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Case report: Use of a transition cow risk assessment tool and economic assessment tool to determine areas of opportunity in a herd with high incidence of transition cow diseases

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Abstract

A 150-cow Holstein dairy herd was experiencing a higher than desirable incidence of displaced abomasum (8% all lactations), ketosis (60% lactation 1, 75% lactation 2 and greater), and metritis (70% lactation 1, 30% lactation 2 and greater) in transition cows. The producer initially refused to implement recommended management changes that would have potentially improved transition cow health of the herd. The increased incidence of transition cow disease, along with the producer's reluctance to make management changes, led the nutritionist and the veterinarian to partner to utilize The Vital 90™ Days risk assessment tool (dRisk) and economic assessment tool (dEconPro) as a way of identifying and motivating management changes. The results from the dEconPro showed a pre-management (1 year prior = group PRE) to post-management (1 year after = group POST) reduction in total cost per calving of $269 due to decreased incidence of ketosis, metritis, and displaced abomasum. There was significant parity-by-group interaction for milk production, with first-lactation POST cows producing more first-test milk than PRE (68.1 vs 63.5 lb [30.9 vs 28.8 kg], P=0.05). There was a tendency for more peak milk and more total 305ME milk for POST vs PRE (84.6 vs 81.0 lb [38.4 vs 36.7 kg], P=0.13 and 25,995 vs 24,953 lb [11,791 vs 11,319 kg], P=0.10 respectively). There was no difference in multiparous cows, and no difference in removals by 60 or 400 DIM for all cows. For reproductive performance, there was a tendency for higher odds of successful first service for POST vs PRE (1.83, P=0.14), but no difference in time to pregnancy through 200 DIM. The results show that The Vital 90 Days dEconPro and dRisk proved to be extremely valuable tools to help motivate positive change on this dairy. The main objective of this case study was to demonstrate how the team approach on a dairy farm could combine with the use of transition cow risk-assessment tools to validate management recommendations and quantify the impact of management changes.

Key words: dairy, risk assessment, The Vital 90 Days

Résumé

Les vaches en période de transition dans un troupeau laitier de 150 vaches Holstein montraient une incidence plus élevée que souhaitable de déplacement de la caillette (8% de toutes les lactations), d'acétonémie (60% pour la première lactation et 75% pour la seconde lactation et les autres) et de métrite (70% pour la première lactation et 30% pour la seconde lactation et les autres). Le producteur avait initialement refusé de mettre en place les changements de régie recommandés qui auraient potentiellement améliorés la santé des vaches en transition dans le troupeau. L'incidence accrue de maladie chez les vaches en transition et la réticence du producteur à instaurer des changements de régie ont mené le nutritionniste et le vétérinaire (l'auteur) à unir leurs efforts et à utiliser un outil d'évaluation du risque (*dRisk*) et un outil d'évaluation économique (*dEconPro*) de *Vital 90™ Days* afin d'identifier et de motiver les changements de régie. Les résultats de l'application de l'outil *dEconPro* ont montré une réduction du coût total par vêlage de 269$ de la période de pré-régie (1 an auparavant = groupe PRE) à la période de post-régie (1 an après, groupe POST) en raison de la réduction de l'incidence d'acétonémie, de métrite et de déplacement de la caillette. Il y avait une interaction significative entre la parité et le groupe pour la production laitière en ce sens que les vaches POST en première lactation produisaient plus de lait que les vaches PRE au premier contrôle laitier (68.1 v. 63.5 lb [30.9 v. 28.8 kg], P=0.05). Par rapport aux vaches PRE, la production laitière chez les vaches POST était marginalement plus élevée pour le pic de production (84.6 v. 81.0 lb [38.4 v. 36.7 kg], P=0.13) et pour la projection de production sur 305 jours (25 995 v. 24 953 lb [11 791 v. 11 319 kg], P=0.10). Il n'y avait pas de différence chez les vaches multipares et pas de différence pour le retrait aux jours en lait 60 ou 400 pour toutes les vaches. Au niveau de la performance de reproduction, les chances de succès au premier service étaient marginalement plus élevées chez les vaches POST que chez les vaches PR (1.83, P=0.14) mais il n'y avait pas de différence pour l'intervalle de temps jusqu'à la gestation sur la période de 200 jours en lait. Les résultats montrent que les outils *dEconPro* et *dRisk* de *Vital 90 Days* ont été particulièrement utiles à l'instauration de changements positifs dans cette ferme laitière. L'objectif principal de cette étude de cas était de démontrer comment une approche d'équipe dans une ferme laitière jumelée à l'utilisation d'outils d'évaluation de risque pour les vaches en transition pouvait valider des recommandations de régie et quantifier l'impact des changements de régie.

