J. Dairy Sci. 101:1–5
https://doi.org/10.3168/jds.2017-14164

Short communication: Model for metritis severity predicts that disease misclassification underestimates projected milk production losses

M. M. McCarthy and M. W. Overton[1]
Elanco Animal Health, 2500 Innovation Way, Greenfield, IN 46140

ABSTRACT

The objective of this research was to determine the effect of disease misclassification on the estimated effect of metritis on milk production. Misclassification introduces bias that usually results in an underestimation of the association between exposure (disease) and the outcome of interest (milk production). This distorted measure of association results from the comparison of an affected population (some of which may not truly be affected) to a nonaffected population (which often includes affected subjects that are unidentified). A convenience sample of DairyComp305 (Valley Agricultural Software, Tulare, CA) data representing 1 yr of calvings (n = 3,277) from 1 Midwestern Holstein herd was used. This herd was chosen because of its ongoing efforts to consistently and completely record all clinical diseases, including the incidence of both mild and severe metritis cases. Metritis was defined as the presence of a flaccid uterus containing fetid fluids or a foul watery discharge within 14 d of calving. Cows that appeared clinically normal other than the discharge were considered mild and those with systemic signs of disease were classified as severe. The original data set included metritis recorded as mild, severe, or not recorded (NR), where no metritis was observed, and was considered to contain the metritis true severity (TrS). First, to evaluate the effect of misclassification bias, we retrospectively randomized 45% of mild metritis to be classified as NR to simulate inconsistent disease recording (IR); then, in a separate model, all mild metritis cases were changed to NR to simulate a situation of very poor disease recording (PR), where only the most severe cases are recorded. The TrS, IR, and PR data sets were analyzed separately in JMP (SAS Institute Inc., Cary, NC). An ANOVA was conducted for second test 305-d mature equivalent milk projection (2nd305ME), and nonsignificant variables were removed, but the variable metritis was forced into all models. Based upon the TrS model, adjusting for effects of lactation group, month of calving, dystocia, twins, retained placenta, early-lactation mastitis, displaced abomasum, and significant interactions, a case of mild metritis was associated with 384 kg less 2nd305ME and a case of severe metritis was associated with 847 kg less 2nd305ME compared with no metritis. For the IR model, a case of mild metritis was associated with 315 kg less 2nd305ME and a case of severe metritis was associated with 758 kg less 2nd305ME compared with no metritis. For the PR model, severe metritis was associated with 680 kg less 2nd305ME compared with NR. The IR and PR models underestimated 2nd305ME loss for severe metritis cases by 89 and 166 kg/cow, and resulted in 180,441 and 330,256 kg of total milk loss unaccounted for at the herd level, respectively, compared with TrS. Overall, misclassification of metritis cases results in greater bias and largely underestimates the true association between metritis and the consequence costs of the disease.

Key words: metritis severity, misclassification bias, disease consequence

Short Communication

Dairy producer-recorded disease incidences are typically lower than the disease incidences that are found in the literature (Parker Gaddis et al., 2012). The reduced incidence of disease in herd-recorded data compared with research data likely represents an under recording, or misclassification, of the disease by dairy producers. Metritis is a costly disease that affects early-lactation dairy cows (Sheldon et al., 2009; Liang et al., 2017) and has been associated with negative downstream outcomes, such as reduced milk production, increased culling risk, and impaired reproduction (Lee et al., 1989; Deluyker et al., 1991; Fourichon et al., 2000; Wittrock et al., 2011). Metritis is also one of the most inconsistently diagnosed and recorded diseases on commercial dairy farms (Kelton et al., 1998; Sannmann et al., 2012). Some of the challenges with metritis diagnosis include inconsistent definition of metritis, inconsistent diagnostic approach and effort between herd personnel, and inconsistency in DIM when the disease evaluations

Received November 20, 2017.
Accepted February 2, 2018.
[1]Corresponding author: moverton@elanco.com

are performed (Espadamala et al., 2016). Inconsistencies in disease recording may preclude us from making faster advances in understanding the effect of disease on performance, as the failure to record disease affects the measurable performance in the herd by introducing bias into the system. This introduction of bias can result from failing to record metritis, failing to correctly distinguish mild cases from severe cases, failing to record mild metritis cases altogether, or misclassifying a normal cow as diseased. All of these scenarios result in misclassification bias, which usually results in an underestimation of the true association between the disease state and the outcome of interest (Johnson et al., 2014). Our working hypothesis was that disease misclassification from inconsistent recording of metritis occurrence, or failure to record mild metritis, would result in an underestimation of the true effect of metritis on projected milk production in a commercial dairy herd. The objective of this research was to determine the effect of simulated disease misclassification on the estimated effect of metritis on projected milk production in a commercial Holstein dairy herd.

