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The effect of repeated episodes of bacteria-specific clinical mastitis on mortality and culling in Holstein dairy cows

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ABSTRACT

The objective of this study was to estimate the effect of a first and repeated cases of bacteria-specific clinical mastitis (CM) on the risk of mortality and culling in Holstein dairy cows. The pathogens studied were *Streptococcus* spp., *Staphylococcus aureus*, *Staphylococcus* spp., *Escherichia coli*, *Klebsiella* spp., *Trueperella pyogenes*, others, and no growth on aerobic culture. A total of 50,166 lactations were analyzed from 5 large, high-milk-producing dairy herds in New York State from 2003/2004 to 2011. Generalized linear mixed models with a Poisson error distribution were used to study the effects of parity, month of lactation, CM, calving diseases, pregnancy status, current season, and economic values on the risk of mortality and culling. Among first-lactation cows, the presence of a first CM case generally exposed cows to a greater risk of mortality in the current month (compared with the absence of a first case). This was especially acute with a first case of *Klebsiella* spp., where cows were 4.5 times more at risk [95% confidence interval (CI): 2.7–7.6] of mortality, and with a first case of *E.* coli were 3.3 times more at risk (95% CI: 2.5–4.5). In first-parity cows, the risk of culling generally increased with a case of bacteria-specific CM. This was observed among cows with a first case of *T.* pyogenes [relative risk = 10.4 (95% CI: 8.4–12.8)], a first case of *Klebsiella* spp. [relative risk = 6.7 (95% CI: 5.5–8.1)], a first case of *Staph.* aureus [relative risk = 4.8 (95% CI: 2.7–8.4)], a first case of *E.* coli [relative risk = 3.1 (95% CI: 2.7–3.6)], and a third case of *Klebsiella* spp. [relative risk = 5.0 (95% CI: 3.1–8.0)]. In general, the presence of a first or second/third case resulted in cows in parity ≥2 with a greater risk of mortality. This was greatest for cows with a first case of *Klebsiella* spp. [relative risk = 3.7 (95% CI: 3.3–4.3)], followed by a second/third case of *Klebsiella* spp. [relative risk = 3.2 (95% CI: 2.5–4.0)], a first case of *E.* coli [relative risk = 3.0 (95% CI: 2.7–3.3)], and a first case of other CM [relative risk = 1.8 (95% CI: 1.6–2.0)]. Among cows of parity ≥2, the risk of culling was greater for cows as they progressed through lactations [i.e., cows in parity 4+ were 2.1 (95% CI: 2.0–2.2) times more likely to be culled compared with cows in lactation 2 (the baseline)]. The risk of culling dependent on the cow's characteristics can be easily calculated from the parameter estimates in the provided tables.
Key words: mortality, culling, bacteria specific, mastitis

INTRODUCTION

Mastitis is one of the top 3 reasons for culling dairy cows, alongside lameness and failure to conceive (Esslemont and Kossaibati, 1997). The effects of mastitis include reduced conception (Hertl et al., 2010), losses to milk yield (Schukken et al., 2009), a higher risk of mortality (Bar et al., 2008a; Hertl et al., 2011), and, depending on the pathogen involved, significant treatment costs. In addition to the presence of disease, the dairy farmer considers milk yield, conception status, stage of lactation and parity when making a decision (Gröhn et al., 1998; Rajala-Schultz and Gröhn, 1999). From this perspective, studies have been performed to identify the cost of mastitis and economically optimal management decisions (Halasa et al., 2009; Sørensen et al., 2010). Farmers may justify that it is economically optimal to replace their diseased cows with newly calved first-lactation animals, in anticipation of accrued losses to production over their projected lifespan (Houben et al., 1994; Bar et al., 2008b; Cha et al., 2011) and management of milk quality.

To estimate the cost of mastitis, it becomes necessary to separate those events that are beyond the control of the dairy farmer from those events that are within the dairy farmer's control. Mortality is a forced event that occurs with a given probability, whereas culling or selling a cow is a decision that may be an economic decision made by a dairy farmer depending on the specific cow involved (Houben et al., 1994; Bar et al., 2008a,b).