Introduction

The transition period of a dairy cow has traditionally referenced 21 days pre-calving to 21 days post-calving.[26] This period is when a dairy cow transitions from a pregnant non-lactating state to a non-pregnant lactating state. This period requires a partitioning of energy to fetal growth, colostrogenesis, calving, milk synthesis, and uterine involution. Nutrient requirements sharply rise during this transition, while the energy intake of the cow is depressed. This results in mobilization of body tissues to fulfill increased energy requirements.[7] The transition period is a time when many metabolic disorders and other diseases occur at economically significant levels on dairy farms, and the occurrence of these diseases is often interrelated.[26]

Dry matter intake (DMI) during the transition period is a key factor in how a dairy cow adapts to the beginning of lactation and the continuation of a successful lactation. There exists a normal reduction in DMI around the time of calving, and a key management objective is to minimize the magnitude of this periparturient drop. The decreased level of feed intake leads to negative balance of both energy and protein, and cows will mobilize body tissue to try and close the gap. Negative protein balance can have negative impacts on lactation performance, reproduction, and immune function.[3,16] Since the majority of catabolized tissue is fat, and fatty acids are cleaved from their glycerol backbone during lipolysis, mobilization of body tissues increases levels of non-esterified fatty acid (NEFA). Once in circulation and then taken up by the liver, the preferred outcome for fatty acids is complete β-oxidation via the tricarboxylic acid (TCA) cycle. However, complete β-oxidation is dependent on adequate amounts of oxaloacetate being available. When there is insufficient oxaloacetate to match up with the acetyl CoA units from the fatty acids, i.e., there is inadequate pyruvate/propionate available or lipolysis is occurring at an excessive rate, fatty acids cannot be completely oxidized. Incomplete β-oxidation yields ketone bodies such as beta-hydroxybutyrate (BHBA).[29] Increased BHBA (hyperketonemia) exacerbates immune suppression[11] and indicates a poor adaptive response to the beginning of lactation.[11,21,23,29] Hyperketonemia is also associated with an increased risk of transition cow diseases such as retained placenta, metritis, and displaced abomasum, and a potential for reduction in future milk yield and reproductive efficiency.[9,15,21,22,29,30]

Further reductions in DMI can exacerbate the impact of many of the transition cow diseases.[6] Factors such as ration design and energy content,[19] grouping strategies[12] for dry cows[5] and post-fresh cows,[27] stocking density,[14,27] and cow comfort[33] are critical to the health and well-being of transition cows. Cows experience a negative energy and protein balance during the periparturient period, but when disruptions occur in any of these factors further reductions in DMI may occur, further exacerbating the nutrient imbalance. When DMI is reduced beyond the normal level in transition cows, negative energy and protein balance becomes more severe and the cow experiences an increased mobilization of body tissues from peripheral sources.[8] Many factors are related to the decline in DMI as cows approach calving, and the level of the decline may range from less than 10%[6] to 20 to 30% or more.[13]

Reductions in DMI and stresses such as inadequate cow comfort, heat stress, improperly formulated or inadequate diets, poor feed bunk management, and poor grouping strategies can contribute to the subacute inflammation[32] and immune suppression that the cow is normally subject to around calving.[4] Complex interactions exist between energy and protein balance, inflammatory mediators, and periparturient diseases in dairy cows.[8,25] These interactions can cause increased risk of inflammatory diseases such as metritis,[32] retained placenta, pneumonia, and mastitis. These diseases lead to increased treatment costs, increased culling and death loss, reduced milk yield, and reduced fertility[10] as well as frustration for animal caretakers on the dairy. Furthermore, negative energy balance predisposes cows to ketosis and displaced abomasum. Both immune suppression and negative nutrient balance are complicated by hypocalcemia at calving. Hypocalcemia at calving can, in turn, increase the risk of development of other transition cow diseases such as mastitis and metritis.[10]

Hypocalcemia is a disease of periparturient cows that occurs when they shift from a non-lactating to a lactating state. There is a sudden demand for calcium just prior to parturition (colostrogenesis), and with the onset of lactation, and it severely challenges the animal's calcium homeostasis.[10] Hypocalcemia results from an impaired or slowed response to parathyroid hormone, partially mediated by metabolic alkalosis in the cow resulting from the feeding of diets high in potassium (a diet with too positive a dietary cation-anion difference).[31] Metabolic alkalosis results in an altered conformation of parathyroid hormone receptors, thus lowering the cow's ability to respond normally to parathyroid hormone. Bone and kidney are then not able to adequately respond to the calcium drain that occurs at calving. Hypocalcemia has a profound effect on transition cow diseases by reducing feed intake at calving, causing greater mobilization of fat and increased risk of hyperketonemia. It also reduces closure of the teat sphincter muscle, increasing risk of mastitis.[13] Hypocalcemia also directly reduces the cow's ability to mount an immune response.[18,20]

Accurately defining and recording diseases is critical in assessing disease incidences and their economic consequences. Transition cow diseases may be defined as follows:[17,26]

Metritis – metritis is recognized when abnormal (fetid and watery) uterine discharge occurs within 21 days of calving. Common metritis is when the cow does not have a fever and has no other systemic signs other than the evidence of uterine changes. Toxic metritis (or acute puerperal metritis) is metritis with systemic involvement, and clinical signs may include fever, reduced appetite, and obtundation.

Ketosis – ketosis is described as elevated ketone levels in the blood or urine (hyperketonemia). Hyperketonemia is commonly defined as elevated blood ketones (>1200 mmol/L betahydroxybutyrate) and can be divided into clinical ketosis, a subset of hyperketonemia where clinical signs of reduced appetite, decreased milk production, and obtundation are present, and subclinical ketosis, where no clinical signs are present.

