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Prediction of bulk tank somatic cell count violations based on monthly individual cow somatic cell count data

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ABSTRACT

The regulatory limit in Canada for bulk tank somatic cell count (BTSCC) was recently lowered from 500,000 to 400,000 cells/mL. Herd indices based on changes in cow somatic cell count over 2 consecutive months (e.g., proportion of healthy or chronically infected cows, cows cured, and new intramammary infection rate) could be used as predictors for BTSCC violations. The objective of this study was to develop a predictive model for exceeding the limit of 400,000 cells/mL in the next month using these herd indices. Dairy Herd Improvement (DHI) data were used from 924 dairy herds in Québec, Canada. Test-day BTSCC was estimated by dividing the sum of all cows' DHI test-day somatic cell count times DHI test-day milk production by the total volume of milk produced by the herd on that test-day. In total, 986 of 8,681 (11.4%) estimated BTSCC exceeded 400,000 cells/mL. The final predictive model included 6 variables: mean herd somatic cell score at the current test-month, proportion of cows >500,000 cells/mL at the current test-month, proportion of healthy cows during lactation at the current test-month, proportion of chronically infected cows at the current test-month, average days in milk at the current test-month, and annual mean daily milk production. The optimized sensitivity and specificity of the model were 76 and 74%, respectively. The positive predictive value and negative predictive value were 25 and 95%, respectively. This low positive predictive value and high negative predictive value demonstrated that the model was less accurate at predicting herds that would violate the estimated BTSCC threshold but very accurate at identifying herds that would not. In addition, the area under the curve for the receiver operating characteristic curve was 0.82, suggesting that the model had excellent discrimination between test-months that did and did not exceed 400,000 cells/mL. An internal validation was completed using a bootstrapped resampling-based estimation method and confirmed that the final model provided a validated estimate of predictive accuracy. This model could be used to monitor and advise clients on impending risks of exceeding the BTSCC limit.
Key words: bulk tank, somatic cell count, prediction model, violation, dairy herd

INTRODUCTION

Milk quality influences the overall success of a dairy farm. In Canada, the Canadian Dairy Commission is responsible for developing quality standards for milk production (Canadian Dairy Commission, 2013). Failure to comply with these standards results in financial penalties and ultimately cessation of milk shipments to the processing plant (Les Producteurs de Lait du Québec, 2013). The regulatory limit for bulk tank SCC (**BTSCC**) on all Canadian dairy farms was recently lowered, as part of an initiative with the Canadian Quality Milk program, from 500,000 to 400,000 cells/mL (Les Producteurs de Lait du Québec, 2014).

Several strategies are available to dairy producers and advisors to help manage and monitor BTSCC. Hand et al. (2012) suggested that participation in DHI programs, wherein individual cow milk samples are frequently tested for SCC, could be used to monitor and improve BTSCC. Monthly SCC data are routinely interpreted by bovine practitioners to evaluate the udder health status of their client herds. To facilitate this practice, new dairy herd health management software has recently been developed and is being used in Québec, Canada [DSAHR (http://www.dsahr.ca/Liens/PageLiens.aspx) and CCStat program software]. Initially, however, region-specific benchmark data needed to be generated for several of the monitored indices to enhance the performance of the software for udder health assessment in Québec dairy herds. Results from this recent benchmark study confirmed that herds with high mean annual SCC had fewer cows with healthy udders and more cows with chronically infected ud-

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ders during lactation compared with low SCC herds (Fauteux et al., 2014).Thus, one could speculate that these herd-level udder health indices could be used as predictors for possible BTSCC violations under the new cutoff of 400,000 cells/mL.

Lukas et al. (2008) demonstrated that monthly mean and standard deviation (**SD**) of monthly BTSCC data can be used to estimate the probability of exceeding 5 different SCC levels, ranging from 200,000 to 600,000 cells/mL, in the subsequent month. Specifically, it was documented that the probability of a specific BTSCC violation was greater as monthly mean and SD BTSCC increased, and that high BTSCC herds had less predictable performance because their monthly BTSCC were usually more variable (Lukas at al., 2008). This research team also developed logistic regression models that demonstrated the odds of exceeding a BTSCC standard were significantly greater in the summer months and for smaller herds. Furthermore, Lievaart et al. (2010) reported that data on herd characteristics, season, management, and monthly SCC could be used to correctly predict more than 70% of the subsequent month herd SCC within a narrow range of 20,000 to 30,000 cells/mL. Hence, predictive models can be useful tools to assist with udder health management assessments and decisions. The objective of this study was to develop a predictive model of exceeding a BTSCC limit of 400,000 cells/mL for dairy farms in Québec, Canada.

