Fresh-cow handling practices and methods for identification of health disorders on 45 dairy farms in California

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ABSTRACT

The aim of the present study was to describe fresh-cow handling practices and techniques used during fresh cow evaluations to identify postpartum health disorders on 45 dairy farms in California ranging from 450 to 9,500 cows. Fresh cow practices were surveyed regarding (a) grouping and housing, (b) scheduling and work organization, (c) screening for health disorders, and (d) physical examination methods. Information was collected based on cow-side observations and responses from fresh cow evaluators. Cows were housed in the fresh cow pen for 3 to 14 (20%), 15 to 30 (49%), or >31 (31%) d in milk. Fresh cow evaluations were performed daily (78%), 6 times a week (11%), 2 to 5 times a week (9%), or were not routinely performed (2%). There was significant correlation between the duration of fresh cow evaluations and the number of cows housed in the fresh pen. Across all farms, the duration of evaluations ranged from 5 to 240 min, with an average of 16 s spent per cow. During fresh cow checks, evaluators always looked for abnormal vaginal discharge, retained fetal membranes, and down cows. Dairies evaluated appetite based on rumen fill (11%), reduction of feed in the feed bunk (20%), rumination sensors (2%), or a combination of these (29%). Milk yield was evaluated based on udder fill at fresh cow checks (40%), milk flow during milking (11%), milk yield records collected by milk meters (2%), or a combination of udder fill and milk meters (5%). Depressed attitude was evaluated on 64% of the dairies. Health-monitoring exams for early detection of metritis were implemented on 42% of the dairies based on rectal examination (13%), rectal temperature (22%), or both (7%). Dairies implementing health-monitoring exams took longer to perform fresh cow evaluations. Physical examination methods such

as rectal examination, auscultation, rectal temperature evaluation, and cow-side ketosis tests were used on 76, 67, 38, and 9% of dairies, respectively. Across dairies, we found large variation in signs of health disorders screened and how those signs were evaluated. Fresh cows were primarily evaluated based on nonspecific and subjective observations during screening. Future research efforts should focus on developing and validating scoring systems to more objectively identify health disorders in postpartum cows.

Key words: postpartum cow, health disorder screening, survey

INTRODUCTION

Dairy cows endure the most physically challenging period in their life cycle when transitioning from the pregnant and nonlactating state to the nonpregnant and lactating state (Goff and Horst, 1997). Most infectious diseases and metabolic disorders, such as milk fever, ketosis, retained fetal membranes (**RFM**), metritis, and displaced abomasum (**DA**), occur during this time, with important economic and animal well-being implications (Kelton et al., 1998; Overton and Fetrow, 2008; Chapinal et al., 2011). Cows undergoing a poor transition may be removed earlier from the herd because of culling or death. Based on DHIA records from 2,574 Pennsylvania herds, approximately 25% of the culled cows were reported to leave the herd during the first 60 DIM, representing 6.8% of the cows in the herd (Dechow and Goodling, 2008). Early identification and treatment of sick fresh cows might prevent disease progression and ensure animal welfare.

After calving, most dairies house fresh cows in pens where they are screened daily by visual inspection or by scheduled fresh cow health-monitoring exams for early detection of metritis (Guterbock, 2004). On large dairy operations, owners, managers, and veterinarians rely on dairy employees to identify sick cows, with variable formal training and supervision. On dairies operating

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under a valid veterinary-client-patient relationship, the veterinarian should provide written protocols for diagnosis and treatment of commonly occurring, easily recognizable conditions of fresh cows (AABP Guidelines, 2013); however, this seems to be not fully implemented. For example, only 23% of bovine practitioners in Ohio consistently provided treatment protocols for antibiotic use to their dairy clientele (Cattaneo et al., 2009). Even when herd health protocols are provided, complete implementation is not guaranteed. A survey of 52 calf operations reported a large communication disconnect regarding calf health goals between upper management and dairy employees (Sischo et al., 2014). Although, 60% of the interviewees, including dairy employees, managers, owners, and veterinarians, reported knowledge of the existence of calf health written protocols, the within-farm agreement to this response ranged from 50 to 100%.

Some mail survey studies focusing on reproductive performance and antibiotic use on dairies provided information about fresh cow-management practices on US dairies regarding facilities, pen movements, and antibiotic therapy (Zwald et al., 2004; Caraviello et al., 2006; Raymond et al., 2006). However, none of the surveys collected information on what signs of health disorders fresh cow evaluators were looking for or if monitoring programs were used. To the best of our knowledge, Heuwieser et al. (2010) is the only study solely focusing on fresh cow-management practices, including housing, fresh cow examinations, and treatment decisions. The study was conducted in Germany through a mail survey. Most dairy managers reported that they used subjective criteria to identify sick cows such as general appearance (97.0%) and appetite (69.7%). Less than half used more objective measurements such as temperature (33.6%), ketone bodies (2.8%), or BCS (36.4%). However, unlike California herds (average herd size: 1,217 cows; CDFA, 2014), most of the 429 respondents represented herds with fewer than 200 lactating cows. It is likely that in these small herds, individuals responding to the fresh cow-management survey were actually the ones conducting fresh cow evaluations. If the same research approach were to be implemented on large dairies, the results might not reflect the actual practices, as fresh cow evaluations are usually done by workers.

Therefore, to understand how postpartum health disorders are identified and defined on larger dairies, researchers must observe dairy workers while they are performing fresh cow evaluations. The overall objective of the current study was to describe how sick postpartum cows were identified in large dairy herds in California by observing fresh cow evaluators perform their work.

MATERIALS AND METHODS

The University of California, Davis Institutional Review Board exemption was acquired before researchers performed the field visits to the study herds. Participant dairies ($n = 45$) were visited from February to August 2015. California county extension advisors, dairy veterinarians, and dairy consultants assisted with dairy recruitment. Enrolled dairies were chosen for their willingness to collaborate with university research. All dairies enrolled in the study were located in the San Joaquin Valley of California.

Prior to the field visit, dairy owners and farm personnel were informed about the nature of the study and the expected length of time to complete the survey. Once dairy participation was confirmed, researchers (2 bilingual veterinarians, A. Espadamala and P. Pallarés) scheduled a single visit during the fresh cow check. Fresh cow evaluators were given the option to communicate with researchers in either English ($n = 8$) or Spanish ($n = 37$).

Survey Tool

A survey questionnaire was designed to describe screening techniques for health disorders and examination methods during fresh cow evaluations. Survey questions were grouped into 5 themes: (1) general herd information, (2) grouping and housing, (3) scheduling and work organization, (4) screening for sick fresh cows, and (5) physical examination methods of sick fresh cows. Once the first survey draft was completed, all authors reviewed the survey for content, structure, and design. The survey was initially beta-tested 2 times on 5 dairies. Visits to those 5 dairies served to expand the scope of the survey tool and to train both observers on data collection.