Left displaced abomasum – left displaced abomasum is recognized when a resonant ping is heard while ausculting with a stethoscope and tapping the left side of the cow between the 9th and 12th ribs.

Retained placenta – retained placenta is recognized when the fetal membranes have not been expelled from the cow's uterus in 24 hours or more after calving. In older cows (second lactation and greater), the highest subsequent lactation and reproductive performance has been associated with fetal membranes being expelled by 6 hours.[34] Physiologically, 6 hours may be a more appropriate definition of retained placenta. For purposes of this assessment, 24 hours remains the cut-point for definition of retained placenta on-farm.

Milk fever – clinical milk fever is recognized when a cow is unable to rise due to low blood calcium levels, typically within 3 days of calving. Signs include muscle weakness, cold ears, and obtundation.

Clinical mastitis – clinical mastitis is described as abnormal milk from the udder. Mastitis is further characterized as mild (abnormal milk only), moderate (abnormal milk in the presence of redness or swelling of that quarter), or severe (abnormal milk, swollen udder, obtundation, and poor appetite).

Ovarian dysfunction – ovarian dysfunction is recognized when a cow is examined and determined to have abnormal patterns of estrus expression caused by ovarian problems, and includes a prolonged post-partum anovulatory condition and cystic ovarian disease.

Lameness – lameness is recognized when a cow is walking or standing in an abnormal way attributable to problems anywhere in the foot, leg, or the hip.

Pneumonia – pneumonia is recognized when a cow has changes in breathing patterns and auscultated respiratory sounds due to a respiratory infection. A fever is typically present, but not always.

While the sample size in this case study was small, the main objective was to demonstrate to other practitioners how to effect change at the farm level by utilizing a transition cow risk-assessment and economic-assessment tool to motivate and quantify change. While this case study inherently contains no controls, the use of historical controls demonstrates that the changes that occurred were significant. In addition, there were no other significant changes to treatment or preventative protocols that might have positively impacted transition cow health in addition to the management changes implemented by the producer.

Materials and Methods

The herd being analyzed is a 150-cow herd of registered Holsteins. Average production level for this herd was 65 to 70 lb (30 to 32 kg) of milk/lactating cow/day, with a bulk milk somatic cell count of 200,000 cells/mL of milk. In regards to transition cows, dry cows were fed a total mixed ration and housed in a single-row free-stall facility with sawdust bedding on mattresses with 24-inch (61 cm) headlocks at the feed bunk and access to pasture with limited nutrients. The barn was naturally ventilated with panel fans over the feedbunk and sprinklers. Dry cows were also housed with heifers that came to the pen at the time of breeding and stayed until calving. There was no dedicated pre-fresh group. After calving, cows and heifers were grouped together in 1 group and fed a total mixed ration via headlocks.

The Vital 90™ Days dRisk[a] tool allowed the producer, veterinarian, and nutritionist to review any underlying factors possibly contributing to the high incidence of clinical ketosis, metritis, and displaced abomasum. Due to the interrelationships of transition cow diseases, there are likely common management factors that will have an effect on most diseases. The dRisk is an iPad[b] application that uses a series of questions and responses to those questions to evaluate the current transition cow housing, management, and nutrition, and generates prioritized recommended management changes. Some of the major factors identified by the dRisk tool are overcrowding; nutritional management opportunities including energy, protein, and water needs; cow handling opportunities such as movement timing in or out of pens and walking distance; and housing challenges such as heat-abatement issues, bedding quantity and quality, and flooring problems affecting dry, maternity, and postparturient cows.

At the end of the assessment, the dRisk tool lists the top opportunities on the dairy, and the consultant can choose 1 to 3 items for presentation to the producer as recommendations for the greatest areas of opportunity for the herd to reduce transition cow diseases.

The producer, veterinarian, and nutritionist then complete The Vital 90 Days dEconPro to estimate the cost per calving. The Vital 90 Days dEconPro is a web-based data input system that quantifies the total estimated economic cost of the full transition period for an individual dairy using on-farm inputs and predicted economic impact of diseases on milk production, reproduction, and culling based upon published research work. Disease costs were divided into direct (drugs, veterinary labor, on-farm labor, lost milk during treatment, and mortality) and indirect (premature culling, reproductive inefficiency, reduced subsequent milk yield) disease costs.[2,24] The herd's recorded disease incidence in the first 30 days-in-milk (DIM) was used to estimate the predicted economic impacts via modeling using published relationships between common periparturient diseases and their anticipated impacts on milk production, reproductive performance, and culling. The economic costs are displayed in a PowerPoint slide set that may be presented to the producer.

