ESTIMATION OF THE ECONOMIC LOSS DUE TO NEW SUBCLINICAL MASTITIS IN DUTCH DAIRIES USING A TEST-DAY MODEL

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1. INTRODUCTION

Most studies regarding the economic losses resulting from mastitis focus on clinical mastitis (Halasa et al., 2007). However, several studies have shown that milk yield losses due to subclinical mastitis can be considerable (Seegers et al., 2003). Results of these studies varied largely and production losses were not estimated precisely enough for economic calculations. Moreover fat and protein loss estimations were scarce and might have underestimated the actual loss (Hortet & Seegers, 1998).

Methodologies to estimate production loss did not succeed to include the natural variations between cows, which might have misestimated the production loss. Random regression test-day modelling (RRTM) was developed to analyze test-day records of cows for genetic evaluation. Because these models are based on herd and cow specific lactation curves, they are more accurate. Our objective was to estimate the economic losses due to new cases of subclinical mastitis, using the RRTM.

2. MATERIALS & METHODS

The Dutch udder health center (UGCN, Deventer, The Netherlands) in cooperation with dairy herd improvement organizations (CR Delta and NRS, Arnhem, The Netherlands) collected cow production and clinical mastitis records in 400 randomly selected dairy farms. Data collection lasted from 1st July 2004 until 30th June 2005. During this period 251,647 TD records from 43,462 lactations of 39,512 cows were collected. Clinical records were based on farmers' diagnosis of abnormal milk color or presence of clots.

The first definition of new subclinical mastitis was based on literature (Doubling50), where a cow was considered to have new subclinical mastitis at test-day i (TD_i) when SCC was < 50,000 cells/ml at TD_{i-1} and > 100,000 cells/ml at TD_i. The second definition (Theshold150/250) was based on Dutch monitoring limits of milk SCC to indicate subclinical mastitis (Schepers et al., 1997). Accordingly a primiparous cow was considered a new case of subclinical mastitis at TD_i if the SCC was < 150,000 cells/ml at TD_{i-1} and > 150,000 cells/ml at TD_i. A multiparous cow was considered a new case of subclinical mastitis at TD_i if the SCC was < 250,000 cells/ml at TD_{i-1} and > 250,000 cells/ml at TD_i. Only the first subclinical mastitis episode was included in the analysis not to bias the results from previous subclinical episodes.

RRTM was used to predict milk, fat, and protein production for each test-day based on previous test-days. Predictions of milk, fat, or protein production were provided for TD_i based on the production at all preceding TDs, corrected for fixed genetic and environmental effects, parity, days in milk (**DIM**) and other important risk factors (De Roos & De Jong, 2006). The predicted production at the subclinical mastitis test-day represents the production of the cow assuming the SCC remained within the healthy limit and the cow follows its expected lactation curve.

The difference (ΔProd) between the actual and the predicted production (milk, fat, or protein) of a cow at TD_i (subclinical TD) reflects the effect of new subclinical mastitis on production for that cow

$$\Delta Prod = \text{Actual Production at } TD_i - \text{Predicted Production at } TD_i \qquad (1)$$

To estimate the loss due to new subclinical mastitis a mixed effect model PROC MIXED in SAS (SAS institute Inc., 2004), was used according to the following equation

$$Y_{hjk} = \beta_o + \beta_1 \times \text{LnSCC} + \beta_2 \times \text{Parity}_h + \beta_3 \times \text{TDInt} + \beta_4 \times \text{DIM}_j + \text{Cow}_k + e_{hjk} \qquad (2)$$

where Y_{hjk} is the change in milk, fat, or protein production (ΔProd) at the subclinical mastitis TD (TD$_i$) for cow k in parity h and DIM class j, β_o is the overall mean ΔProd, β_1 is the linear regression coefficient of the natural logarithm of SCC $\times 10^3$ cells/mL (**LnSCC**), LnSCC is the fixed effect of LnSCC at TD$_i$, β_2 is the linear regression coefficient of the hth class of parity, Parity$_h$ is the fixed effect of class h of parity (5 classes, parity = 1, 2, 3, 4, and $\geq$ 5), β_3 is the linear coefficient of TD interval, TDInt is the fixed effect of the time interval (in days) between TD$_{i-1}$ and TD$_i$, β_4 is the linear coefficient of the jth class of DIM, DIM$_j$ is the fixed effect of class j of DIM (30 classes) at TD$_i$, Cow$_k$ is the random effect of cow k, and e_{hjk} is the residual error. The model was run separately for each definition of new subclinical mastitis.