Questions regarding general herd information (herd size and average daily milk yield per cow) were obtained from dairy owners or managers. Description of fresh cow facilities and stocking density was based on a combination of observations and facility measurements performed during the field visit. Cows housed in the fresh cow pen were counted at the end of the evaluation while restrained in headlocks. Some dairies housed fresh cows in the hospital pen for a short period to discard milk with antimicrobial residues. Cows housed in those pens were not included in the final count of fresh cows. The number of stalls and headlocks were counted, and the dimensions of the dry lot were obtained with a distance measuring wheel.

Information on work organization during fresh cow evaluations was based on observations by researchers,

with the exception of frequency of fresh cow evaluations and time relative to milking, which were asked of farm personnel. Information on signs of health disorders screened for and physical examination methods used was collected based on a combination of observations and responses from the individuals evaluating fresh cows. At the beginning of each visit, researchers focused on observing fresh cow evaluators and on taking written notes of each of their actions. As the assessment progressed, they formulated questions following the survey tool. When more than one individual participated in fresh cow checks, one researcher was positioned at the back of the cow and the other at the front of the cow.

Information regarding the schedule of fresh cow health-monitoring exams was based on responses obtained from evaluators. During most field visits, researchers were able to observe diagnostic methods and criteria used to define metritis (38/45) and RFM (25/45) on at least 1 fresh cow. However, when no health disorders were observed at the time of the visit, open-ended questions were the major source of information. At the end of each fresh cow check, both researchers reviewed their notes and completed the survey tool by questioning the main fresh cow evaluator.

To minimize behavioral changes or reactivity during the assessment, fresh cow evaluators were assured that data would be collected for research purposes only. To increase data accuracy, questions related to disease were asked twice at different times during the interview process. Furthermore, when possible, responses were corroborated with observations. If disagreements were noted between field observations and the responses obtained from fresh cow evaluators, only observations were included in the final data set. Each day upon returning from the field visit, A. Espadamala and P. Pallarés met for 2 to 3 h to compare their field notes, write a report, and enter data into spreadsheets for analysis (Excel 2010, Microsoft Corp., Redmond, WA).

Intensity of Health Disorder Screening Techniques

To describe how thoroughly fresh cows were screened, each sign of health disorder was classified as evaluated with low, moderate, or high screening intensity.

Feed Bunk. Reduction and disturbance of feed in the feed bunk (feed bunk evaluation) was classified as low intensity when the fresh cow evaluator glanced at the feed bunk while standing at the rear end of cows restrained on headlocks. Moderate intensity was recorded when the main evaluator checked cows from behind and relied on his assistant to evaluate the feed bunk of those cows suspected to be sick. Likewise, the high intensity classification occurred when the main fresh cow evalua-

tor systematically walked in front of the cows to assess the feed bunk before evaluating cows from the back.

Rumen Activity or Fill. Evaluation of rumen activity or fill was classified as low intensity when the fresh cow evaluator conducted a quick visual inspection of the paralumbar fossa to assess rumen fill; as moderate intensity when the evaluator observed and palpated the paralumbar fossa; and as high intensity when dairies used rumination sensors.

Udder Fill. The udder fill evaluation was classified as low intensity when it was performed ≤ 2 h after milking, and as moderate intensity when it was assessed at ≤ 2 h before milking or between milkings.

Milk Yield. The milk yield evaluation was classified as moderate intensity when milk yield was assessed during milking by observing milk flow, and as high intensity when milk yield was evaluated using milk meters and computerized records.

Depressed Attitude. Evaluation of general appearance and depressed attitude was classified as low intensity when the fresh cow evaluator glanced at the cow's face while standing at her back. When the main evaluator relied on his assistant to evaluate the cow's depressed attitude only for those cows suspected to be sick this was recorded as moderate intensity. High intensity was recorded when the main fresh cow evaluator systematically walked in front of the cows to assess the cow attitude and appearance before evaluating cows from the back.

Rectal Temperature. Fresh cow health-monitoring exams that evaluated rectal temperature on targeted dates were classified as low intensity when evaluated from calving up to 3 DIM, as moderate intensity when evaluated from calving up to 6 DIM, and as high intensity when evaluated from calving to 10 DIM or more.

Rectal Examination. The intensity of monitoring strategies for performing rectal examination on targeted dates was considered as low intensity when performed once or twice within 10 DIM, as moderate intensity when 3 to 5 evaluations were performed within the first 15 DIM, and as high intensity when more than 5 evaluations were performed during the first 15 DIM or until the cow presented a normal discharge. Fresh cow evaluators screened cows for abnormal feces or signs of respiratory disease, such as dyspnea and ocular or nasal discharge. However, the intensity of screening methods for these signs of health status was not classified, as they were not specific problems of fresh cows. The duration of fresh cow checks (time to identify cows with signs of health disorders, time to perform physical examinations, time to administer treatments) was recorded during each visit. The time evaluators spent diagnosing and treating fresh cows at the hospital pen was not included.

Based on the intensity of evaluation, the assessment of health disorders was assigned a score of 0 (not evaluated), 1 (low intensity), 2 (moderate intensity), or 3 (high intensity). Scores were adjusted if signs of health disorders were only evaluated in primiparous cows (1/3 of the score) or multiparous cows (2/3 of the score). Based on the intensity of health disorders evaluations, each dairy was assigned an overall final score calculated as the sum of the scores given to each individual sign of health disorders evaluated. Accordingly, dairies were grouped into 3 equally distributed categories and classified as having poor screening intensity (overall final score: 0–2), moderate screening intensity (3–6), and high screening intensity (>6).

Data Analysis

The association between duration of fresh cow evaluations and both herd size (excluding dairies 45 and 18) and fresh cow pen size (excluding dairies 16, 18, 42, and 45) was evaluated using the PROC CORR procedure of SAS 9.4 (SAS Institute Inc., Cary, NC). The LSMEANS statement from the GLM procedure of SAS was used to study the duration of fresh cow evaluations per cow (s/cow) among different screening intensity groups and among dairies with and without monitoring programs. All models were adjusted by the number of cows in the fresh cow pen. Reported percentages were rounded to the nearest whole percentage point.

RESULTS AND DISCUSSION

Data Screening

Forty-three dairies performed fresh cow checks with cows restrained in headlocks, except for dairies 42 and 16. On dairy 42, screening of fresh cows and treatment administration were performed during milking. On dairy 16, cows were screened while walking to the parlor or at the parlor. Therefore, some screening methods, such as feed bunk evaluations, were not evaluated on those 2 dairies. Dairy 45 was a transition cow herd, housing animals from 3 wk before calving up to 40 DIM. Dairy 18 housed primiparous cows after calving in a different facility where they were kept at least until 40 DIM.

Our study assessed practices during fresh cow evaluations by capturing information through observations and a questionnaire. However, the presence of 2 researchers might have changed the behavior of the observed subjects. During the assessment, fresh cow evaluators might have acted more diligently than usual; therefore, our results might depict management practices that, to some degree, differ from the ones that were routinely implemented. To reduce reactivity, subjects have to

be observed without their knowledge (Kazdin, 1979); however, ethical and logistical issues prevented us from pursuing this approach. Collecting information through a mail questionnaire, a method commonly used in descriptive studies, has similar or greater limitations.