The dEconPro places a monetary cost on the preventive measures currently being utilized to mitigate disease risk and on the predicted consequence cost of transition cow diseases that are specific to the herd under evaluation. The data entered is based on current market conditions and product/service costs, including current milk price, cull-cow price, waste milk utilization, labor costs, percent of all calvings that are first-lactation, and value of first-lactation cows. Preventive protocols and the percentage of animals who receive each product are entered into the tool to determine cost. These are stratified by lactation number (L1 and L2+) as well as by lactation status (far dry, close-up dry, and fresh). Some preventive products include vaccinations, feed additives, foot trimming, intramammary antibiotics, and teat sealants. Disease incidence (shown in Tables 1 and 2) and treatments are then entered into the tool. The disease events that are recorded are mastitis (mild, moderate, and severe); hyperketonemia and clinical ketosis; retained placenta; milk fever; metritis (common and toxic); displaced abomasum (left or right); diarrhea or digestive disturbance; dystocia (moderate or major); and pneumonia in The Vital 90 Days. Specific data are collected on drug cost, labor cost, and percentage of each treatment's use.

The analysis of the economic impact of transition cow disease was generated using the dEconPro, and this impact is reported in many different ways. "The Vital 90 Days Cost per Calving" is the average estimated cost per cow for the dry period and 30 days post-calving period. Within the total cost are the "investment costs per calving," which include disease prevention measures, and the "consequence costs per calving." The consequence cost per calving is stratified into direct and indirect disease costs. The direct and indirect disease costs are further broken down within each disease category. The disease data was gathered for 1 year before management changes (November 2013 through November 2014) and 1 year after management changes were fully implemented (March 2015 through March 2016). To account for seasonal variation in disease rates, a full calendar year was utilized for the dEconPro analysis before and after management changes. The nutritionist and the veterinarian (GEM) partnered to utilize The Vital 90 Days risk assessment tool (dRisk) and economic assessment tool (dEconPro) as a way of identifying and motivating management changes.

After implementation of transition cow management changes, transition cow disease incidence continued to be recorded. In addition, at the herd health visit, which occurred every 14 days, cows that were 3 to 16 DIM had blood ketone levels analyzed using the Nova Vet Ketone Meter.[1c] Blood was drawn from 62 cows and heifers during the year after management changes were implemented. The cut point for hyperketonemia was 1.2mmol/L.[23]

The diet was analyzed by the authors and the nutritionist. The dRisk tool specifically asks about metabolizable protein levels in different transition cow groups. The metabolizable protein levels were not directly reported in the ration; however, they were estimated using the following formula: DMI x CP% x 0.65 = pounds MP x 454 gm/lb = grams MP. The multiplier of 0.65 is used when adequate levels of rumen degradable protein and starch are fed in the ration, as was the case in these diets.[d]

In an effort to evaluate the measurable impact of the management changes independent of the dEconPro tool, milk production, culling, and reproduction parameters were analyzed in a commercial statistical program[e] using historical controls. While historical controls are not ideal, it was the only option available since the adopted management changes were made across the entire transition period and affected all animals. The management changes began in November 2014 and were completed in early 2015; consequently, the cows were divided into 2 groups based on calving dates. Due to the small herd size, a desire to include the same calendar months in each group, and the extended follow-up time available at the time of this analysis, a decision was made to include data from cows and heifers with calving dates of March 01, 2013 through October 31, 2014 in the pre-management change group (group = PRE) and calving dates of March 01, 2015 through October 31, 2016 for the post-management change period (group = POST).

Multivariable models were built to examine the relationship between time period groups (PRE vs POST) and various production, culling, and reproductive outcomes. Normally distributed continuous variables including first-test milk (Milk1), peak milk, projected 305d mature equivalent milk (305ME), and first-test linear somatic cell count (1st LSCC) were analyzed with ANOVA linear regression and least squares means were reported. Ordinal logistic regression was used to analyze removals by 60 DIM (not culled vs sold vs died). Cox proportional hazards models were used to analyze time-to-event outcomes including reproductive performance (through 200 DIM) and culling (through 400 DIM). First-service conception risk was evaluated using nominal logistic regression, and odds ratios were reported.

Variables suspected of having biologically significant relationships on the outcomes of interest were offered to the multivariable models. Parity was categorized into a 3-level variable (first, second, and third or greater). Potential explanatory variables offered to the models differed depending on the outcome under consideration and the parity group(s) being evaluated. In general, models were built including the following variables: month of calving, parity (1, 2, or 3+), and group (PRE or POST). A parity * group interaction term was offered to all models if more than 1 parity was evaluated but removed if $P>0.20$. For the evaluation of first-test milk production in lactation = 1, month of calving, first-test DIM (and its squared term), and group were used as explanatory variables. For Milk1 in lactation > 1, previous lactation 305ME and lactation group (2 or 3+) were used in addition to the variables in the lactation = 1 model. For peak milk and 305ME, the same parity-specific models used in first-test milk were used, except first-test DIM and its squared term were not used. Explanatory variables for first-test linear somatic cell count included first-test DIM, parity, month of calving, and group. Culling models were offered parity, month of calving, and group; the same variable plus 305d projected mature equivalent milk (305ME) were used in the time-to-pregnancy models. For first-service conception risk, DIM at first service (and its squared term) were offered in addition to the other variables in the time-to-pregnancy model.