MATERIALS AND METHODS

Herds and Data

Individual cow DHI data were used of 924 Québec, Canada, dairy herds from October 1, 2007, to December 31, 2008. To be eligible for inclusion in the study, herds had to be monitored at least on a monthly basis by their herd veterinarian using the DSAHR software, had to be enrolled in the DHI milk recording program, and had to have completed at least 6 DHI tests during the 2008 calendar year. Moreover, all participating herds had to have a minimum average herd size of 30 cows in lactation. Herd udder health indices were calculated using data from 2 consecutive DHI tests, and the interval between these 2 tests had to be $\leq$50 d. Data from 4 successive test-months were used to construct the predictive model: 3 predictive test-months and 1 predicted test-month. Therefore, herds had to present with at least 4 consecutive DHI test-months, each separated by $\leq$50 d, to be included in the database. Herd selection is summarized in Figure 1. The final database included primarily Holstein cows, along with some Jersey, Ayrshire, and Brown Swiss cows.

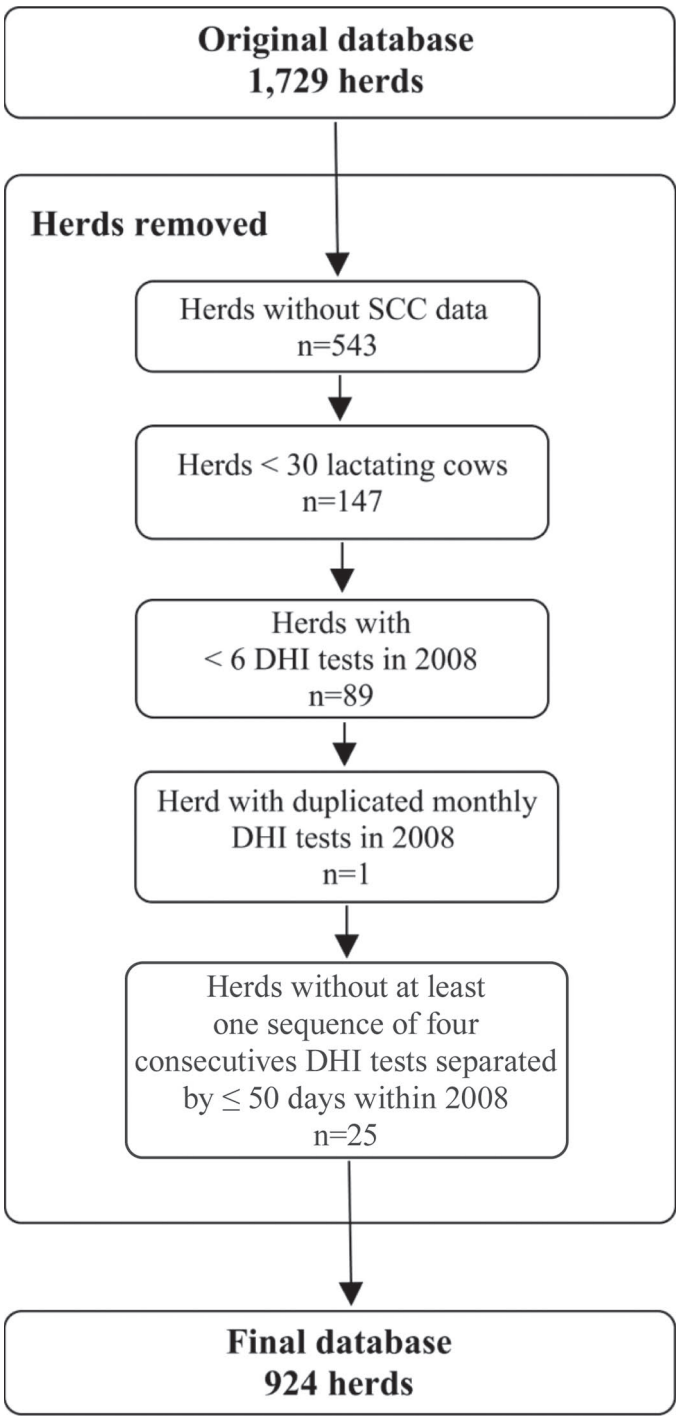

Figure 1. Summary of the herd selection process performed before the construction of a model to predict 400,000 cells/mL-estimated bulk tank SCC violations using individual cow DHI data from 924 dairy herds in Quebec, Canada, between October 1, 2007, and December 31, 2008.