On 10 dairies, fresh cow evaluators reported that written herd health protocols existed, but researchers only had access to those on 4 dairies. On most surveyed dairies, fresh cow evaluators reported following protocols taught by another coworker or the dairy veterinarian. Therefore, except in the 4 dairies, observed management practices could not be compared with written protocols.

General Herd Information

Herds ranged in size from approximately 450 to 9,500 lactating cows. Each dairy was given an identification number according to its herd size, from largest (dairy 1) to smallest (dairy 45). Herd size distribution of enrolled herds was $\leq 1,000$ cows (15%), $>1,000$ to $\leq 2,000$ cows (38%), and $>2,000$ cows (47%). Overall average herd size was 2,581, whereas average herd size in the San Joaquin Valley was 1,217 cows (CDFA, 2014). The fresh cow pen housed from 9 to 700 cows that represented $<8\%$ of the herd (42%), 8 to 15% of the herd (42%), or $>15\%$ of the herd (16%). On most dairies, milkings were scheduled twice (56%) or thrice (29%) a day. However, some herds (11%) milked twice a day except for fresh and high-producing cows that were milked thrice. One dairy milked fresh cows 4 times and the rest of the herd 3 times (dairy 31), whereas another dairy milked the entire herd 3 times and the hospital pen 2 times. Daily milk yield ranged from 31.8 to 44.5 kg across Holstein herds ($n = 39$) and across from 23.6 to 31.8 kg Jersey and crossbred herds ($n = 6$).

Grouping and Housing

After freshening, cows were housed in freestalls (71%) or dry lots (27%; Table 1). However, dairy 37 housed multiparous fresh cows in a freestall pen and primiparous fresh cows in a dry lot pen. This management strategy was expected to reduce postpartum stress of primiparous cows because they had never been housed in freestalls before. Stocking density ranged from 38 to 121% for headlocks and from 53 to 107% for freestalls. Overall, we noted 10 and 3 dairies that had less than 70% stocking density for headlocks and freestalls, respectively. The one dairy with 38% of headlocks stocking density kept cows in the fresh cow pen only until 3 DIM. Four and 3 dairies had greater than 100% occupancy for headlocks and freestalls, respectively. In dry lot fresh pens, cows had 25 to 82 m² available per

Table 1. Herd size, length of time on fresh cow pen, and fresh cow facility type for first-lactation cows (P) and cows in lactation ≥ 2 (M) on 45 dairy farms in California

Dairy identification	Herd size	Cows in the fresh pen (no.)			Duration of fresh cow evaluations (min)	Time in fresh pen ¹		Facility type
		All	P	M		P	M	
1	9,500	700	250	450	20	3	3	Stall
2	8,900	520	260	260	60	5	5	Stall
3	5,580	524	239	285	60	4	4	Stall
4	5,400	222	—	—	30	4	4	Stall
5	5,200	203	101	102	90	2	2	Stall
6	4,600	392	184	208	120	5	5	Stall
7	4,400	420	—	—	80	3	3	Stall
8	4,200	450	210	236	240	4	4	Stall
9	3,600	347	160	187	60	3	3	Stall
10	3,400	250	—	—	5	5	5	Stall
11	3,400	255	110	145	80	3	3	Stall
12	3,350	470	120	350	80	5	5	Stall
13	3,200	213	—	—	50	3	3	Stall
14	2,950	338	195	143	120	4	3	Stall
15	2,850	364	259	105	30	5	1	Stall
16	2,650	150	—	—	NA ³	2	2	Dry lot
17	2,600	140	—	—	45	2	2	Stall
18	2,300	185	—	—	15	NA	4	Stall
19	2,300	111	—	—	60	2	2	Dry lot
20	2,200	153	—	—	50	3	3	Stall
21	2,000	172	93	79	30	4	4	Stall
22	2,000	172	—	—	30	4	4	Stall
23	1,900	182	88	94	60	5	5	Stall
24	1,830	328	142	186	20	5	5	Dry lot
25	1,800	120	—	—	15	4	4	Stall
26	1,800	55	—	—	10	2	2	Dry lot
27	1,700	89	—	—	50	3	3	Dry lot
28	1,700	118	—	—	90	4	4	Stall
29	1,600	240	—	—	150	4	4	Stall
30	1,500	132	65	67	100	4	4	Stall
31	1,500	361	255	104	20	5	4	Stall
32	1,500	114	—	—	10	4	4	Stall
33	1,320	115	—	—	35	2	4	Stall
34	1,300	172	—	—	15	5	5	Stall
35	1,250	180	—	—	20	5	5	Stall
36	1,230	103	—	—	10	5	5	Stall
37	1,100	185	96	89	20	5	5	Stall ²
38	1,050	116	—	—	30	4	4	Dry lot
39	980	200	97	103	40	5	5	Dry lot
40	980	158	83	75	20	5	5	Stall
41	930	15	—	—	10	1	1	Dry lot
42	850	11	—	—	NA	1	1	Dry lot
43	710	218	105	113	15	5	5	Dry lot
44	600	9	—	—	5	1	1	Dry lot
45	450	298	138	160	50	5	5	Dry lot
25th percentile	1,300	120	97	102	20			
50th percentile	1,900	185	138	143	35			
75th percentile	3,350	328	210	208	60			

¹Maximum time cows were housed in the fresh pen: 3 to 7 (1), 8 to 14 (2), 15 to 21 (3), 22 to 30 (4), or >31 DIM (5).

²Primiparous cows were housed in dry lot and multiparous cows in stalls.

³NA = not applicable.

cow. In California, a certain degree of calving seasonality is associated with heat stress and more calvings occur per month from July to October (Silva-del-Río et al., 2012). Therefore, as most of the dairy visits were conducted between February and June, our study likely did not capture the maximum occupancy of the fresh cow pens.

Immediately after calving, most dairy farms (82%) moved multiparous fresh cows to nonsaleable milk pens, either to a hospital (55%) or colostrum (27%) pen with the intent to harvest colostrum from the first 2 milkings (38%) or from 3 to 6 milkings (42%). Some dairies (18%) opted to move all primiparous and multiparous cows directly to the fresh pen. On these dair-

ies, milk from multiparous cows was either discarded up to 5 milkings (5%), or, if dry cow therapy had no milk withdrawal period, just colostrum was harvested (13%). Few dairies (5%) moved only primiparous fresh cows directly into the fresh cow pen. Dairies housing primiparous cows immediately after calving in a colostrum or hospital pen (77%) limited their stay to the first 2 milkings to harvest colostrum.

When fresh cows were housed in the hospital pen to harvest colostrum, they comingled with sick and lame cows (33%), or with sick, lame, and mastitic cows (67%). Dairy 11 used prophylactic treatment for metritis on primiparous cows, forcing heifers to stay longer in the hospital pen. On dairy 8, all fresh cows were housed in the hospital pen alongside mastitic cows until daily rumination time was greater than 300 min/d (HRLD, SCR Engineers Ltd., Netanya, Israel). On dairy 36, cows calved on a different facility and were moved 3 to 10 d after calving to the lactating cow dairy.

