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Pathogen-specific effects on milk yield in repeated clinical mastitis episodes in Holstein dairy cows

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ABSTRACT

The objective of this study was to estimate the effects of clinical mastitis (CM) cases due to different pathogens on milk yield in Holstein cows. The first 3 CM cases in a cow's lactation were modeled. Eight categories of pathogens were included: *Streptococcus* spp.; *Staphylococcus aureus*; coagulase-negative staphylococci (CNS); *Escherichia coli*; *Klebsiella* spp.; cases with CM signs but no bacterial growth (above the level detectable by our microbiological procedures) observed in the culture sample, and cases with contamination ($\geq$3 pathogens in the sample); other pathogens that may be treated with antibiotics (included *Citrobacter*, *Corynebacterium bovis*, *Enterobacter*, *Enterococcus*, *Pasteurella*, *Pseudomonas*; "other treatable"); and other pathogens not successfully treated with antibiotics (*Trueperella pyogenes*, *Mycoplasma*, *Prototheca*, yeasts; "other not treatable"). Data from 38,276 lactations in cows from 5 New York State dairy herds, collected from 2003–2004 until 2011, were analyzed. Mixed models with an autoregressive correlation structure (to account for correlation among the repeated measures of milk yield within a lactation) were estimated. Primiparous (lactation 1) and multiparous (lactations 2 and 3) cows were analyzed separately, as the shapes of their lactation curves differed. Primiparas were followed for up to 48 wk of lactation and multiparas for up to 44 wk. Fixed effects included parity, calving season, week of lactation, CM (type, case number, and timing of CM in relation to milk production cycle), and other diseases (milk fever, retained placenta, metritis, ketosis, displaced abomasum). Herd was modeled as a random effect. Clinical mastitis was more common in multiparas than in primiparas. In primiparas, *Streptococcus* spp. occurred most frequently as the first case. In multiparas, *E. coli* was most common as the first case. In subsequent cases, CM cases with no specific growth or contamination were most common in both parity groups. The hazard of CM increased with case number. Mastitic cows were generally higher producers before the CM episode than their nonmastitic herdmates. Milk loss varied with pathogen and case number. In primiparas, the greatest losses were associated with *E. coli* and "other not treatable" organisms. In multiparas, the greatest losses were associated with *Klebsiella* spp. and "other not treatable" organisms. Milk loss was not associated with occurrence of CNS. The findings may help farmers to make optimal management decisions for their cows.

Key words: milk yield, mastitis, pathogen, mixed model

INTRODUCTION

Clinical mastitis (**CM**) is an ongoing problem in many dairy herds around the world. In addition to reduced cow welfare and increased veterinary costs, episodes of CM are associated with markedly reduced milk production (Houben et al., 1993; Bar et al., 2007; Hagnestam et al., 2007; Schukken et al., 2009b), decreased fertility (Santos et al., 2004; Hertl et al., 2010), and increased risk of culling and death (Waage et al., 2000; Hertl et al., 2011).

Clinical mastitis may be due to a wide variety of organisms and may occur multiple times within a single lactation and across lactations. Because large differences exist between major mastitis pathogens in the pathobiology of inflammatory response after an IMI (Schukken et al., 2011), it may be expected that milk production losses will be different between pathogens. Precise knowledge of pathogen-specific milk loss is important for decision making in regard to treatment and production prognosis of affected cows, including replacement decisions.

Pathogen-specific milk losses are not just of recent concern. In a British study, mastitic cows from which no organisms were isolated had slightly higher milk yields than nonmastitic cows, whereas cows with *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, or staphylococci infections had

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significantly lower yields (King, 1969). Natzke et al. (1972) found that coliforms, streptococci, and *Staphylococcus aureus*, among other organisms, were associated with 305-d milk losses of >500 kg. In a Michigan study, cows with CM lost over 300 kg of milk during the 60 d after diagnosis (including both actual losses and milk withheld due to antibiotic treatment); in that study, milk loss did not vary substantially with etiologic agent (*Streptococcus* spp., *Staph. aureus*, CNS, coliforms, others). The authors reported that milk loss was higher for first cases (366 kg) than for subsequent cases (300 kg), although this difference was not statistically significant (Bartlett and van Wijk, 1991). In our previous studies on repeated cases, we determined that a second case with an organism of the same Gram classification as the first case in the same lactation did not differ in milk loss compared with a second case with an organism of a different Gram classification (Schukken et al., 2009b).

