Cumulative effect of clinical mastitis episodes on culling of dairy cows

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Abstract

Clinical mastitis (CM) is a costly problem in dairies. It can occur multiple times throughout lactation. Revenue is lost due to lower production, unsaleable milk, and culling of affected cows. Our objective was to estimate the cumulative effect of CM episodes on culling in 2693 Holstein dairy cows in two New York herds. The data, including information on repeated occurrence of CM episodes, were fit in a proportional hazards regression model. Cows were followed for one lactation, from calving until culling or censoring. As well as CM episodes, parity, calving season, and other diseases were also modeled. Milk yield was excluded as it was an intervening variable.

2206 cows (81.9%) had no CM episodes during the study lactation, 381 (14.1%) had one episode, 76 (2.8%) had two episodes, 24 (0.9%) had three episodes, and six cows (0.2%) had four episodes. 20% of the cows were culled. After one CM episode, CM cows were 3.3 times more likely to be culled than were non-CM cows. After two episodes, CM cows were 3.6 times more likely to be culled. After three and four episodes, CM cows were 6.6 and 8.8 times, respectively, more likely to be culled than non-CM cows. This study demonstrates the importance of estimating the cumulative effect of CM on culling, as culling likelihood varies with episode. Modeling separate terms for each CM episode illustrates the difference in magnitude of their effects.

Introduction

CM is a major problem on dairies worldwide, causing lower milk production, unsaleable milk due to antibiotic presence, and culling of affected cows. We studied the effect of the 1st occurrence of pathogen-specific CM on herd life (Gröhn et al. 2005). However, CM can occur several times during a cow's lactation, and the effects may vary with episode. Survival analysis, with a counting process to account for recurrent events, can handle this (Therneau and Grambsch 2000). Our aim in this study was to estimate the cumulative effect of CM episodes on culling, using such a process.

Materials and Methods

Calving, culling, and health data, including information on all CM episodes, were available for 2693 Holsteins, calving from October 1999 to July 2001, in two New York herds. Milk samples from all quarters with signs of CM were collected by farm personnel and sent to the Quality Milk Production Services Central Laboratory at Cornell University for microbiological diagnosis.

We used survival analysis, with a Cox proportional hazards model (PROC PHREG (SAS 1999)), to estimate the cumulative effect of CM episodes on culling. We followed cows for one lactation, from calving until culling, subsequent calving, or end of study; cows that did not have the event of interest (culling) were censored. To account for multiple CM occurrences, we used the Andersen-Gill approach to construct the data set (Therneau and Grambsch 2000): each non-CM cow was represented by one observation, having a start time of calving date and end time of calving or censoring date. A cow with one CM episode was allocated two observations; the first covered the period from calving date to date of 1st CM episode, and the second from date of 1st CM episode to culling or censoring date. A cow with two CM episodes had three observations, covering the following time intervals: 1) calving date to date of 1st CM episode; 2) date of 1st CM episode to date of 2nd CM episode; and 3) date of 2nd CM episode to culling or censoring date. Similarly, cows with three or four CM episodes were allocated four and five observations, respectively. If CM and culling occurred on the same day, CM was assumed to occur first. Eg if a cow had CM and was also

culled, both on day-in-milk (DIM) 68, she was coded as having CM on DIM 68 and being culled on DIM 68.1. This avoided deletion of observations with an interval length of zero by PROC PHREG.

The data were stratified by herd, denoting the herd-specific baseline hazard functions. Our model was of the form:

*(t1, t2)*censor(0)= CM_episode parity calving_season other_diseases*

where *t1* and *t2* denote the beginning and end times (expressed as DIM) of the interval for a particular observation; *censor* is a censoring indicator (0 is the censoring (ie not culling) value); *CM_episode* denotes which CM episode (0, 1st, 2nd, 3rd, 4th) the observation pertains to; and *other_diseases* represents diseases (other than CM) with significant effects on culling. We excluded milk yield: it is an intervening variable in the CM-culling association (Gröhn et al. 2005). Frailty (random effect for excess risk in a cow (or herd)) was not modeled.

Model output is in the form of hazard ratios, which measure a risk factor's effect on time to culling.

Results and Discussion

The model included terms for CM episodes, parity, calving season, and displaced abomasum (DA). Parity 3 and 4+ cows were 2.4 and 3.6 times, respectively, more likely to be culled than primipara. Spring and summer calvers were 1.6 times, more likely to be culled than fall calvers. Cows with DA were 1.6 times more likely to be culled than cows without DA.

Table 1 shows the number of cows and median DIM and range for each CM episode, and hazard ratios and their 95% confidence intervals for culling. One in five cows had at least one episode, occurring throughout lactation. Culling hazard increased with episode. After one episode, CM cows were 3.3 times more likely to be culled than were their non-CM herdmates. There was a particularly large jump in culling hazard between 2nd and 3rd episodes. By the time a cow had four episodes, she was nearly nine times more likely to be culled, compared to a non-CM cow. CM is thus detrimental to herd life, and its effect is larger when more episodes occur. Farmers behave rationally by culling cows with more CM episodes at a higher rate. Also, there appears to be a threshold for tolerance of CM episodes: cows with one or two episodes had similar culling hazards, but cows with three or four episodes had higher culling hazards. Modeling CM in this way, rather than treating it as a one-time event, provided more accurate estimates of its cumulative effect on culling.