Cows were housed in the fresh cow pen for 3 to 7 (9%), 8 to 14 (11%), 15 to 21 (18%), 22 to 30 (31%), or >30 (31%) DIM (Table 1). The fresh cow pen represented 1 to 31% of the cows in the herd (median: 9%). Thirty-eight percent of dairies opted to minimize days in the fresh cow pen to simplify management; however, most dairies (62%) kept fresh cows from 22 to 60 DIM to facilitate the implementation of the presynchronization portion of synchronization of estrus and ovulation protocols. On 4 dairies, time in the fresh cow pen was determined by parity. On dairies 14, 15, and 31, primiparous fresh cows were housed 10 to 30 d longer than multiparous cows to ease their transition to lactating pens; however, on dairy 33, multiparous cows were kept 15 d longer on the fresh cow pen than primiparous cows.

Fifty-one percent of dairies, ranging in size from 600 to 5,400 cows, housed primiparous and multiparous cows in the same fresh cow pen, whereas 49% of dairies, ranging in size from 450 to 9,500 cows, segregated cows by parity. Separating primiparous cows from multiparous cows after calving positively affected production and health of primiparous cows (Østergaard et al., 2010). However, in our study, approximately half of the dairies were still housing them together, perhaps because of limitations associated with facility design and space availability.

Scheduling and Work Organization

On most dairies (80%), fresh cow evaluations were performed daily. However, some dairies limited fresh cow evaluations to 2 ($n = 1$), 3 ($n = 2$), 5 ($n = 1$), or 6 ($n = 5$) times a week. Dairy 16 did not perform structured fresh cow evaluations, and cows with health disorders were identified by dairy employees while

walking cows to the milking parlor for milking or during milking. On this dairy, the owner was in charge of treating sick cows and administered treatments once a day while cows were restrained in headlocks.

The fresh cow evaluator was either a nonsupervisor employee (62%), a supervisor employee (29%), or a dairy owner (7%). On some dairies 1 (29%) or ≥ 2 (11%) additional employees assisted the fresh cow evaluator with treatment administration. Not surprisingly, this occurred mostly on large herds (>2,000 cows) where 2 or more employees performed fresh cow evaluations (Figure 1). Employees assisting during fresh cow checks were in charge of administering prophylactic oral treatments, evaluating signs of health disorder when asked, or keeping records.

Cows were examined and treated while restrained in headlocks, except for 1 dairy that evaluated and treated fresh cows during milking in a flat barn parlor. Although all enrolled dairies evaluated fresh cows from their back, only 49% of dairies also evaluated cows from the front by walking the feed bunk. However, it is recommended to walk in front of the cows to evaluate appetite and attitude (Guterbock, 2004).

Most fresh cow evaluations were done in the morning and started from 0500 to 0700 h (49%), after 0700 to 0900 h (36%), or after 0900 h to noon (7%); however, 7% of the dairies evaluated fresh cows in the afternoon. During fresh cow evaluations, all dairies had abundant feed available in the feed bunk, but no information was obtained regarding the schedule of fresh cow feed delivery or push up. Fresh cow checks were performed 2 h or less before milking (31%), 2 h or less after milking (53%), between milkings (7%), or during milking (2%). Two dairies had different schedules for fresh cow evaluations based on parity; multiparous fresh cows were evaluated at least 2 h after milking and primiparous fresh cows at least 2 h before milking or between milkings. On most dairies, fresh cow evaluations were performed after milking. Most likely the time for fresh cow evaluations was dictated by the convenience of restraining cows in headlocks when eating after milking; however, this practice makes it difficult to collect important information regarding udder fill.

The duration of fresh cow evaluations ranged from 5 to 240 min (median: 35 min). It was associated with fresh cow pen size ($r = 0.354$, $P = 0.019$; Figure 1) and tended to be associated with herd size ($r = 0.259$; $P = 0.093$); however, the association was weak. In our study, fresh cow checks were performed fairly quickly on most dairies, with 1 to 46 s spent per cow (Table 1). Most fresh cow evaluators were very conscientious about a prolonged lock-up time; nevertheless, on 4 dairies the length of fresh cow evaluations forced cows to be restrained for over 1 h. The duration of fresh cow

evaluations might have been influenced by the intensity of screening for health disorders, the exploratory methods used, the implementation of monitoring programs, the administration of prophylactic treatments, or the number of individuals administering treatments.

Screening Fresh Cows for Health Disorders

The screening methods used to evaluate the health status as well as the intensity used to observe signs of health disorders are described in Figure 2.

Down Cows, RFM, and Vaginal Discharge. All dairies screened fresh cows to identify down cows, RFM, and abnormal vaginal discharge (VD). Four dairies only screened for those 3 signs of health disorders. The definition of RFM was the same across dairies: placenta hanging from the vulva 24 h after calving. On most dairies, RFM cases were treated without any further screening; however, on 5 dairies cows were inspected daily and treatment was limited to cows with fetid VD, fever, or systemic signs of disease, such as lack of appetite or drop in milk yield. To find abnormal VD, fresh cow evaluators walked behind the cows and observed the cow tail and perineum as well as the floor. However, definition of abnormal vaginal discharge was subjective and was mostly based on odor and color, with great variation across dairies.

Appetite. Dairies evaluating appetite based their assessment on rumen fill (11%), feed bunk evaluation (20%), rumination sensors (2%), a combination of rumen fill and feed bunk evaluations (24%), or a combination of rumination sensors and feed bunk evaluations (5%). Appetite was not evaluated on 38% of the dairies. Dairies that inspected feed bunks mostly used a low to moderate screening intensity. Although information on feeding and push-up schedules was not collected in the present study, it was observed that on all dairies cows had access to abundant feed while restrained in stalls. Most likely, dairies coordinated the time of fresh cow checks with either feeding or feed push-up to encourage cows to use headlockers. Further studies should evaluate if feeding management practices on dairies are optimal for feed bunk evaluation at fresh cow checks.

Rumen fill evaluations were mostly performed with low screening intensity. An exception was dairy 14, where rumen fill was carefully evaluated and weighted heavily in treatment decisions. Both feed bunk and rumen fill evaluations are very subjective ways to evaluate appetite. Researchers attempted to develop a rumen fill score at a herd level using a 5-point system (Zaaijer and Noordhuizen, 2003; Burfeind et al., 2010); however, neither the repeatability of visual rumen fill evaluations nor its relationship with production or intake has been evaluated in fresh cows.

Figure 1. Association between duration of daily fresh cow evaluations and the number of cows in the fresh pen. Dairies had 1 (circles), 2 (triangles), or 3 or more (squares) dairy employees during fresh cow evaluations ($r = 0.354$, $P = 0.019$) on 45 dairy farms in California.