A convenience sample of individual cow data representing 1 yr of calvings (n = 3,427) from 1 Midwestern Holstein herd was exported from DairyComp305 (Valley Agricultural Software, Tulare, CA). To be included in the final set of production models, cows must have calved during the year of interest and must have had milk production results through the second test. Of the 3,427 cows originally evaluated, 98/2,451 (4.0%), 39/849 (4.6%), and 13/127 (10.2%) of the cows with no metritis recorded, mild metritis, and severe metritis, respectively, were culled before completing a second milk test, resulting in 3,277 cows with complete data for the modeling exercise. Of the 150 excluded cows, 27 were first lactation and represented 2% of that parity. For the older cows, 59 were second lactation (5.1%) and 64 were from lactation 3 and higher (6.8%). This herd was chosen because of its ongoing efforts to consistently and completely record all clinical diseases, including mastitis, hyperketonemia, retained placenta, displaced abomasum, and both mild and severe metritis. The owner and manager is a veterinarian and invested considerable time and effort in training the on-farm staff to carefully examine each cow using a consistent and repeatable approach to help ensure greater consistency with disease diagnosis. The dairy's normal routine was to assess postparturient animals daily for any sign of illness for up to 14 d following parturition. Any cows that were not eating, appeared dull, or that displayed any evidence of foul vaginal discharge or straining from the rear were examined more completely. Upon palpation per rectum, any cow that had a flaccid uterus containing fetid fluids or possessing a foul watery discharge within 14 d of calving was diagnosed as having metritis and treated. Cows that appeared clinically normal other than the watery, fetid discharge were administered ceftiofur hydrochloride at a dose of 2.2 mg/kg i.m. once daily for 5 d. Any cow with metritis that displayed systemic signs of disease, including a rectal temperature greater than 39.4°C, inappetence, or obtundation, received ampicillin suspension at a dose of 11 mg/kg i.m. once daily for 5 d. Cows were retrospectively classified into metritis categories based upon the presence or absence of a metritis event and its treatment remark (ceftiofur or ampicillin). Cows receiving ceftiofur for metritis were labeled as mild and those receiving ampicillin for metritis were identified as severe. Cows with no recorded metritis event were identified as not recorded (**NR**). The information as obtained from the farm's records was considered to contain the true metritis incidence and true severity (**TrS**).

The TrS model contained 2,353 cows with no metritis recorded, 810 mild metritis cases (24.7% incidence), and 114 severe metritis cases (3.5% incidence). First, to evaluate the effect of misclassification bias, we retrospectively randomized 45% of mild metritis cases (363/810) to be classified as NR to represent a scenario of inconsistent disease recording (**IR**), where not all cases of mild metritis are properly identified and recorded; this set contained 2,716 cows with no apparent metritis recorded, 447 mild metritis cases (13.6% apparent incidence), and 114 severe metritis cases (3.5% incidence). In the second simulation, all mild metritis cases (810/810) were changed to NR to represent a scenario of poor disease recording (**PR**),

Table 1. Herd demographic data for cows and variables that were included in the model exercise simulations

Item	No. of cows	% of herd
Lactation group		
1	1,310	40.0
2	1,088	33.2
3+	879	26.8
Calf outcome[1]		
Twin	145	4.4
Singleton	3,132	95.6
Health disorder[2]		
Dystocia	319	9.7
Retained placenta	123	3.8
Hyperketonemia	563	17.2
Mastitis	93	2.8
Displaced abomasum	100	3.1
Metritis	924	28.2

[1]Of all animals included in this data set, an average of 8.3% of animals calved each month (SD = 0.009; range = 6.9 to 9.6% of herd).

[2]Dystocia = calving ease score >1 on a 1 to 5 scale; retained placenta = presence of retained fetal membranes at ≥24 h postcalving; hyperketonemia = blood BHB ≥1.2 mmol/L within 14 DIM; mastitis, displaced abomasum, and metritis all refer to treated clinical diseases diagnosed within first 30 DIM.