The fit of the RRTM was assessed by the residuals normal distribution, fitted values, leverage, and Cook's distance plots. The influence of observations that had Cook's distance > the accepted upper limit according to Dohoo et al. (2004) was assessed based on the following equation

$$\text{Influence} = 3 \times K / N \qquad (3)$$

Where Influence is the accepted upper limit for Cook's distance, K is the number of parameters in the model (excluding the intercept) and N is the total number of observations included in the model.

3. RESULTS

Primiparous cows comprised 31.6% of the whole study population. Mean milk production for primiparous cows was 23.2 kg/d with a geometric mean SCC of 65,000 cells/mL. For multiparous cows mean milk production was 28.33 kg/d with a geometric mean SCC of 105,000 cells/mL. the model fitted the data properly, the residuals were approximately normally distributed and the fitted values were homogenously distributed showing no trend. The leverage showed few outliers and their influence was tested using the Cook's distance (Figure 1). The upper limit of the influence was 0.001, and 139 observations exceeded this limit.
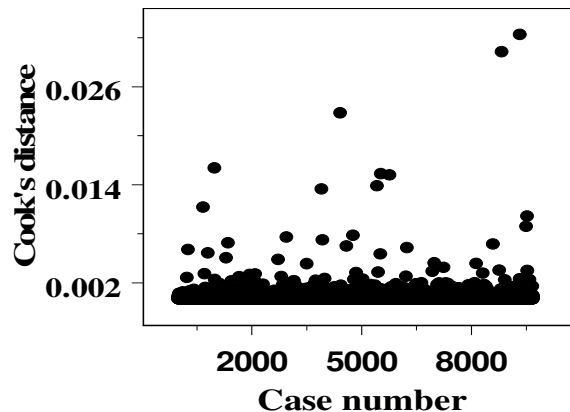

Figure 1. Cook's distance values for the change in milk production model using definition Doubling50.

There was no significant difference in production loss among multiparous cows and therefore results are presented for primiparous and multiparous cows. There was no significant effect of TDInt on the change in milk, fat, or protein production (lowest P-value = 0.15). Similarly, none of the 30 classes of DIM were found to affect the change in milk, fat, or protein production significantly (lowest P-value = 0.65) and therefore TDInt and DIM were not included in the final model. The number of new subclinical mastitis cases was 3030 and 6658 for primiparous and multiparous cows, respectively.

Milk, fat and protein loss due to new subclinical mastitis are shown in Table 1 per definition. Using Doubling50, a primiparous cow is estimated to lose 0.41 kg milk, 4.51 g fat, and 10.23 g protein per day during the period of new subclinical mastitis at the level of SCC 200,000 cells/ml. A multiparous cow is estimated to lose 0.6 kg milk, 10.16 g fat and 12.49 g protein per day during the period of new subclinical mastitis at SCC 200,000 cells/ml. Using Threshold150/250, a primiparous cow is estimated to lose 0.41 kg milk, 4.51 g fat, and 10.23 g protein per day during the period of new subclinical mastitis at SCC 200,000 cells/ml. A multiparous cow is estimated to lose 0.72 kg milk, 15.53 g fat and 9.65 g protein per day during the period of new subclinical mastitis at SCC 300,000 cells/ml. Cows are estimated to lose more milk according to doubling50 for low SCC

compared to Threshold150/250. However, this estimation is opposite for high SCC, which could be explained by the different limits of healthy SCC level.

