carefully consider this impact, which may differ across herds with different reproductive management and performance.

METHODS AND RESULTS

A deterministic partial budget approach was developed by Elanco Knowledge Solutions and was used to estimate the current cost of a case of mastitis that occurs in the first 30 d of lactation. The average results are shown in Table 1. In constructing the model, care was taken to consider many different areas that contribute to the total cost of mastitis, including both direct and indirect costs. *Direct disease costs* include any cost associated with diagnostics and therapeutics for clinical mastitis, discarded milk during treatment and during any required withdrawal period, veterinary services, labor, and death losses that are directly associated with mastitis. *Indirect Disease Costs*, on the other hand, include future milk production losses due to damage to the mammary gland and due to the negative impact of the inflammatory response on feed intake, future culling losses, on-going diagnostics or monitoring costs, and future reproductive losses attributable to mastitis.

Table 1 contains the original reported data and the inflation adjusted estimates for the cost of mastitis from four publications. These publications were chosen for comparison because they have a relatively clear presentation of the major components of their cost estimates and allowed for improved cross-study comparison. Under each of the four study headings, there is a *Reported* column that refers to the actual numbers taken from the respective study and an *Adjusted* column that contains inflation adjusted estimates for each study. The inflation adjusted cost values were estimated using an online inflation calculator (http://www.usinflationcalculator.com/) to create more comparable estimates between the studies. The year of data collection for each study was entered and the values were adjusted to the values expected for 2013. For the remainder of this paper, inflation adjusted values will be utilized.

On the far right side of Table 1 are the two cost estimates for an average case of mastitis occurring in the first 30 d of lactation as estimated by Overton 2013 in the Elanco Knowledge Solutions' Economic Assessment Tool™. The two columns within this section refer to how the waste (hospital) milk was handled. In the *Feed Calves* column, milk that was withheld from sale due to treatment withdrawal requirements was used to displace milk replacer for young calves. In the *Dump Milk* column, this same milk was discarded.

The first obvious finding is the wide range in reported values for the cost of a case of mastitis with a low of $200 and a high of $667. There are a number of reasons why the estimates differ, but one key difference is that the four published studies considered an average case of mastitis using the data available to them, which had varied average days in milk for the herds as opposed to the first case of mastitis that occurred within the first 30 d of lactation as used by Overton. One impact of this difference is the reported milk loss per case. Below the total cost per case is the reported breakdown by cost category for each estimate. The two lowest reported estimates for milk loss [Miller and Dorn (1990) with $75 and Kossaibati and Esselmont (1997) with $93 of milk loss value] were both derived from producer surveys and represent a common finding - producers usually underestimate the milk loss due to mastitis. The other three studies report a milk loss ranging from $115 to $207 and are based on either author-generated milk loss estimates via computer simulation modeling (Bar et al., 2008; Heikkila et al., 2012) or by referencing previously reported milk loss

Table 1. Comparison of cost estimates for a single case of mastitis. The first four estimates are from the published peer-reviewed literature. The fifth estimate is from Overton 2013 (Elanco Knowledge Solutions' Economic Assessment Tool™).

	(Miller and Dorn, 1990)		(Kossaibati and Esslemont, 1997)		(Bar et al., 2008)		(Heikkila et al., 2012)		(Overton, 2013)	
Approach Used	Producer Survey		Survey-Based Partial Budget		Dynamic Optimization Model		Dynamic Optimization Model		Partial Budget	
	Reported	Adjusted[1]	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	Feed calves[2]	Dump Milk[3]
Total Cost per Case	$108	**$222**	$183	**$281**	$179	**$200**	$623	**$667**	**$398**	**$496**
Milk loss	$37	$75	$61	$93	$115	$129	$193	$207	$115	$115
Treatment (Total)	$26	$52	$58	$89	$50	$56	$287	$307	$112	$211
Drugs, Labor, +/- Vet	NR[4]	NR	$36	$55	$30	$34	$174	$187	$95	$95
Discarded milk	NR	NR	$22	$33	$20	$22	$112	$120	$17	$116
Culling & mortality	$46	$94	$65	$99	$14	$16	$143	$153	$154	$154
Fertility	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$17	$17
Milk price per cwt	NR	NR	$11	$17	$14	$16	$21	$22	$20	$20
Avg milk yield (lb RHA)	15,000		13,000		24,000		21,000		24,000	

[1]Adjusted refers to an inflation adjustment of the original reported cost estimates from the time of the data collection until 2013.
[2]Milk collected from treated cows during mastitis treatment and throughout the prescribed withdrawal period is utilized as calf feed and retains significant value, i.e., the cost of milk collected during treatment is greatly reduced.
[3]Milk collected from treated cows during mastitis treatment and throughout the prescribed withdrawal period is dumped and not utilized as calf feed. The full value of the potential value of the milk is lost.
[4]NR refers to values not reported by the authors.

estimates from the published literature. The Overton 2013 estimate used two recent estimates of milk loss that allowed the calculation of losses over smaller, discrete periods of time but stopped counting the milk losses once the modeled cows were culled from the herd (Schukken et al., 2009; Wilson et al., 2004). As a consequence, this estimate of milk loss likely underestimates the true expected milk loss since only the surviving cows contributed to additional milk loss in the published studies. Overall, the difference between the survey reported average milk loss and the simulation-based average loss was $66. While the price (value) of the milk has a large impact on the magnitude of the economic loss, the variation in milk price was not large enough to explain the large differences between published estimates.

