J. Dairy Sci. 97:1–14
http://dx.doi.org/10.3168/jds.2012-6440

Risk factors for postpartum problems in dairy cows: Explanatory and predictive modeling

C. F. Vergara,* D. Döpfer,* N. B. Cook,* K. V. Nordlund,* J. A. A. McArt,† D. V. Nydam,† and G. R. Oetzel*[1]
*School of Veterinary Medicine, University of Wisconsin, Madison 53706
†Department of Population Medicine and Diagnostic Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853

ABSTRACT

The postpartum period is associated with a high incidence of most dairy cattle diseases and a high risk of removal from the herd. Postpartum diseases often share risk factors, and these factors may trigger a cascade of other diseases. The objective of this cohort study was to derive explanatory and predictive models for treatment or removal from the herd within the first 30 d in milk (TXR30). The TXR30 outcome was specifically defined as ≥1 treatment for ≥1 occurrence of milk fever, retained placenta, metritis, ketosis, displaced abomasum, lameness, or pneumonia; removal from the herd (sold or died); or both treatment and later herd removal. The study population consisted of 765 multiparous and 544 primiparous cows (predominantly Holstein) from 4 large commercial freestall-housed dairy herds. Treatment or removal from the herd was recorded as a binary outcome for each cow. Potential explanatory and predictive variables were limited to routine cow data that could be collected either before or within 24 h of calving. Models for multiparous and primiparous cows were developed separately because previous lactation variables are available only for multiparous cows. Adjusted odds ratios for TXR30 in the explanatory model for the multiparous cohort were 2.1 for lactation 3 compared with lactation 2, and 2.3 for lactation 4 or greater compared with lactation 2; 2.3 for locomotion score 3 or 4 compared with score 1; 3.3 for an abnormality at calving compared with no calving abnormality; 1.8 for each 1-standard deviation increase in previous lactation length; and 0.4 for each 5,000-kg increment in previous lactation milk yield in cows with longer previous lactation length. The final predictive model for TXR30 in multiparous cows included predictors similar but not identical to those included in the explanatory model. The area under the curve for the receiver operating characteristic curve from the final predictive model for the multiparous cohort was 0.70, with 60% sensitivity. For the primiparous cohort, calving abnormality increased the odds of TXR30 and was the only variable included in both the explanatory and predictive models. The area under the curve for the receiver operating characteristic curve from the final predictive model for the primiparous cohort was 0.66, with 35% sensitivity. This study identified key risk factors for TXR30 and developed equations for the prediction of TXR30. This information can help dairy producers better understand causes of postpartum problems.
Key words: transition period, explanatory modeling, predictive modeling, postpartum problems

INTRODUCTION

The 3- to 4-wk period before and after calving (the transition period) is crucial for a cow's health and longevity and for the profitability of the lactation. Calving is accompanied by the most significant endocrine changes at any point in time during the lactation cycle (Grummer et al., 2004). In addition, cows going through the transition period shift from positive energy balance to negative energy balance and experience substantial immune suppression (Burton et al., 2005; Hammon et al., 2006). Approximately 75% of disease in dairy cows occurs in the first 30 DIM (LeBlanc et al., 2006) and 30 to 50% of high-producing cows may be affected by some disease around calving (LeBlanc, 2010). The postpartum diseases of greatest interest are milk fever (**MF**), ketosis, displaced abomasum (**DA**), retained placenta (**RP**), uterine infections, and lameness. Incidences of these diseases and their relationship to changes that occur around calving have been described in detail (Ingvartsen et al., 2003; Nordlund and Cook, 2004).

Besides the occurrence of specific diseases, removal of a cow from the herd (due to either culling or death) during the postpartum period is another indication of difficulties during the transition period. Healthy cows are rarely culled in the postpartum period because they have the potential to produce milk for the remainder of the lactation. De Vries et al. (2010) reported that removals in early lactation were more likely to be due to death or injury compared with removals later in

Received November 30, 2012.
Accepted February 25, 2014.
[1]Corresponding author: groetzel@wisc.edu

lactation. Dechow and Goodling (2008) concluded that herds with high early-lactation cull rates are likely to have poor transition cow health. Because cows may develop severe disease and either die or be removed from the herd before being fully diagnosed or treated, it is useful to include early-lactation removals in the evaluation of postpartum problems. More intensive monitoring or prophylactic treatment might prevent premature herd removal.