Dairies	Appetite		Milk yield		Attitude	Temperature Monitoring	Rectal exam Monitoring	Points	Intensity
	Feedbunk	Rumen fill	Udder fill	Milk yield					
1								0	Low evaluation intensity
10								0	
16								0	
31								0	
32								0	
26								1	
36								1	
43								1	
13								1	
25								1	
22*								2	
38*								2	
41								2	
42								2	
35								2	
44								2	
7								3	Moderate evaluation intensity
18								3	
15			**	***				3.6	
4*								4	
29								4	
19								5	
23								5	
24								5	
33							**	5.3	
3								6	
9								6	
14								6	
17								6	
34								6	
37								6	
5								7	High evaluation intensity
21								7	
8								8	
12								8	
30								8	
39								8	
2								9	
28								9	
40								9	
45								9	
20								10	
11								11	
27								12	
6				***				18	

Figure 2. Classification of 45 dairy herds in California according to the intensity [not evaluated (white), low (light gray), moderate (dark gray), and high (black)] fresh cows were screened, based on appetite, decrease in milk yield, attitude, temperature, and rectal evaluation (* fresh cows were evaluated ≤ 3 times a week; ** only applies to primiparous cows; *** only applies to multiparous cows).

Dairies equipped with rumination sensors (7%) were classified as high screening intensity for cows off-feed. One dairy used Cowmanager sensors (Cow Manager B.V., Utrecht, the Netherlands), and 2 dairies were equipped with HRLD rumination collars (SCR Engineers Ltd.). All dairies using rumination sensors reported having adopted this technology less than 1 yr before our visit. Studies have found that rumination sensors are accurate tools to monitor rumination (Schirrmann et al., 2009; Liboreiro et al., 2015). It has been reported that cows with metritis or subclinical ketosis had lower rumination time (Liboreiro et al., 2015). However, due to the relatively minor differences in postpartum daily rumination time between healthy and unhealthy cows, it is not recommended to use rumination time data as the sole diagnostic tool for health disorder detection (Liboreiro et al., 2015). In our study, dairy 9 relied solely on rumination sensors to identify cows off-feed and based treatment decisions on these data.

Milk Yield. Dairies evaluated milk yield based on electronic records from milk meters (2%), milk flow during milking [assessed by milkers (9%) or fresh cow evaluators (2%)], udder fill at fresh cow checks (40%), or a combination of udder fill and milk meters (5%). Milk yield was not evaluated on 42% of dairies. Dairies with computerized daily milk yield records generated a list before starting their fresh cow checks. On 1 dairy, the fresh cow evaluator identified cows with lower milk yield than expected during milking. He wrote the identification of cows suspected to be sick in a pocket notebook that he consulted during fresh cow checks. On 3 dairies, fresh cow evaluators relied on milkers to identify fresh cows with low milk yield. Milkers shared this information as written (paper note, wall-mounted board) or verbal communications.

Udder fill evaluations were performed either after milking (11%; low screening intensity), 2 h before milking (29%; moderate screening intensity), or between milkings (4%; moderate screening intensity). Two dairies evaluated udder fill before milking on multiparous cows, but either after or between milkings on primiparous cows. Guterbock (2004) recommended evaluation of milk yield before milking by palpating the udder right above the base of the teats to assess the pressure in the gland cistern. However, in our study, none of the fresh cow evaluators palpated the udder. It should be noted that when heifers have udder edema it is difficult to assess udder fill even when palpating. Some fresh cow evaluators reported assessing udder fill after milking. Although this approach may be useful to detect clinical mastitis, it does not provide milk production information that may be useful for early detection of other health problems. Moreover, udder fill evaluation is a subjective measurement. An electronic dynamom-

eter has been proposed to objectively evaluate udder firmness (Bertulat et al., 2012) as a proxy for udder fill; the practicality of its implementation on farms is dubious, however. Research efforts need to be devoted to developing and evaluating a scoring system that can be easily implemented by dairy workers.

Daily milk yield data have been shown to aid in early detection of ketosis, left DA, and digestive disorders on fresh cows (Edwards and Tozer, 2004), although a notable lack of adoption of milk meter technology on large California dairies has been noted. One of the challenges associated with using daily milk weights data is to ensure the correct identification of cows at milking. Healthy cows could show a decrease in milk yield as a result of missing data during milking, or sick cows might not be identified if the software estimates yields of missing records (Guterbock, 2004). Two of the 3 dairies using milk meters only used the data to identify drops in production from multiparous fresh cows but not from primiparous cows. Postpartum milk yield generally increases more slowly for primiparous than multiparous cows, and changes in milk yield might not be as obvious on primiparous cows.

Valuable information on milk yield could be collected during milking by observing milk flow; however, on most large dairies, milkers were not involved in sick cow identification. Fresh cow programs would likely gain value if milkers were trained on how to evaluate udder fill and flagged suspicious cows to fresh cow evaluators.

General Appearance and Attitude. The general appearance and attitude of fresh cows and the appearance of eyes and ears were not evaluated (36%) or were visually evaluated with low (24%), moderate (27%), or high (13%) screening intensity (Figure 2). It is usually accepted that the evaluation of the general appearance and attitude of the cow is a very important part of fresh cow evaluations (Guterbock, 2004; Aalseth, 2005; Smith and Risco, 2005; LeBlanc, 2008). However, fresh cow evaluators used subjective criteria to identify cows with dullness. A 4-point scoring system has been proposed to evaluate the general appearance of the cow based on the position and appearance of the eyes and ears (Smith and Risco, 2005); however, none of the fresh cow evaluators were familiar with this system.

Fresh Cow Health-Monitoring Examinations. Scheduled rectal examinations (13%), body temperature measurement (20%), or both (7%) were implemented on dairies as fresh cow health-monitoring examinations for early metritis detection. The span of time that scheduled body temperature measurements were performed is represented in Figure 3. Daily body temperatures were collected from calving up to 3 DIM (4%; low screening intensity), from calving up to 7 DIM (4%; moderate screening intensity), and from calving to

*Body temperature collected with Cowmanager sensors.

Figure 3. Duration of fresh cow health status monitoring based on daily body temperature by screening intensity [low (up to 3 DIM; light gray), moderate (dark gray; up to 7 DIM), or high intensity (at least until 10 DIM; black)] on 14 dairy farms in California. *Cowmanager sensors (Cow Manager B.V., Utrecht, the Netherlands).

10 DIM or more (20%; high screening intensity). In addition, dairy 6 was equipped with temperature meters on ear-tags and rumination sensors (Cowmanager sensor, Cow Manager B.V.); thus, this dairy was classified as high screening intensity for elevated temperatures. Elevated rectal temperature in postpartum cows is considered a sign of health disorder, most likely associated with an infectious disease (Risco and Benzaquem, 2011). Thus, daily evaluation of rectal temperature has been proposed as a management strategy for early identification of sick cows that may require treatment. However, it is remarkable that 44 to 68% of healthy postpartum cows had at least 1 elevated temperature during the first 10 DIM (Kristula and Smith, 2001; Wenz et al., 2011). Therefore, using rectal temperature could lead to overdetection (type I error) of sick animals and unnecessary use of antibiotic treatments. Fever in healthy postpartum cows has been speculatively explained by

tissue damage after calving, undetected disease, measurement errors, or normal variation within the population (Wagner et al., 2008; Wenz et al., 2011). However, Benzaquen et al. (2007) observed that 58.5% of cows with abnormal VD did not exhibit fever. This finding indicates that reliance on rectal temperature may lead to underdetection (type II error) of metritis cases. The duration and frequency of rectal evaluations on commercial dairies was quite varied (Figure 4). Most research studies evaluating rectal temperature in postpartum cows conducted daily evaluations for the first 10 d postpartum, as suggested by Upham (1996). However, Sannmann et al. (2013) has questioned the need to implement monitoring strategies immediately after calving, as 21.8% of the cows with metritis self-recovered within the first 4 d after calving. In our study, fever was defined as a temperature of $\geq 39.5^{\circ}\text{C}$, except for 3 dairies that used a cutoff point of