Results

The nutritionist and the veterinarian (author, GEM) had suggested management changes identified by the dRisk tool with the producer, but these changes were not implemented. In November 2014, the producer, nutritionist, and the author (GEM) completed the dRisk tool. This tool assesses the factors that could be contributing to transition cow diseases. Broadly speaking, these factors are categorized into "environment, nutrition, and management." For example, metabolizable protein content of rations, energy content of the diets, stocking density of feeding space, body condition scores, cow comfort parameters and bedding management, and cow movement strategies of both dry cows and fresh cows less than 30 days post-calving are just a few of the many factors covered by the dRisk tool.

After completion of the dRisk assessment, the herd was also given a color-based score (red = high risk, yellow = moderate risk, green = low risk) for their transition cow management in general, as well as risk within the areas of environment, nutrition, and management for their transition cow groups (far-off dry, close-up dry, and fresh). In general, the herd scored at the moderate (yellow) risk level. They scored high (red) risk for all aspects of dry-cow parameters and moderate (yellow) risk for all aspects of fresh-cow parameters.

The 3 areas of greatest opportunity to reduce transition cow disease were:

- maternity and fresh cows – reduce stocking density;
- maternity and fresh cows – group heifers and cows separately;
- dry cows – reduce stocking density and house heifers separately.

Another item that was identified by the veterinarian, nutritionist, and the dRisk tool was to create a pre-fresh group for cows and heifers.

The producer did not implement every recommendation due to facility and financial constraints. He did institute a separate post-fresh group as suggested. This group was housed in a 2-row free-stall barn with outside covered access to a feed bunk. He also removed 40 pregnant heifers from the dry-cow pen. These heifers were to be raised by a custom heifer grower from pregnancy confirmation at 60 days post-breeding until around the time of calving. At the time of the initial evaluation, stocking density was 162% in the dry-cow pen and 139% for post-fresh cows based on headlock space (24 inch [61 cm] headlock). After changes were made, stocking density was typically around 100% for dry cows and 80 to 90% for post-fresh cows, based on headlock space. These changes came closer to satisfying the industry standard recommendation of 30 inches (76 cm) of bunk space for transition cows.

For the period of November 15, 2013 to November 15, 2014, The Vital 90 Days Cost of Calving was $433 per calving. The investment cost was $59 per calving, while the consequence cost per calving was $374. A breakdown of the PRE disease costs and disease incidence levels are depicted in Table 1. This data is standardized for milk priced at $20/hundredweight. The number of calvings depicted in this data was 160.

The producer completed implementation of changes 2 months after the initial evaluation. From March 15, 2015 to March 15, 2016, The Vital 90 Days Cost of Calving was $164

Table 1. Initial cost per calving for all lactations (L) for major transition cow diseases.

Disease	Incidence L1	Incidence L2+	Total cost per calving	Direct cost per calving	Indirect cost per calving	Cost per case L1	Cost per case L2+
Clinical ketosis	60%	75%	$77	$33	$44	$111	$125
Mastitis	10%	10%	$36	$11	$25	$309	$354
Metritis	70%	30%	$198	$82	$116	$359	$401
Displaced abomasum	8%	8%	$30	$20	$10	$558	$562

per calving. The investment cost was $64 per calving, while the consequence cost per calving was $100. This number was standardized for milk priced at $20/hundredweight. The improvement in consequence cost per calving is a result of predicted reductions in treatment costs, reduced death and culling, and a predicted improvement in reproductive efficiency and milk production due to the reduction in disease incidence as reported in the farm records. A breakdown of the POST disease costs and disease incidence levels are shown in Table 2. The number of calvings depicted in this data was 165.

Management changes implemented created a reduction of $264 per calving due to decreased transition cow disease incidence.

Using a cut point of 1.2mmol/L, 10 of 62 cows of all lactations had hyperketonemia at the time of the bi-weekly blood draw, representing a prevalence of 16.1%. Blood was collected during the year after management changes were implemented as a method to monitor for hyperketonemia.

The nutritionist and veterinarian (GEM) analyzed the ration. The dRisk tool had identified an opportunity to increase metabolizable protein in the close-up ration; however, there were no significant differences in the pre- and post-management rations regarding energy density, metabolizable protein, macromineral levels or micromineral levels. Consequently, it is highly unlikely that any reduction in transition cow disease incidence was the result of nutritional changes.

In total, 231 and 253 cows were included in the PRE and POST groups, respectively. Table 3 contains the results of the milk production models, stratified into lactation =1 and lactation > 1 models due to the inclusion of previous lactation 305ME as an explanatory variable in the multiparous model. A similar variable was not available for the primiparous cows. Though there was no difference found in the multiparous cows, there was significantly more Milk1 (68.1 vs 63.5 lb [30.9 vs 28.8 kg]) in the primiparous POST cows and a tendency to see higher peak and 305ME milk as well.

In the remaining models, there were no parity X group interactions retained and the final results are shown in Table 4. First-test linear somatic cell count was evaluated using ANOVA and the predicted least squares estimates were not

Table 2. New cost per calving for all lactations (L) for major transition cow diseases

Disease	Incidence L1	Incidence L2+	Total cost per calving	Direct cost per calving	Indirect cost per calving	Cost per case L1	Cost per case L2+
Clinical ketosis	25%	13%	$16	$5	$11	$95	$121
Mastitis	1%	7%	$18	$4	$14	$303	$333
Metritis	4%	6%	$22	$9	$13	$318	$358
Displaced abomasum	3%	3%	$12	$8	$4	$611	$621

Table 3. Milk production predicted least squares means and *P*-values by parity group.