The greatest advances in dairy health in the last decades have been the shift to disease prevention, rather than treatment, as well as the shift from a focus on individual cows to groups of cows at risk. The recognition of the multifactorial nature of almost all diseases and the interconnected risk factors have been fundamental in understanding the biology of transition dairy cows (LeBlanc et al., 2006). For example, subclinical hypocalcemia can cause poor rumen motility, leading to reduced feed intake and increased risk of ketosis and displaced abomasum. Hypocalcemia can also cause dystocia due to poor uterine motility, which increases the risk of retained placenta and metritis (Guterbock, 2004). However, metritis or ketosis can occur without underlying hypocalcemia and can be primary conditions themselves that trigger a cascade of postpartum problems. These observations suggest that postpartum problems are appropriately evaluated as a combined outcome (i.e., the occurrence of any disease condition or herd removal during the postpartum period) and should not necessarily be restricted to evaluations of individual disease or herd removal outcomes. A limited number of studies have evaluated combined outcomes for postpartum problems (Ospina et al., 2010a; Huzzey et al., 2011). Combining postpartum disease occurrence and herd removal into a single outcome also has practical advantages, as it would enable dairy producers to better understand why certain cows require management attention after calving and others go through the postpartum period without problems.

Laboratory measurements have been used to predict cows that are at higher risk of certain diseases after calving or early culling. Elevated serum NEFA prepartum (LeBlanc, 2010; Ospina et al., 2010a; Chapinal et al., 2011), blood BHBA prepartum (LeBlanc et al., 2005; Chapinal et al., 2011; Roberts et al., 2012), serum Ca the week before and soon after calving (Chapinal et al., 2011; Seifi et al., 2011; Roberts et al., 2012), and fecal cortisol and haptoglobin (Huzzey et al., 2011) have been used to predict postpartum diseases. Of these tests, only BHBA can currently be conducted cowside. The other tests generally require submission of a sample to a laboratory, which is costly and delays receipt of the test result (LeBlanc, 2010). Thus, laboratory tests are limited in their practical value for identifying cows in the field that are at high risk of postpartum problems.

Several low-cost measures have been identified as potential predictors for postpartum health disturbances. Body condition score has been shown to be a useful monitor of energy balance during this period (Ingvartsen, 2006; Hoedemaker et al., 2009). Locomotion score has been widely used in epidemiological studies for prevalence of lameness calculations (Cook, 2003; Espejo and Endres, 2007), and lameness has been associated with increased risk of postpartum health problems and decreased survivability (Hoedemaker et al., 2009; Calderon and Cook, 2011; Machado et al., 2011). Lameness has also been associated with decreased feeding time (Gomez and Cook, 2010) and increased blood BHBA concentrations after calving (Calderon and Cook, 2011). In addition, other risk factors such as previous lactation milk yield, previous lactation length, dry period length, gestation length, twins, dystocia, and stillbirths may be important determinants of postpartum performance in dairy cows (Fleischer et al., 2001; Ingvartsen, 2006; LeBlanc et al., 2006); however, they have not been combined into predictive models.

Modeling of postpartum problems must necessarily be different for primiparous versus multiparous cows. Primiparous cows have no previous lactation data to consider; thus, they have fewer variables available for evaluation as risk factors for postpartum problems. Underlying biological differences between primiparous and multiparous cows might also exist due to parity in transition cows. Cheong et al. (2011) reported that early lactation milk yield had opposite effects on the odds for subclinical endometritis in primiparous versus multiparous cows (increasing milk yield increased the odds for subclinical endometritis in primiparous cows but lowered the odds for multiparous cows). Ospina et al. (2010b) reported that primiparous cows with elevated prepartum NEFA had increased milk yield in the subsequent lactation, but that multiparous cows with elevated prepartum NEFA had decreased milk yield.

Statistical modeling can involve 3 approaches (Shmueli, 2011). Explanatory modeling is oriented toward causal explanation of the outcome, predictive modeling emphasizes mathematical prediction of the outcome, and descriptive modeling represents the data in a compact manner. Explanatory modeling is done to test causal hypotheses and is the most common approach for evaluating biological outcomes. The purpose of explanatory modeling is to identify all possible risk factors (including as many interactions as feasible) and to then characterize the direction and magnitude of the effects. In contrast, the purpose of predictive modeling is the prediction of new or future observations; it em-