$\geq 39.2^{\circ}\text{C}$ for all cows ($n = 1$), only for primiparous cows ($n = 1$), or only during the summer ($n = 1$). Several studies have reported that on primiparous cows body temperature is 0.1 to 0.2°C higher than on multiparous cows (Wenz et al., 2011; Burfeind et al., 2014); therefore, lowering the cutoff for fever for primiparous cows most probably will increase the likelihood of type I errors. Although Aalseth (2005) speculated that infectious disease progressed more rapidly during hot weather and recommended lowering the cutoff point for fever by at least 0.3°C (0.5°F) during summer, the prevalence of elevated body temperatures ($\geq 39.5^{\circ}\text{C}$) is higher in healthy early postpartum cows during hot weather (28.1%) than during mild seasons (7.4%; Burfeind et al., 2012). Thus, under extreme hot weather conditions a good management practice is to adjust the cutoff point for fever based on the body temperature of seemingly healthy animals.

The presence of fever alone does not define metritis, as cows must exhibit at least 2 of the following signs: fetid VD, fever, or systemic illness (LeBlanc, 2008; Sannmann et al., 2012). Thus, fresh cow health-monitoring

exams for early detection of metritis propose to assess both temperature and perform rectal palpation for VD evaluation (Galvao, 2012); however, in the present study only 7% of dairies used both monitoring strategies. Thirteen percent of the dairies used only rectal palpation. Rectal examinations were performed with various frequencies across dairies once or twice within the first 10 DIM (7%; low screening intensity), thrice within the first 2 wk postpartum (7%; moderate screening intensity), or daily from 5 up to 15 DIM or until a normal VD was observed (7%; high screening intensity). Regular vaginal examination after calving was performed only on dairy 3 to determine if prophylactic antibiotic treatment was necessary in case of vaginal lacerations.

Although most metritis cases occur during the first 2 wk postpartum and peak around 5 to 7 DIM (Galvao, 2012), 2 dairies concluded their monitoring exams before the peak of metritis incidence. Dairies implementing monitoring strategies most likely improved their early detection of sick animals. However, if treatment decisions are based on the observation of a single sign

Figure 4. Duration of fresh cow health status monitoring based on rectal evaluation by screening intensity [low (1 or 2 evaluations; light gray), moderate (3 to 5 evaluations; dark gray), or high intensity (daily evaluations; black)] on 10 dairy farms in California.

of health disorder, fresh cow health-monitoring exams probably will lead to an unnecessary use of antibiotics. Moreover, although systemic antibiotic therapy might reduce fever and improve the color and odor of VD in metritis cases (Dubuc et al., 2011; Galvao, 2012; McLaughlin et al., 2012), the long-term effects on milk yield and reproductive efficiency have yet to be proven. Most recently, LeBlanc (2013) has proposed that beyond body temperature and VD evaluation, trained personnel should regularly screen cows for attitude, appetite, rumination, DA, and ketosis.

Fresh cow evaluations took longer per cow on dairies that implemented fresh cow health-monitoring exams than on dairies that did not ($P < 0.001$; Figure 5). Dairies implementing health-monitoring exams are more likely to early identify animals requiring an intervention; however, longer fresh cow evaluations limit the time cows have access to feed, water, or rest.

In our study, dairies were classified in 3 groups based on their overall screening intensity of health disorders. The length of fresh cow evaluations per cow was not different ($P = 0.199$; Figure 5) across low, moderate, and high intensity groups. Although the implications of the various screening intensities on early identification of health disorders was not evaluated, it is noteworthy that little consistency was observed across dairies on the fresh cow-screening protocols, even within each intensity group. Moreover, each sign of health disorder was evaluated with various degrees of intensity across dairies. These observations reflect the lack of a gold standard to screen for signs of health disorders of postpartum cows. Future studies should focus on developing and validating scoring systems for signs of health disorders on postpartum cows (i.e., rumen fill, udder fill), that can be easily implemented by dairy employees.

Although each dairy might need to tailor the fresh cow health exams to their needs based on postpartum health history, production and reproduction efficiency, facilities design, herd size, fresh cow evaluator skills, and maximum lock-up times allowed, there should be more consensus across dairies on what screening signs should be evaluated and how they should be evaluated. We observed that some dairies screened for very few signs of health disorders on fresh cows. Those herds perceived postpartum health as well as production and reproduction performance as desirable or did not find value on detailed fresh cow evaluations. In contrast, some dairies were extremely concerned with early disease detection. On those dairies, to minimize unnecessary interventions, evaluators should be properly trained on what signs of health disorders need to be evaluated and how to evaluate those signs to reach treatment decisions.

Figure 5. Box plot distribution of the time spent per cow during fresh cow evaluations on dairies performing health-monitoring exams versus those that did not ($P < 0.001$) and dairies with low, medium, and high screening intensity ($P < 0.199$). Each boxplot shows the 50th percentile (median, line within the box), 25th and 75th percentile (box), 10th and 90th percentiles (whiskers), and outliers (dots).

Physical Exploratory Methods

On most dairies, cows identified with a health disorder during screening or after monitoring evaluations received a physical examination based on some of the following methods.

Temperature Evaluation. Cows suspected of having a health disorder had their rectal temperature taken on 16% of the enrolled dairies. On these dairies, the cutoff temperature used for fever was $\geq 39.5^{\circ}\text{C}$. On most dairies, temperature information was collected rectally, but dairy 30 did vaginal temperature evaluation and disinfected the thermometer with alcohol in between cows. On dairy 36, cows with depressed general appearance were checked for fever by touching the ear. Heuwieser et al. (2010) reported that 34% of German herds checked temperatures in fresh cows. Similar results were obtained in our study (36%) after adding dairies that took the temperature of cows only when suspected to have a health disorder (9%), dairies that took the temperature of cows only during monitoring evaluations (20%), and dairies that took the temperature of cows in both scenarios (7%).

Rectal Examination. Most dairies performed rectal (60%) or vaginal (2%) examination after observing abnormal VD on tail, perineum, or floor. Some dairies limited rectal examinations to cows detected with fever (7%) or as part of health-monitoring exams (7%). But, 24% of dairies did not perform rectal examinations even when cows were suspected to have a health disorder.

On 3 dairies, rectal examinations were done but only integrated into scheduled monitoring fresh cow-health exams. Rectal examination could help to evaluate the status of the uterus as well as the odor and color of VD (Guterbock, 2004; Smith and Risco, 2005). However, only 7 of the 34 evaluators performing rectal examination evaluated uterus involution status and cervix inflammation, and only 16 evaluators reported assessing the smell of VD before making a treatment decision. Metritis has been defined as an abnormally enlarged uterus with fetid red-brown, watery VD, usually accompanied by fever ($>39.5^{\circ}\text{C}$; Sheldon et al., 2006). Nevertheless, the evaluation of VD has been shown to be very subjective even among trained veterinarians (Sannmann and Heuwieser, 2015).