The risk of mortality and culling is dependent on the pathogen causing the clinical mastitis (**CM**), the

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repeatability of cases, seasonality, and cow characteristics. For example, a study of mortality among Danish dairy cattle showed that the most-frequent specific diagnosis among udder/teat disorders resulting in death was septic mastitis caused by *Escherichia coli* (Thomsen et al., 2004). Hazlett et al. (1984) similarly found that *E. coli*, followed by *Klebsiella* spp. were the most common causes of fatal mastitis. The severity of mastitis has been shown to be calendar time dependent; Bradley and Green (2001) demonstrated that *E. coli* mastitis had a tendency of being more severe between October and March than between April and September in the Northern hemisphere. The authors reason that this may be due to alterations in pathogenicity of the organisms present among environmental pathogens at various times of the year (Bradley and Green, 2001). A trend also existed toward more severe mastitis occurring in the first 90 d of lactation than in the latter periods of lactation. This parallels the findings of Lehtolainen et al. (2003), where cows' responses, defined by local and systemic signs to intramammarily infused *E. coli* endotoxin, were significantly more severe in early lactation than late lactation. We have studied the risk of repeated cases of bacteria-specific CM and have found that a previous case with the same pathogen will put cows at greater risk of a subsequent case (Schukken et al., 2009). Earlier, Bradley and Green (2001) reported similar results [i.e., repeat cases of CM occurred in 46 (16.4%) of affected quarters and in 24 (8.6%), the repeat cases were due to the same species of pathogens as the initial case]. Although previous studies have examined the effects of repeated episodes of non-bacteria-specific CM (Bar et al., 2008a), repeated episodes of gram-positive, gram-negative, and other CM (Hertl et al., 2011) and a first case of pathogen-specific CM on mortality and culling in dairy cows (Hazlett et al., 1984; Gröhn et al., 2005), no study has investigated the role of repeated cases of pathogen-specific CM. Specifically, it is unclear if repeated cases of the same pathogen and if a shorter time interval between repeated cases put cows at a greater risk of being culled. Therefore, the objective of this study was to estimate the effect of a first and repeated cases of bacteria-specific CM on the risk of mortality and culling in Holstein dairy cows.

MATERIALS AND METHODS

Herd Descriptions

Data from 50,166 lactations were assembled (18,420 of parity 1 and 31,746 of parity 2 and greater) from 23,409 cows. The data in this study were collected from 2003/2004 to 2011 (7–8 yr) from 5 large dairy herds in New York State. The 305-d rolling herd average milk production ranged from 11,260 to 13,123 kg/cow per year, and the monthly mean SCC ranged from 137,000 to 262,000 cells/mL.

Cows were housed in freestalls. Feed was provided in the feed alleys with headlocks, which facilitated the treatment and examination of cows. Cows were stratified by lactation, production, and reproductive status into feeding groups that were fed a TMR. Cows were milked 3 times per day and the milking units automatically recorded milk production. Lactation, reproductive, and medical information was entered into DairyComp305 herd management software (Valley Agricultural Software, Tulare, CA) by herd personnel. Information on parity, diseases, drying off, calving, and exit from all herds was available, as it was used by herd personnel for management of the dairy (Bar et al., 2008a; Hertl et al., 2011).

The variables relating to milk yield, mastitis culture results, diseases, and reproduction necessary to conduct this study were exported to ASCII files from DairyComp305 and imported into SAS v. 9.2 software (SAS Institute, 2008). The quality of the data was assessed through preliminary descriptive analyses of the variables of interest.

Case Definition

All lactating cows in the 5 herds were eligible for inclusion in the study. Cows were identified as having CM based on (1) milkers observing clinical signs of CM (i.e., a warm, swollen udder or changes in milk color or consistency); (2) otherwise, the remaining cases that were missed by milkers were identified by herdspersons who examined cows due to elevated milk electrical conductivity in addition to a sudden concurrent milk loss (at the cow level) as alerted by the farm computer system (Maatje et al., 1992; Nielen et al., 1995; Norberg et al., 2004). The treatment protocol for diseased cows was similar across the 5 dairy herds and throughout the study. Herd personnel collected milk samples from quarters with signs of CM for microbiological culturing at the Quality Milk Production Services laboratories located in NY State. The culture procedures are described in more detail in Gröhn et al. (2004). Briefly, milk samples were plated by streaking 0.01 mL on Trypticase soy agar II with 5% sheep blood and 0.1% esculin (BBL; Becton Dickinson Microbiology Systems, Cockeysville, MD). Plates were incubated at 37°C for 48 h. Following observation of colony morphology and hemolytic patterns on blood agar, isolates were examined by means of 3% KOH, Gram-staining organisms, catalase and oxidase testing, and additional biochemical and metabolic evaluations as required. Colony morphology on MacConkey agar and the BBL Crystal ID