Lactation = 1	Milk1	Peak	305ME
Pre (lb)	63.5	81.0	24,953.2
Post (lb)	68.1	84.6	25,995.4
P-value	0.05	0.13	0.10
Lactation >1	Milk1	Peak	305ME
Pre (lb)	84.8	98.7	24,170.93
Post (lb)	83.9	99.3	24,258.38
P-value	0.64	0.74	0.84

Table 4. Final results for all other outcomes, not including milk production, with all parities combined.

	Pre	Post	*P*-value
Removals by 60 DIM			
(Ordinal logistic regression, incidence reported)			0.62
Not culled	94.4%	92.5%	
Sold	2.6%	6.3%	
Died	3.0%	1.2%	
First-test linear somatic cell count	2.4	2.6	0.55
Culling by 400 DIM			
(odds of culled [sold or died] vs not culled)	Referent	1.13	0.42
First-service conception risk			
(odds of pregnant vs open)	Referent	1.84	0.14
Pregnancy by 200 DIM	Referent	1.03	0.83

different. Culling through 60 DIM was evaluated by ordinal logistic regression (not culled, sold, or died), and the actual incidence for each category by group is reported in Table 4. There were no differences by group. Culling was also evaluated through 400 DIM by a Cox Proportional Hazards model and the resulting risk ratios are presented in Table 4. This approach was taken vs a more simple logistic model to account for time throughout lactation. There was no difference found by group. First-service conception risk was assessed by nominal logistic regression, and there was a tendency for improved reproductive performance found in the POST group (1.84 times higher odds of successful first service, P=0.14). However, looking at a longer time at risk for reproductive management using a Cox Proportional Hazards model through 200 DIM showed no difference by group.

Discussion

The Vital 90 Days tools dEconPro and dRisk proved to be extremely valuable to motivate positive change on this dairy. The tools provided a structured approach to investigating management issues, and provided an economic value that served as an incentive or motivator of change. The tools also fostered a team approach (producer, veterinarian, nutritionist) in evaluating issues on the dairy. The economic data allowed the producer to make informed decisions affecting the future regarding financial benefit of changes in the fresh-cow disease reduction. For example, the producer recognized the tremendous economic impact the post-fresh group provided on this dairy, so he invested in a more permanent post-fresh housing situation. The post-fresh facility was an existing free-stall facility, and the producer used outdoor feed bunks with vinyl covers to protect feed and cows from weather. The actual financial outlay to retrofit the facility was minimal.

Prior to the launch of the dEconPro and dRisk tools, it was the author's (GEM) experience that producers were hesitant to make major management changes despite high incidence of transition cow diseases. Nutritional consultants were also more likely to simply make changes to the diet because of the producer's unwillingness to address underlying facility or management bottlenecks. These tools have allowed the veterinarian, nutritionist, and key dairy personnel to gather for a discussion on how to reduce the incidence of transition cow diseases. The producer was more inclined to implement the recommended changes due to the fact that the dRisk tool stated where the management problems lie. The dEconPro tool also made the producer see the economic impact of transition cow diseases on his dairy and the financial advantage that occurred over time as a result of his management and facility changes. The tool created an economic incentive to implement management changes and facilitated quantification of results after a specified amount of time. The Vital 90 Days tools expand the traditional transition period to encompass the full 60-day dry period and the first 30 days after calving to more fully evaluate the actual time frame when physiological and nutritional changes occur to determine if a successful lactation was achieved.[f]

The blood ketone herd-level monitoring served as a more accurate and real-time indicator of transition cow management changes on the dairy. This testing was selected due to the high incidence of clinical ketosis on this dairy. The diagnostic testing approach used in this report may have led to some deficiencies. For example, to determine the degree of hyperketonemia, blood was drawn and analyzed using the Nova Vet Ketone Meter approximately every 2 to 4 weeks at the veterinary herd health visit. This frequency of sampling, combined with a limited sample size, potentially led to an underestimation of hyperketonemia in this herd since some cows may have had an episode of hyperketonemia that resolved with or without treatment in between the blood sampling interval. The hyperketonemia percentage reported is representative of the prevalence, which is the number of existing cases and new cases during a particular point in time. The incidence of hyperketonemia may have been more useful information. Incidence is defined as the number of cows that develop a new case of hyperketonemia during a specified period of time divided by all of the at-risk animals during the same time period. Data suggests that the incidence of hyperketonemia is approximately double the prevalence.[28] In addition, there is no blood ketone data prior to the initial evaluation to use as comparison. Taking these diagnostic shortfalls into consideration, the farm consultants hypothesized that the 16.1% prevalence or 32% incidence of hyperketonemia was likely an improvement over the previous scenario prior to the management changes.