Table 1. Effects of an increased SCC during a new case of subclinical mastitis on milk, fat and protein production for primiparous and multiparous cows and for definitions Doubling50 and Threshold150/250.

SCC at TD_i	Doubling50						Threshold150/250					
	Milk		Fat		Protein		Milk		Fat		Protein	
	Parity 1	Parity ≥ 2	Parity 1	Parity ≥ 2	Parity 1	Parity ≥ 2	Parity 1	Parity ≥ 2	Parity 1	Parity ≥ 2	Parity 1	Parity ≥ 2
200	0.41	0.60	4.51	10.16	10.23	12.49	0.36	-	0.7	-	9.1	-
300	0.50	0.79	8.91	18.10	13.75	17.64	0.61	0.72	3.14	15.53	15.6	9.65
400	0.56	0.93	12.03	23.67	16.24	21.29	0.78	0.90	4.87	22.00	20.21	17.59
500	0.61	1.03	14.45	28.02	18.17	24.13	0.92	1.05	6.21	27.00	23.8	23.76
600	0.65	1.12	16.43	31.58	19.75	26.44	1.04	1.17	7.31	31.07	26.72	28.79

4. DISCUSSION

Economic damage due to subclinical mastitis has been mainly attributed to the fact that a subclinical cow is a constant source of infection to other cows and to milk production loss (Swinkels et al., 2005). However, fat and protein losses were not included in previous calculations, which could be more important than milk loss in countries such as the Netherlands because farmers are paid according to fat and protein content of the milk.

Using Doubling50, milk production loss was found to be 0.41 and 0.6 kg/d for primiparous and multiparous cows, respectively, at SCC 200,000 cells/mL. Literature estimates of milk production loss for two-fold increase in crude SCC are 0.40 and 0.60 kg/d for primiparous and multiparous cows, respectively (Seegers et al., 2003), which is close to the estimates in this study (would be 0.38 and 0.46 kg/d for the same relationship). In this study, the clinical records were excluded from the analysis, consistent with Hortet et al. (1999) and Koldeweij et al. (1999). Fat and protein production were also affected negatively with increased SCC. Using Doubling50 (Table 1) primiparous and multiparous cows are estimated to lose 4.51 and 10.16 g/d of fat, respectively, during a SCC increase to 200,000 cells/mL. For the same relationship, primiparous and multiparous cows are estimated to lose 10.23 and 12.49 g/d of protein, respectively. Previous research found fat and protein losses of 5 and 4 g/d, respectively (assuming a cow produces 25 kg milk per day) per two-fold increase in SCC, regardless of the parity of the cow and ignoring other risk factors (Hortet and Seegers, 1998). Koldeweij et al. (1999) found close estimates to this study.

There is a general debate in literature regarding the definition of a new subclinical case in relation to SCC. Djabri et al. (2002) found that the average SCC for culture-negative quarters was 68,000 cells/mL. In a review by Seegers et al. (2003) a healthy udder was defined if SCC < 50,000 cells/ml. Threshold150\250 assumes an udder healthy if SCC < 150,000 and < 250,000 cells/mL, for primiparous and multiparous cows, respectively. Doubling50 seems more consistent with recent literature on the definition of a healthy udder. Production loss was found to be different using Doubling50 than Threshold150\250 (Table 1) for the same increased SCC level. This could indicate that the manner of change of the SCC might be as important as the level of increase in SCC.

Ideally, intramammary infections would be monitored using bacterial culturing of milk samples. However, the availability of such datasets is limited to small-scale datasets for research purposes (Schukken et al., 2003). Evaluation of economic damage due to subclinical mastitis demands a large dataset, which is not available due to high costs. The availability of large datasets of SCC makes it an attractive proxy to bacterial culture samples.

In conclusion, Random regression test-day modeling is a good technique to estimate the effect of new subclinical mastitis on production. There is a significant loss in milk, fat, and protein production of dairy cows with new lactational subclinical mastitis. The magnitude of the loss is determined by the definition of new subclinical mastitis and the SCC elevation.

5. ACKNOWLEDGMENTS

6. REFERENCES

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