RELEVANCE OF MASTITIS CONTROL STRATEGIES: PROFITABILITY OF LACTATIONAL TREATMENT FOR SUBCLINICAL INFECTIONS IN DAIRY HERDS, ASSESSED BY A BIO-ECONOMIC SIMULATION MODEL

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Abstract

Currently under French conditions, mastitis control schemes rarely include lactational treatment of subclinical intramammary infections (LT). A bioeconomic simulation model (ECOMAM) was used to examine the economic consequences of control strategies including LT of young cows. The core-model of ECOMAM was developed as dynamic (daily time stepping), mechanistic (individual representation of heifers and cows) and stochastic (using probabilities for simulation of both occurrence and consequences of mastitis). This model was used to study the economic worth of several control strategies based on LT applied to different udder health statuses of a 800 000 l-quotum dairy herd with 100 year-present cows under the context of western France. To be profitable, control strategies with LT had to be able to create a sufficient decrease in the incidence of new infections (obtained by improved prevention). Strategies based on strict culling rules resulted in rapidly improved herd SCC but led very often to not to fill up the quota, implying lower revenue. Finally, except for borderline unsatisfactory statuses (levels of SCC penalties <1.5% of the milk price), to implement LT, without any strong culling policy but with an improved prevention, was profitable in most cases.

Key-words: Dairy Cow; Intramammary Infection; Lactational Treatment; Economics.

INTRODUCTION

High BTSCC (bulk-tank-milk somatic cell count) lead farmers to implement control strategies directed towards udder infection control. One possible control option to lower TBSCC is antibiotic treatment of infected cows during lactation even in absence of clinical signs, here called LT (lactational treatment), especially under situations where persistent infections due to pathogens with an udder reservoir (as *Staphylococcus aureus*) are predominant. Commonly, LT is very seldom used by French farmers, due to a perceived low interest: treatments have a cost and require a subsequent milk withdrawal from collection. Moreover, their technical efficiency is often challenged or considered being very low. Nevertheless no real relevant economic approach of the question was undertaken since milk quotas establishment and under French context. Moreover, some recent data showed that efficiency of LT is quite acceptable in young cows and recent infections. A restricted used targeted on such cases could thus be of interest in situations of high predominance of udder-reservoir pathogens.

Therefore, the present study aimed at determining the situations where control strategies including LT of young cows are economically relevant. Due to multiple biases and confounding factors in case of observational approaches, this question has to be answered using a modeling and simulation approach.

MATERIAL AND METHODS

1. Simulation model (Hortet, 2000; Seegers et al., 2000)

ECOMAM is a dynamic time stepping model with time steps of one day. It is a mechanistic model simulating the herd dynamics indirectly through simulation of each cow within the herd. The herd is represented as a group of cows and heifers. Events are simulated at the cow level. Management decisions are defined at the herd level. It is a stochastic model: occurrence of discrete events is triggered stochastically and based on probabilities. Consequently, different runs of the model will result in variable outcomes and provide distribution describing variability of expected results. Birth and reproduction, milk yield, feed consumption, culling and replacement and quota management are modeled using specific variables and simulation processes or decisions rules mimicking those made by farmers.

Four types of mastitis can be defined assuming 4 different categories of pathogens. Definition relies on a set of parameterized characteristics: risk of occurrence, proportion of clinical and subclinical cases at occurrence, persistence (rates for self cure during lactation and at re-calving), effects on yield, milk somatic cell count (SCC), culling or death. SCC at a given day is modeled as the sum of a baseline SCC for a cow without udder infection (function of parity and lactation stage), an additional term according to infection status (type of mastitis, stage in evolution, treatment implemented) and a random variation term. The infection-related additional term is stochastically triggered from a set of possible evolution profiles (declining or flat slope). Reduction in milk yield is modeled from individual cow SCC, according to Hortet et al. (1999). Every day, each cow is at risk of experiencing each type of mastitis, according to a probability defined by a risk function. For each type of mastitis, a baseline cow-level risk functions is defined in 5 different periods with regard to lactation stage. This baseline risk is increased or decreased according to herd-level modifiers (season, prevalence of contagious pathogens and herd-level prevention) and cow-level modifiers (production level, parity, disease history, inter-individual variability and individual prevention).

To run simulation experiments, a same initial herd is simulated over several months or years, first when nothing is changed (reference scenario), and second, when an alternative control plan is implemented according to the decision rules programmed.

2. Herd and udder-health initial situations

This paper reports results for a herd of about 100 year-present Holstein cows producing 8,250 liters each, in average at 43.5 g/l fat and 33.0 g/l protein. Usual mastitis control actions are supposed intermediate in efficiency: wet udder preparation, postmilking teat disinfection, systematic treatment at drying-off, and culling mainly based on production and reproduction, but taking also the individual SCCs into account when possible (in managing the quotum fulfillment). Purchase of cows or heifers are not allowed, the quota of 800,000 l is fulfilled despite of the prevalence of mastitis and cow milk is given to calves. A priori, this is a very demanding context to evidence any profitability of additional or modified mastitis control options. Four initial udder-health situations were studied:

- *Very high penalties:* 430,000 cells/ml, 55 clinical cases for 100 year-present cows and 1.33 cent penalties /liter.

- *High penalties:* 360,000 cells/ml, 45 clinical cases for 100 year-present cows and 1.00 cent penalties /liter.
- *Substantial penalties:* 300,000 cells/ml, 35 clinical cases for 100 year-present cows and 0.60 cent penalties /liter.
- *Low penalties:* 260,000 cells/ml, 28 clinical cases for 100 year-present cows and 0.33 cent penalties /liter.