Key herd performance indicators were analyzed based on calving date rather than test date in order to gain a true indication of the effect of transition cow management changes on the cows within the pre- and post-management change groups. Significant interactions occurred between groups on first-test-day milk in lactation 1 (increased), peak milk in lactation 1 (increased), and mature equivalent 305-day milk production in lactation 1 (increased). It would be expected to see lactation 1 animals respond most positively to the transition cow management changes. First-service conception risk was higher across all lactations in the POST group. This improvement is likely explained by a reduction in transition cow disease and a more positive energy status in early lactation, leading to improved reproductive efficiency in early lactation. Despite the use of a higher P-value cut-point (0.2 due to the relatively small sample size) for evaluating potential interactions of group by parity, milk was the only variable where outcome by group differed by parity.

This herd's major transition cow disease challenges appeared to be metritis, ketosis, and displaced abomasum. After the Vital 90 recommended changes were implemented, disease incidence monitoring and hyperketonemia testing revealed that the economic impact of these changes was extremely positive. While there may be other factors involved in transition cow disease on this dairy, The Vital 90 Days dRisk effectively identified the major factors, and The Vital 90 Days dEconPro provided the economic incentive to make changes.

The main objective of motivating and quantifying change at the farm level appears to have been accomplished. This is particularly true in the face of very little change in treatment or preventative protocols that would have improved transition cow health and other outcomes apart from the management changes. In fact, after the transition cow assessments, the producer likely had increased diligence in diagnosis and treatment of transition cow disease, which may have actually contributed to higher *apparent* disease incidence levels in the POST group. While the sample size may have been relatively small and there was not a control group in the case study, the use of historical controls and utilization of odds ratio of PRE vs POST demonstrate that management changes actually impacted several of the outcomes.

Conclusions

The Vital 90 Days dRisk helped provide consultants to this dairy a method of discussing and validating their recommended transition cow management changes, as well as the financial impact of changes. The incidence of transition cow disease was greatly reduced in the 12 months following implementation of a post-fresh cow group and reduction in stocking density of the dry cow group.

The Vital 90 Days dEconPro allowed the producer to see the predicted or estimated cost of the high incidence of transition cow diseases on his dairy. It also allowed him to see the positive economic effect in the 12 months following those changes. This economic data allowed more informed decisions for future management changes, and the team's plan is to complete the economic assessment tool annually to track changes in consequence per calving, as well as disease incidence levels.

Endnotes

[a] The Vital 90™ Days, Elanco Animal Health, Greenfield, IN
[b] iPad, Apple Inc., Cupertino, CA
[c] Nova Vet Ketone Meter, Nova Biomedical, Watham, MA
[d] Bill Weiss, personal communication, March 19, 2015
[e] JMP® Pro version 13, SAS Institute Inc., Cary, NC
[f] Overton M. The Vital 90™ Days and why it's important to a successful lactation, in *Proceedings.* Ohio Dairy Health and Management Certificate Program Module 4, 2015;43-55