The incidence rate of the next case of CM of the same pathogen as the previous case was shown to increase after a previous case of CM. Among cows that had experienced a first case of CM in lactation, we observed a higher incidence rate of second cases, and among cows with 2 cases of CM, the rate of third cases was again higher (Bar et al., 2008). Similar to the incidence rate and persistent high loss of repeated cases of mastitis within a single lactation, the risk of death was similar in multiparous cows after every occurrence of CM in the same lactation and the risk of culling increased with every occurrence of mastitis in both primiparous and multiparous cows (Bar et al., 2008).

All these findings, somewhat surprisingly, indicate no immunological benefit of a previous case of CM with regard to the ability to respond to the next case of CM, even when the 2 subsequent cases involved organisms of the same Gram classification. Of course, the similarity of Gram classification does not guarantee that the first and second cases were caused by the same pathogen. A more detailed analysis that includes knowledge of the actual pathogen is therefore needed to better understand the biology and possible presence or absence of reduced severity of multiple cases of CM with the same pathogen.

For these reasons, considerable biological-immunological and management interest exists in pathogen-specific milk loss data in case of a first or recurrent episode of CM. This study explores that issue as part of a progression of the work our group has done on CM for several years. We first studied the effects of the first case of pathogen-specific CM in a single lactation on milk yield (Gröhn et al., 2004). We later examined the effect of recurrent cases of pathogen-unidentified CM on milk yield (Bar et al., 2007). We have collected sufficient data to study the effects of different groupings (gram-positive, gram-negative, other) of recurrent CM cases on milk yield (Schukken et al., 2009b). We have now accumulated sufficient additional data to study recurrent cases of pathogen-specific CM. The objective of this study was to estimate the effects of episodes of CM caused by specific pathogens on milk yield (mean daily yield in each week) throughout lactations in Holstein dairy cows.

MATERIALS AND METHODS

Herd Descriptions

Five well-managed, high-producing Holstein herds, 3 from central New York State, 1 from northern New York, and 1 from western New York, with an average herd size of 1,140 cows, participated in the study. The 305-d rolling herd average milk production ranged from 11,260 to 13,123 kg/cow per year; monthly mean SCC ranged from 137,000 to 262,000 cells/mL. Data on milk production, milk conductivity, parity, reproduction success, diseases, calving, drying-off, and herd exit were available for 7 to 8 yr. Farm personnel used DairyComp305 herd management software (Valley Agricultural Software, Tulare, CA) to record information. Cows were housed in freestalls in covered barns and were managed in groups according to lactation month, production, and reproduction status. They were fed a balanced TMR and milked 3 times daily.

Case Definition

All lactating cows in the 5 herds were eligible for inclusion in the study. Milkers discovered most CM cases, characterized by a warm, swollen udder or changes in milk consistency. Additional cases were found by herdspersons examining cows whose milk electrical conductivity was elevated (>115% of the average of the previous 10 d) and that experienced a sudden concurrent milk loss (<70% of the average of the previous 10 d). Sick cows were treated according to well-defined protocols that were similar across the 5 farms and throughout the study. Farm personnel collected milk samples from quarters with signs of CM and sent them to the Quality Milk Production Services laboratories (in Ithaca, Canton, and Geneseo, NY) for culturing (Hertl et al., 2011). The bacteriological culture procedures used in this study are described in detail in Gröhn et al. (2004).

If 2 different pathogens (e.g., *Streptococcus* spp. and *Staph. aureus*) were isolated from the same or a different quarter on the same day, both contributed to the analysis. That is, both *Streptococcus* spp. and *Staph. aureus* were considered causative agents of that