Table 1 Number and proportion of cows, median DIM and range of occurrence, and hazard ratios and 95% confidence intervals (CI) for culling, by CM episode, in 2693 Holstein dairy cows in two herds

CM episode number	Number (%) of cows[a]	Median DIM (range)[b]	Hazard ratio (95% CI)
Zero	2206 (81.9%)	--	--
1st	381 (14.1%)	66 (1-407)	3.27 (2.6-4.0)
2nd	76 (2.8%)	136 (5-375)	3.63 (2.4-5.4)
3rd	24 (0.9%)	175 (25-327)	6.58 (3.4-12.6)
4th	6 (0.2%)	204 (139-374)	8.81 (3.1-24.7)

[a]Number of cows with no CM episodes, only one episode, only two episodes, only three episodes, and only four episodes; percentages do not sum exactly to 100% due to rounding.
[b]Total number of CM episodes; the median DIM for eg the 1st episode (66) includes cows with one episode, with two episodes, with three episodes, and with four episodes, ie it is based on 381+76+24+6 episodes = 487 episodes (it is the median DIM for all 1st cases, whether the cow had only one episode, had two episodes, had three episodes, or had four episodes).

Figure 1 shows survival curves for cows with 0-4 CM episodes during lactation. Non-CM cows had a slow, steady rate of decline in survival; by 300 DIM, 85% were still alive. One-episode cows had a greater rate of decline in survival beginning at about 100 DIM, compared to non-CM cows; by 300 DIM, only 70% were still alive. Two-episode cows had a survival curve roughly parallel to that

of one-episode cows, but slightly higher. Three-episode cows began to have a lower survival rate at about 80 DIM. Their survival rate remained below that of cows with fewer CM episodes for the remainder of lactation. The survival rate for four-episode cows remained high until 140 DIM, when it began to drop sharply, until by 300 DIM, only about half of these cows were still alive. Figure 1 thus illustrates the difference in survival rate at different stages of lactation, depending on CM episode number, attesting to the need to model the cumulative effect of CM on culling.

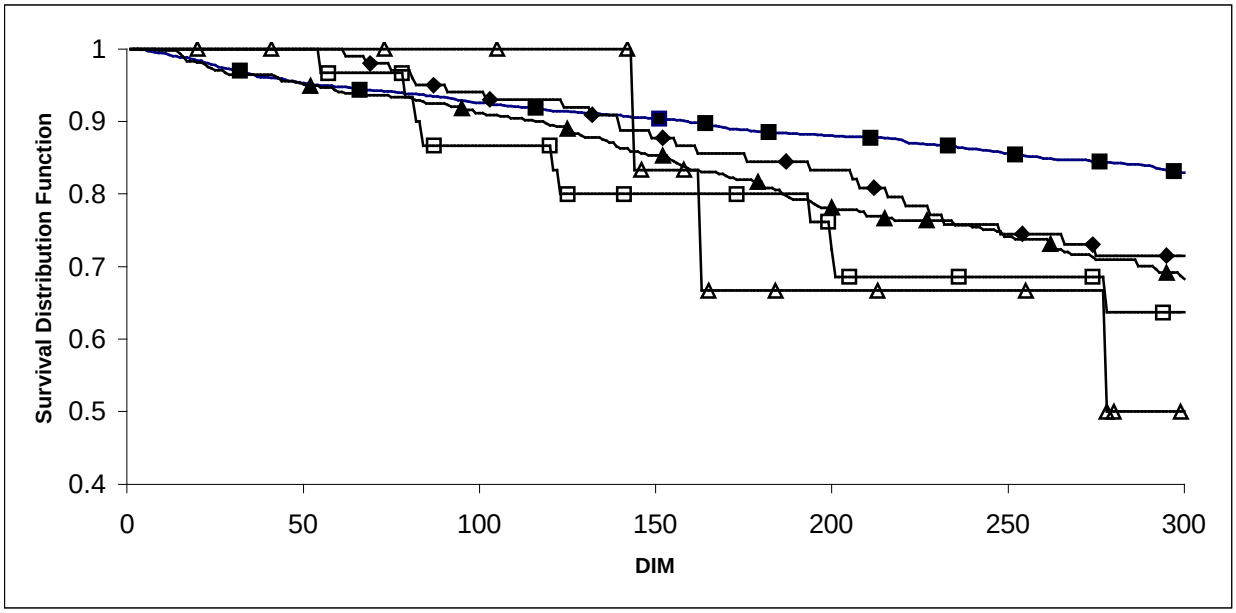

Figure 1 Survival curves for cows with 0, 1, 2, 3, or 4 clinical mastitis episodes during lactation (0 CM episodes: --• --; 1 CM episode: --• --; 2 CM episodes: --• --; 3 CM episodes: --• --; 4 CM episodes: --• --).

Conclusions

CM is an important disease in the dairy industry, causing significant losses in revenues, due to lower productivity (including both lower production and lost milk due to antibiotic use), veterinary treatment costs, and increased culling. We used survival analysis with a counting process to model CM's cumulative effect on culling, to see how culling hazard varied with CM episode. Culling hazard increased with increasing CM episode number, with an especially large jump between 2nd and 3rd episodes. The results imply that CM cows with one or two episodes are evaluated similarly for culling, while CM cows with three or four episodes are evaluated differently, with a higher likelihood of culling. This shows that farmers act rationally in managing CM cows. Future analysis will include a frailty term, to account for excess individual-cow risk.

References

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