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References

1. Bach KD, Heuwieser W, McArt JA. Technical note: Comparison of 4 electronic handheld meters for diagnosing hyperketonemia in dairy cows. *J Dairy Sci* 2016;99:9136-9142.
2. Bar D, Tauer LW, Bennett G, González RN, Hertl JA, Schukken YH, Schulte HF, Welcome FL, Gröhn YT. The cost of generic clinical mastitis in dairy cows as estimated by using dynamic programming. *J Dairy Sci* 2008;91:2205-2214.
3. Bell AW, Burhans WS, Overton TR. Protein nutrition in late pregnancy, maternal protein reserves and lactation performance in dairy cows. *Proc Nutr Soc* 2000;59:119-126.
4. Bradford BJ, Yuan K, Farney JK, Mamedova LK, Carpenter AJ. *Invited review*: Inflammation during the transition to lactation: New adventures with an old flame. *J Dairy Sci* 2015;98:6631-6650.
5. Contreras LL, Ryan CM, Overton TR. Effects of dry cow grouping strategy and prepartum body condition score on performance and health of transition dairy cows. *J Dairy Sci* 2004;87:517-523.
6. Dann HM, Morin DE, Bollero GA, Murphy MR, Drackley JK. Prepartum intake, postpartum induction of ketosis, and periparturient disorders affect the metabolic status of dairy cows. *J Dairy Sci* 2005;88:3249-3264.
7. Drackley JK. Biology of dairy cows during the transition period: The final frontier? *J Dairy Sci* 1999;82:2259-2273.
8. Esposito G, Irons PC, Webb EC, Chapwanya A. Interactions between negative energy balance, metabolic diseases, uterine health and immune response in transition dairy cows. *Anim Reprod Sci* 2014;144:60-71.
9. Gilbert RO, Shin ST, Guard CL, Erb HN, Frajblat M. Prevalence of endometritis and its effects on reproductive performance of dairy cows. *Therio* 2005;64:1879-1888.
10. Goff JP. The monitoring, prevention, and treatment of milk fever and subclinical hypocalcemia in dairy cows. *Vet J* 2008;176:50-57.
11. Goff, JP. Transition cow immune function and interaction with metabolic diseases, in *Proceedings.* Tri-State Dairy Nutrition Conference 2008;45-57.
12. Grant RJ, Albright JL. Effect of animal grouping on feeding behavior and intake of dairy cattle. *J Dairy Sci* 2001;84:E156-E163.
13. Hayirli A, Grummer RR. Factors affecting dry matter intake prepartum in relationship to etiology of peripartum metabolic disorders: A review. *Can J Anim Sci* 2004;84:337-347.
14. Huzzey JM, DeVries TJ, Valois P, von Keyserlingk MAG. Stocking density and feed barrier design affect the feeding and social behavior of dairy cattle. *J Dairy Sci* 2006;89:126-133.
15. Huzzey JM, Veira DM, Weary DM, von Keyserlingk MA. Prepartum behavior and dry matter intake identify dairy cows at risk for metritis. *J Dairy Sci* 2007;90:3220-3233.
16. Ji P, Dann HM. Negative protein balance: Implications for fresh and transition cows, in *Proceedings.* Cornell Nutrition Conference 2013.
17. Kelton DF, Lissemore KD, Martin RE. Recommendations for recording and calculating the incidence of selected clinical diseases in dairy cattle. *J Dairy Sci* 1998;81:2502-2509.
18. Kimura K, Reinhardt TA, Goff JP. Parturition and hypocalcemia blunts calcium signals in immune cells of dairy cattle. *J Dairy Sci* 2006;89:2588-2595.
19. Mann S, Yepes FA, Overton TR, Wakshlag JJ, Lock AL, Ryan CM, Nydam D. Dry period plane of energy: Effects of feed intake, energy balance, milk production, and composition in transition dairy cows. *J Dairy Sci* 2015;98:3366-3382.
20. Martinez N, Risco CA, Lima FS, Bisinotto RS, Greco LF, Ribeiro ES, Maunsell F, Galvão K, Santos JE. Evaluation of peripartal calcium status, energetic profile, and neutrophil function in dairy cows at low or high risk of developing uterine disease. *J Dairy Sci* 2012;95:7158-7172.
21. McArt JA, Nydam DV, Oetzel GR, Overton TR, Ospina PA. Elevated nonesterified fatty acids and beta-hydroxybutyrate and their association with transition dairy cow performance. *Vet J* 2013;198:560-570.
22. McArt JA, Nydam DV, Oetzel GR. Dry period and parturient predictors of early lactation hyperketonemia in dairy cattle. *J Dairy Sci* 2013;96:198-209.
23. McArt JA, Nydam DV, Oetzel GR. Epidemiology of subclinical ketosis in early lactation in dairy cattle. *J Dairy Sci* 2012;95:5056-5066.

24. McArt JA, Nydam DV, Overton MW. Hyperketonemia in early lactation dairy cattle: A deterministic estimate of component and total cost per case. *J Dairy Sci* 2015;98:2043-2054.
25. Miltenburg CL, Duffield TF, Bienzle D, Scholtz EL, LeBlanc SJ. The effect of prepartum feeding and lying space on metabolic health and immune function. *J Dairy Sci* 2018;101:5294-5306.
26. Mulligan FJ, Doherty ML. Production disease of the transition cow. *Vet J* 2008;176:3-9.
27. Nordlund K, Cook N, Oetzel G. Commingling dairy cows: Pen moves, stocking density and health, in *Proceedings.* 39th Annu Conf Am Assoc Bov Pract 2006;36-42.
28. Nydam DV, Ospina PA, McArt JA, Overton TR. Monitoring negative energy balance in transition dairy cows for herd results, in *Proceedings.* Tri-State Dairy Nutrition Conference 2013;9-22.
29. Ospina PA, Nydam DV, Stokol T, Overton TR. Associations of elevated nonesterified fatty acids and beta-hydroxybutyrate concentrations with early lactation reproductive performance and milk production in transition dairy cattle in the northeastern United States. *J Dairy Sci* 2010;93:1596-1603.
30. Ospina PA, Nydam DV, Stokol T, Overton TR. Association between the proportion of sampled transition cows with increased nonesterified fatty acids and beta-hydroxybutyrate and disease incidence, pregnancy rate, and milk production at the herd level. *J Dairy Sci* 2010;93:3595-3601.
31. Overton TR, Waldron MR. Nutritional management of transition dairy cows: Strategies to optimize metabolic health. *J Dairy Sci* 2004;87:E105-E119.
32. Ribeiro ES, Gomes G, Greco LF, Cerri RLA, Vieira-Neto A, Monteiro Jr PLJ, Lima FS, Bisinotto RS, Thatcher WW, Santos JEP. Carryover effect of postpartum inflammatory diseases on developmental biology and fertility in lactating dairy cows. *J Dairy Sci* 2016;99:2201-2220.
33. Singh SS, Ward WR, Lautenbach K, Hughes JW, Murray RD. Behaviour of first lactation and adult dairy cows while housed and at pasture and its relationship with sole lesions. *Vet Rec* 1993;133:469-474.
34. van Werven T, Schukken YH, Lloyd J, Brand A, Heeringa HTj, Shea M. The effects of duration of retained placenta on reproduction, milk production, postpartum disease, and culling rate. *Therio* 1992;37:1191-1203.