Auscultation. Most evaluators (67%) were equipped with a functional stethoscope; however, researchers only witnessed its use for DA diagnosis on 20% dairies and to evaluate rumen contractions on 2% of dairies. On those 22% of dairies, cows with undisturbed feed, poor rumen fill, or producing less milk than expected were ausculted for DA. In addition, on 4 dairies researchers witnessed fresh cow evaluators ausculting lungs of cows suspected to have pneumonia based on difficult respiration or abnormal nasal discharge. On dairy 3, the fresh cow evaluator was extremely concerned with early identification of respiratory problems and ausculted the lungs of 3 cows during the farm visit.

Checking of Ketone Bodies. Only 7% of dairies evaluated ketone bodies with urine strips either on cows with depressed appetite or drop in milk yield. One dairy tested all fresh cows weekly for milk ketone bodies. Despite the lower sensitivities and specificities that these tests offer compared with blood tests (Oetzel, 2004), their lower prices and easier use seem to make urine or milk ketosis tests more appealing to farmers. However, urine collection can be a lengthy task and might be the reason most fresh cow evaluators did not check ketosis. Similarly, very few dairy herds in Germany (3%) evaluated ketosis with cow-side tests (Heuwieser et al., 2010).

Cows observed with abnormal VD or systemic signs of disease, such as off-feed, drop in milk yield, or depressed general attitude, should receive a more detailed physical evaluation that can help the fresh cow evaluator determine what action should be taken. Based on examination, fresh cow evaluators may decide to treat (i.e., drugs, surgery), to wait and evaluate disease progression, or to remove the cow from the herd (Guterbock, 2004). Mostly, the physical examination methods implemented on dairies are limited to temperature evaluation, rectal examination, and auscultation. Five dairies decided to perform interventions based only on

signs of health disorders observed during screening, without any subsequent physical exam. Moreover, only 12 dairies performed a thoughtful physical evaluation of cows presenting signs of health disorders at screening.

Judicious use of antibiotics on dairies is a timely topic in the wake of The National Action Plan for Combating Antibiotic-Resistant Bacteria (The White House, 2015). To promote judicious use of antibiotics, it is critical to design an efficient fresh cow health evaluation exam with an acceptable specificity and sensitivity for detection of health disorders. The present study reveals the need to develop tools to train fresh cow evaluators on how to screen for health disorders, and how to systematically collect physical information from cows showing signs of health disorders. This could help farm personnel make rational decisions regarding treatments.

CONCLUSIONS

Knowing how fresh cows with signs of health disorders were identified on large California dairies reveals areas where improvements in management exams might be implemented to prevent disease spread and ensure animal well-being. Limited consistency was observed across dairies regarding fresh cow-screening practices. Dairies varied on both which signs of health disorders they chose to screen for and also the intensity of how those signs were evaluated. This lack of consensus indicates the need to design standardized screening strategies that clearly define what and how signs of health disorders should be evaluated. Technologies that have been shown to aid in screening for fresh cow health disorders, such as milk meters and rumination sensors, were fairly uncommon. Most techniques used to screen for health disorders were based on nonspecific and subjective observations. Objective diagnostic methods, such as thermometers or ketosis tests, should be more frequently incorporated into fresh cow evaluations. Further research should be conducted to develop and validate scoring systems to screen for sick cows in the fresh pen. Moreover, to improve judicious use of antibiotics on dairies, it is critical that before treatment decisions are made, cows showing signs of health disorder receive a comprehensive physical evaluation including not only body temperature and rectal examination but also attitude, appetite, ketosis status, and auscultation of flank and lungs.