3. Parameters for udder infections

To simulate predominance of udder pathogens responsible for persistent infections, the 4 types of infections were modeled as displayed in Table1.

Table 1. *Parameters for udder-infection types modeled*

Type	% of clinical expression when infection	% of total clinical cases observed in herd	% self cure in lactation
Staphyloccus aureus	25	29	20
Streptococci	60	32	30
Gram -	90	23	80
Minor pathogens	15	16	50

4. Simulated control plans and utility criterion

Several types of control plans were defined, combining LT of young cows (lactation 1 and 2 or 1 to 3), strict culling rules applied to other cows persistently infected (or, when possible, anticipated drying-off) and improved pre- and post milking prevention. Plans are activated when BTSCC is higher than 250,000 cells/ml for 2 months for at least 100 days. LT and strict culling rules are deactivated at 275,000 cells/ml and improved prevention at 100,000 cells/ml. Simplified plans including only on action of the combined options were also run.

Two hypotheses of cost, duration and efficiency of LT were simulated: a high one (cost of 27 €, duration of 2 d, withdrawal time of 4 d, cure rates of 60%, 65%, 85% et 95% for the types *staphyloccus. aureus*, streptococci, Gram - and minor pathogens, respectively); and a moderate one (cost of 22,50 €, duration of 2 d withdrawal time of 4 d, cure rates of 40%, 55%, 85% et 90% for the 4 types, respectively). These efficiency values were applied for 2nd lactation cows and were set lower for older cows and higher for 1st lactation cows.

A 3-year simulation horizon was considered (100 replications). The simulation model provided (for each simulated year in a replication) a gross margin (including a herd-assets value modification). An annual discount rate of 5% was applied before summing the 3 annual margins of a replication. Plans giving the highest average discounted gross margin, in comparison to the reference scenario, were considered being the most relevant. An analysis of variance allowed to test the differences

RESULTS AND DISCUSSION

Summary economic results are given in Table 2. In most of the insufficient udder-health situations considered here, some control plans including LT (according to specific implementation rules) were found being the most or close to the most profitable. However, LT alone was never found being a relevant control option.

Table 2. *Simplified results from simulation experiments*

Udder health situation	Best control plans in terms of discounted gross margin over a 3-year horizon	Improvement in gross margin (€ /year and /1000 l quota)
Very high penalties	Plans with extended LT (lactations 1 to 3), with improved prevention, without any strict culling rule	+ 3,5 to + 5,7 ($p<0.05$)
High penalties	Plans with extended LT (lactations 1 to 3) or non extended LT (lactations 1 and 2), with improved prevention, without any strict culling rule	+ 4,0 to + 6,1 ($p<0.05$)
Substantial penalties	Plans with non extended LT (lactations 1 and 2), with improved prevention, without any strict culling rule *and* Plans without LT and with improved prevention and strict culling	+ 2,2 to + 3,9 ($p< 0.10$)
Low penalties	No significant differences with the reference plan	NS

Average gross margin improvement generated by the best plans remained quite low and varied between replications. Intrinsic worthiness of such plan can nevertheless be good when penalties due to BTSCC are high, due to the fact that their implementation costs are low and do only little increase the total expenses (comparatively to the reduction of the losses). This is especially the case for LT, which is only implemented on a small number of animals, according to the kind of rules here simulated

Main mechanisms influencing profitability were:

1. *Fulfillment/or not of the quota*, which is depending on the absence/existence of strict culling rules and on the number of target cows for culling. Culling a large number of cows according to systematic rules leads to keep an insufficient number of producing cows in herd (in the simulations no external cow purchase was allowed). Strict systematic culling rules do not handicap the quota fulfillment when the number of target cow is low. However, plans including strict culling recommendations are often advised by vets or technical extensionnists because they allow to lower quickly the BTSCC;
2. *Speed of the BTSCC decrease*, and related decrease of penalties, especially in 1st year;
3. *Variations in herd asset values* (lowering the herd size leads to a depreciation);
4. *Level of extra-expenses for improved prevention*, which have quite to be faced during the 3 years in most of the udder-health situations simulated here.

The simulated differences in efficiency and cost of LT showed only very secondary effects on results. Higher contagiousness was favoring inclusion of LT or systematic culling rules in the control plans. This is due a direct short term effect after implementation: elimination of infected cows or extra-cure (in comparison to no culling or having only a self cure level) reduces the udder-reservoir of pathogens in the herd and, thereby, also the occurrence risk. Effect on occurrence is than higher with a simulated high contagiousness.

Extrapolation to smaller herds should be done with caution because variability of results becomes then higher (data not shown here). Extrapolation to other countries is a priori not valid because economic contexts are different. Nevertheless LT can be more profitable than under the French context (BTSCC penalty is quite mild and quotas are strong limits, as there is no borrowing system and purchase of additional quota is only possible by purchase of farmland having already a quota).

Finally, regarding consumer and society's requests, is noticeable that LT only led to a short term increase of the total number of antibiotic treatments in the herd at beginning of the plans: later the number of subclinically infected cows treated in lactation was low and was counterbalanced by a lower number of treatments for clinical cases.

CONCLUSION

Under the current French context and in large size Holstein herds, antibiotic lactational treatment of young cows subclinically infected can be reasonably advised as a component of control plans when prevalence of subclinical infections is high and penalties represent more than 1.5 % of the price of the milk liter. Nevertheless, antibiotic lactational treatment should be combined with improved prevention in order to reduce the occurrence of new infections. From the economic point of view, to fulfill the quota is the main objective and therefore, although very worthy to reduce quickly the bulk-tank-milk SCC, culling is to use with caution as a control option.

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