Another large source of variation across the reported estimates is the total treatment cost. The estimate for this cost ranged from a low of $52 to a high of $307 and can be influenced by approach to therapy (intramammary vs. systemic), duration of therapy, cost of drugs used, cost of labor, whether or not a veterinarian was utilized for treatment, how the discarded milk was valued, and the distribution of mastitis cases between mild, moderate, and severe. As can be seen in the Overton 2013 estimation, feeding calves waste milk removes much of the cost of discarded milk, and influences the economic impact of a case of mastitis. However, no additional cost for the use of a pasteurizer to prepare the milk for the young calves was considered.

Culling and mortality is another large source of difference between the published estimates for the cost of mastitis. The values cited in these sources ranged from $16 to $154 per case, but the Bar et al. (2008) value was significantly lower than the others. Potential sources of variation for these estimates include the attributable mortality or culling risk due to mastitis, how sold cows were handled financially (cash replacement cost or difference in depreciated cow vs. replacement value), market cow value for culled cows, cash cost for replacement animals, and modeling approach used (partial budget vs. dynamic optimization). When mastitis occurs within a lactation, the production status of the cow affected can also play a significant role in determining the true financial impact of mastitis on premature culling and mortality.

As previously mentioned, most mastitis economic models fail to account for the financial impact of mastitis on fertility. Of the studies compared in Table 1, only Overton 2013 calculated an economic cost for fertility. This estimate was based on Santos et al. (2004) that reported a 4 d delay in time to first service and a 25 % reduction in first service conception risk. The $17 cost reported is based on the aforementioned impact on first service in a herd that normally has an 18 % 21-d pregnancy rate. Presumably, the impact on reproduction of an early case of mastitis is that the disease process creates an inflammatory response that negatively impacts early return to cyclicity and, as mentioned previously, the negative impact of mastitis on reproduction has been demonstrated early in lactation and in other stages of lactation as well (Ahmadzadeh et al., 2009; Huszenicza et al., 2005; Moore et al., 2005; Suriyasathaporn et al., 1998).

For comparison, consider the decision tree analysis approach published by researchers at the University of Wisconsin (Pinzón-Sánchez et al., 2011). These researchers evaluated the impact of mild and moderate cases of clinical mastitis that occurred in early lactation by comparing several management interventions. The total cost of clinical mastitis in their model ranged from $106 to $867 and included the cost of drugs, labor, discarded milk, milk loss due to clinical and subclinical mastitis, culling, and recurrent cases. The wide range in the estimated cost was due to the incorporation of several additional layers of management alternatives that included on-farm culture for treatment decision making and the consideration of different treatment options – including no intramammary therapy or 2, 5, or 8 d of therapy When examined with a single, representative milk price of $20/cwt and stratified by parity groups, the authors reported an expected cost of $311 to $515 for primiparous cows and $204 to $517 for multiparous cows, depending upon the cause of the mastitis and the treatment strategy used. These wide ranges in cost estimates provide reasonable estimates to evaluate approximate ranges of costs for mild and moderate cases but do not consider farm-specific variables; nor do they consider the economic impact of severe cases, which tend to occur more commonly in early lactation and typically comprise 5 - 20 % of total mastitis cases (Ruegg, 2011). If 10 % of cases are in fact severe and receive more intensive and thorough treatment strategies as is typically done, the average cost per case can easily rise by $30 to $50, not accounting for any differences in culling or mortality risk.

CONCLUSIONS

Mastitis is a costly disease issue no matter when it occurs, but the true cost is often underestimated, especially when considering the impact of cases that occur early in lactation. The cost of a case of mastitis depends on a lot of factors including farm factors (milk price, feed price, pathogen prevalence, culling philosophy, vaccination philosophy, detection intensity, and treatment success), cow factors (stage of lactation, level of milk production, parity, and immune status), as well as pathogen factors (species and bacterial load). Previous estimates of the economic impact of mastitis may not be applicable to today's dairy farms. While additional research is needed to more accurately assess the long term production and reproduction effects of early lactation mastitis, this new model addresses some of the shortcomings of previous research and provides an updated estimate of the expected cost of early lactation mastitis by considering more recently published research and allowing for farm-specific, customizable inputs of treatment approaches, pathogen distribution, recurrence risk, milk price, and feed price.

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