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REFERENCES

- AABP Guidelines. 2013. Establishing and Maintaining the Veterinary-Client-Patient Relationship in Bovine Practice. American Association of Bovine Practitioners (AABP), Auburn, AL.
- Aalseth, E. 2005. Fresh cow management. What is important, what does it cost, and what does it return? Pages 1–12 in Proc. 7th West. Dairy Management, Reno, NV. Kansas State University, Manhattan, KS.
- Benzaquen, M. E., C. A. Risco, L. F. Archbald, P. Melendez, M. J. Thatcher, and W. W. Thatcher. 2007. Rectal temperature, calving-related factors, and the incidence of puerperal metritis in postpartum dairy cows. *J. Dairy Sci.* 90:2804–2814.
- Bertulat, S., C. Fischer-Tenhagen, A. Werner, and W. Heuwer. 2012. Technical note: Validating a dynamometer for noninvasive measuring of udder firmness in dairy cows. *J. Dairy Sci.* 95:6550–6556.
- Burfeind, O., V. S. Suthar, and W. Heuwer. 2012. Effect of heat stress on body temperature in healthy early postpartum dairy cows. *Theriogenology* 78:2031–2038.
- Burfeind, O., V. S. Suthar, R. Voigtsberger, S. Bonk, and W. Heuwer. 2014. Body temperature in early postpartum dairy cows. *Theriogenology* 82:121–131.
- Burfeind, O., M. A. G. von Keyserlingk, D. M. Weary, D. M. Veira, and W. Heuwer. 2010. Technical note: Evaluation of a scoring system for rumen fill in dairy cows. *J. Dairy Sci.* 93:3635–3640.
- Caraviello, D. Z., K. A. Weigel, P. M. Fricke, M. C. Wiltbank, M. J. Florent, N. B. Cook, K. V. Nordlund, N. R. Zwald, and C. L. Rawson. 2006. Survey of management practices on reproductive performance of dairy cattle on large US commercial farms. *J. Dairy Sci.* 89:4723–4735.
- Cattaneo, A. A., R. Wilson, D. Doohan, and J. T. LeJeune. 2009. Bovine veterinarian's knowledge, beliefs, and practices regarding antibiotic resistance on Ohio dairy farms. *J. Dairy Sci.* 92:3494–3502.
- CDEA (California Department of Food and Agriculture). 2014. California Dairy Statistic Annual 2014. CDEA Dairy Marketing Branch, Sacramento, CA.
- Chapinal, N., M. Carson, T. F. Duffield, M. Capel, S. Godden, M. Overton, J. E. Santos, and S. J. LeBlanc. 2011. The association of serum metabolites with clinical disease during the transition period. *J. Dairy Sci.* 94:4897–4903.
- Dechow, C. D., and R. C. Goodling. 2008. Mortality, culling by sixty days in milk, and production profiles in high- and low-survival Pennsylvania herds. *J. Dairy Sci.* 91:4630–4639.
- Dubuc, J., T. F. Duffield, K. E. Leslie, J. S. Walton, and S. J. LeBlanc. 2011. Randomized clinical trial of antibiotic and prostaglandin treatments for uterine health and reproductive performance in dairy cows. *J. Dairy Sci.* 94:1325–1338.
- Edwards, J. L., and P. R. Tozer. 2004. Using activity and milk yield as predictors of fresh cow disorders. *J. Dairy Sci.* 87:524–531.
- Galvao, K. N. 2012. Postpartum uterine diseases in dairy cows. *Anim. Reprod.* 9:290–296.
- Goff, J. P., and R. L. Horst. 1997. Physiological changes at parturition and their relationship to metabolic disorders. *J. Dairy Sci.* 80:1260–1268.
- Guterbock, W. M. 2004. Diagnosis and treatment programs for fresh cows. *Vet. Clin. North Am. Food Anim. Pract.* 20:605–626.
- Heuwer, W., M. Iwersen, J. Gosselin, and M. Drillich. 2010. Short communication: Survey of fresh cow management practices of dairy cattle on small and large commercial farms. *J. Dairy Sci.* 93:1065–1068.
- Kazdin, A. E. 1979. Unobtrusive measures in behavioral assessment. *J. Appl. Behav. Anal.* 12:713–724.
- Kelton, D. F., D. L. Kerry, and E. M. Rochelle. 1998. Recommendations for recording and calculating the prevalence of selected clinical diseases of dairy cattle. *J. Dairy Sci.* 81:2502–2509.
- Kristula, M., and B. Smith. 2001. The use of daily postpartum rectal temperatures to select dairy cows for treatment with systemic antibiotics. *Bovine Pract.* 35:117–125.
- LeBlanc, S. J. 2008. Postpartum uterine disease and dairy herd reproductive performance—A review. *Vet. J.* 176:102–114.
- LeBlanc, S. J. 2013. Inflammation, metritis, and reproduction. Pages 90–97 in Proc. Dairy Cattle Reproduction Conference, Indianapolis, IN. Dairy Cattle Reproduction Council, Champaign, IL.
- Liboreiro, D. N., K. S. Machado, P. R. B. Silva, M. M. Maturana, T. K. Nishimura, A. P. Brandão, M. I. Endres, and R. C. Chebel. 2015. Characterization of peripartum rumination and activity of cows diagnosed with metabolic and uterine diseases. *J. Dairy Sci.* 98:6812–6827.
- McLaughlin, C. L., E. Stanisiewski, M. J. Lucas, C. P. Cornell, J. Watkins, L. Bryson, J. K. Tena, and J. R. Chenault. 2012. Evaluation of two doses of ceftiofur crystalline free acid sterile suspension for treatment of metritis in lactating dairy cows. *J. Dairy Sci.* 95:4363–4371.
- Oetzel, G. R. 2004. Monitoring and testing dairy herds for metabolic diseases. *Vet. Clin. North Am. Food Anim. Pract.* 20:651–674.
- Østergaard, S., P. T. Thomsen, and E. Burow. 2010. Separate housing for one month after calving improves production and health in primiparous cows but not in multiparous cows. *J. Dairy Sci.* 93:3533–3541.
- Overton, M., and J. Fetrow. 2008. Economics of postpartum uterine health. Pages 39–43 in Proc. Dairy Cattle Reprod. Council Conv., Omaha, NE. Dairy Cattle Reproduction Council, Champaign, IL.
- Raymond, M. J., R. D. Wohrle, and D. R. Call. 2006. Assessment and promotion of judicious antibiotic use on dairy farms in Washington State. *J. Dairy Sci.* 89:3228–3240.
- Risco, C. A., and M. E. Benzaquen. 2011. Monitoring health and looking for sick cows. Pages 27–31 in Dairy Production Medicine. C. A. Risco and P. M. Retamal, ed. John Wiley & Sons Inc., West Sussex, UK.
- Sannmann, I., S. Arlt, and W. Heuwer. 2012. A critical evaluation of diagnostic methods used to identify dairy cows with acute postpartum metritis in the current literature. *J. Dairy Res.* 79:436–444.
- Sannmann, I., O. Burfeind, R. Voigtsberger, and W. Heuwer. 2013. Comparison of two monitoring and treatment strategies for cows with acute puerperal metritis. *Theriogenology* 79:961–969.
- Sannmann, I., and W. Heuwer. 2015. Technical note: Intraobserver, interobserver, and test-retest reliabilities of an assessment of vaginal discharge from cows with and without acute puerperal metritis. *J. Dairy Sci.* 98:5460–5466.
- Schirmann, K., M. A. G. von Keyserlingk, D. M. Weary, D. M. Veira, and W. Heuwer. 2009. Technical note: Validation of a system for monitoring rumination in dairy cows. *J. Dairy Sci.* 92:6052–6055.
- Sheldon, I. M., G. S. Lewis, S. J. LeBlanc, and R. O. Gilbert. 2006. Defining postpartum uterine disease in cattle. *Theriogenology* 65:1516–1530.
- Silva-del-Río, N., A. Lago, B. Veerboort, and J. Beaulieu. 2012. Seasonal variation in milk production and culling in California dairy herds. Page 264 in Proc. American Association of Bovine Practitioners, Montreal, Canada. American Association of Bovine Practitioners, Opelika, AL.
- Sischo, W. M., D. A. Moore, M. A. Davis, D. L. Moore, J. Vanegas, S. Kurtz, K. Heaton, D. Kinder, J. D. Siler, R. V. Pereira, and L. D. Warnick. 2014. Intra-farm communication on dairy calf health. Northeast Dairy Production Medicine Symposium (NDPMS). Syracuse, NY. Pages 19–20 in Proc. Northeast Dairy Production

- Medicine Symposium. Syracuse, NY. Accessed Aug. 16, 2016. http://prodairy.cals.cornell.edu/sites/prodairy.cals.cornell.edu/files/shared/documents/NEDPA2014_Pereira.pdf.
- Smith, B. I., and C. A. Risco. 2005. Management of periparturient disorders in dairy cattle. *Vet. Clin. North Am. Food Anim. Pract.* 21:503–521.
- The White House. 2015. The National Action Plan for Combating Antibiotic-Resistant Bacteria. Accessed Apr. 13, 2015. https://www.whitehouse.gov/sites/default/files/docs/national_action_plan_for_combating_antibiotic-resistant_bacteria.pdf.
- Upham, G. L. 1996. A practitioner's approach to management of metritis/endometritis early detection and supportive treatment. Pages 19–21 in *Proc. American Association of Bovine Practitioners*, Spokane, WA. American Association of Bovine Practitioners, Opelika, AL.
- Wagner, S. A., D. E. Schimek, and F. C. Cheng. 2008. Body temperature and white blood cell count in postpartum dairy cows. *Bovine Pract.* 42:18–26.
- Wenz, J. R., D. A. Moore, and R. Kasimanickam. 2011. Factors associated with the rectal temperature of Holstein dairy cows during the first 10 days in milk. *J. Dairy Sci.* 94:1864–1872.
- Zaaijer, D., and J. P. Noordhuizen. 2003. A novel scoring system for monitoring the relationship between nutritional efficiency and fertility in dairy cows. *Ir. Vet. J.* 56:145–151.
- Zwald, A. G., P. L. Ruegg, J. B. Kaneene, L. D. Warnick, S. J. Wells, C. Fossler, and L. W. Halbert. 2004. Management practices and reported antimicrobial usage on conventional and organic dairy farms. *J. Dairy Sci.* 87:191–201.