THE IDENTIFICATION OF MANAGEMENT FACTORS ASSOCIATED WITH CHANGES IN BULK TANK SOMATIC CELL COUNTS (BTSCC).

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Introduction

In previous work, Goodger[1] developed and validated a milking management scoring instrument which included 48 individual management variables in 12 categories. This model of management practices was tested to establish that it reflected general expert opinion regarding practices which represent milking management and that there was reliability among users of the scoring instrument. The purpose of this study was to further refine the 48-measure milking management instrument and to explore the instrument's ability to account for changes in and interactions among management practices and udder health over time.

Materials and Methods

The refined instrument contained 48 questions within 12 categories (4 questions per category). The 12 categories are listed in Table 1. The scoring of these 12 categories was done through questions answered by the dairy operator or through the interviewer's observations. The method to score the 48 questions is described in a manual. A full listing of categories with their refined questions is available from the authors on request.

Table 1: Description of instrument categories and reviewed literature per category.

CATEGORY NUMBER	CATEGORY	CATEGORY NUMBER	CATEGORY
1(c1)	General sanitation	7(c7)	Pre-Milking procedures
2(c2)	Milking equipment	8(c8)	Milking procedure
3(c3)	Adequate milking system	9(c9)	Post-Milking procedures
4(c4)	Condition of cows	10(c10)	Mastitis treatment
5(c5)	Efficient traffic flow	11(c11)	Mastitis control
6(c6)	Milker performance	12(c12)	Record use

The manual was developed with for types of scoring criteria: 1) specific measurements such as measuring teat end vacuum fluctuations at the milking unit most distant from the receiver jar (c3); 2) comparing the management situation and the manager's perception of it by comparing body condition scores of cows in the dry pen and the manager's perception of the condition of these cows (c4); 3) a cumulative score based on the practices necessary for a good management, such as techniques used when treating cows, giving points for washing the teat end with alcohol soaked cotton, using separate treatment tubes for each teat, dipping teats after treatment, etc. (c10); 4) gradations from bad to good management, such as evaluating cow traffic lanes by a range of scores based on the percent of the lanes that are dirty (c1). Each question called for the evaluator to assign a score of from 0 to 20 points, making a maximum of 80 points for each category score.

All the dairies involved in the project were located in Tulare county, California and were DHIA members. A random sample was taken from the DHIA list of dairies until 55 dairies were identified. Management was scored on each dairy, beginning in November, January, March, and May 1989 to monitor changes in management practices over time. It took about two months to score and sample all 55 dairies for each time period.

Scoring began with an interview with the dairy owner or manager. Observations followed and were guided by means of a checklist. Notes were taken, with the observations providing a reliability check of the dairy operator's answers along with yielding independent data. Also, a BTSCC was obtained at the time of the interview or from current creamery results. Following the interview, impressions were not shared with the dairy operator to ensure that the manager would not alter management practices for the next scoring period. The interview notes of the dairy were reviewed, the scoring form filled out, and the dairy scored within 1-3 hours of the interview.

Statistical Methods

Multivariate analysis of variance (MANOVA) was used to determine whether there was a significant time period effect between the four time periods (November-December, January-February, March-April, and May-June). Conventional multivariate statistical tests (Wilk's Lambda, Pillai's trace, the Hotelling-Lawley trace and Roy's Greatest root) were used to detect any significant difference between the four time periods for the 12 categories. Univariate F tests were used to evaluate the categories that accounted for any difference between time periods. Multiple pairwise comparisons of each significant mean category score for each time period was completed using Tukey's procedure.

The general linear models approach using stepwise all possible subsets regression analysis was used to predict the BTSCC score from the management category scores: <u>BTSCC</u>= <u>xb</u> + <u>e</u> where BTSCC represents the transformed bulk tank somatic cell counts on a dairy basis, x is the design matrix of category scores and interaction terms, b is the vector of regression coefficients of the category scores and interaction terms, and e is the error vector assumed to be normally distributed with mean zero and variance 1.

All main effects and two-way interactions (including squared terms) were allowed to enter the model to ensure that the data were well described. A large number of possible models were identified for relating the category scores to BTSCC. From this large set, a much smaller set of more plausible models was obtained by insisting that, to be retained as a predictor, a main effect (linear term) had to express itself significantly ($p<.05$) and a quadratic, cubic, or interaction term had to express itself highly significantly ($p<.01$).

Results

Multiple Analysis of Variance

The category scores when subjected to MANOVA exhibited a highly significant ($P=0.0001$) time period effect. This effect was demonstrated by all four multivariate statistical tests used. Univariate F tests showed the significant time period effect could be accounted for by the following category scores: c1 ($P=0.0002$), c4 ($P=0.001$), c6 ($P=0.0001$), c8 ($P=0.0001$), and c11 ($P=0.0002$). All other category scores had decidedly nonsignificant time period effects.

Multiple pairwise comparisons (using Tukey's procedure with a level of significance of 5% over all comparisons for a given set of comparisons) of the time period mean scores for categories exhibiting significant time period effects are summarized in Table 2. The pattern of significance was not consistent over the five categories, in that the change in category score over time differed by category.

Table 2: Summary of time period effect on category scores.

			Mean category scores			
Time period	n	C1	C4	C6	C8	C11
Nov-Dec 55	49.1[b]	73.2[a]	56.5[a]	53.0[b]	44.7[b,c]	
Jan-Feb 46	42.7[b]	69.9[a,b]	47.8[b]	53.3[b]	41.6[c]	
March-April	51	49.1[b]	69.3[b]	49.1[b]	57.9[a,b]	49.8[a,b]
May-June 53	53.3[a]	67.6[b]	56.5[a]	65.0[a]	52.1[a]	

For each category, means with one superscript in common are not statistically significant different from each other with a level of significance of 5% over all comparisons. No significant (at the $P=0.05$ level) time period effect was observed for other categories.

Regression Analysis

The model selected using the November-December data had a linear and quadratic c1 term and a linear c10 term; the R-squared for the model was .41. General sanitation (c1) had a negative sign, which indicates an increase in practices directed at sanitation results in a decrease in BTSCC. The significant quadratic component for general sanitation (c1) indicates that the relationship between general sanitation and BTSCC has a non-linear component. Mastitis treatment (c10) had a negative sign, which indicates an increase in practices directed at mastitis control results in a decrease in BTSCC.

The only model that was identified from the January-February data had no main effects and the single interaction between c1 and c12. The R-squared for the model was .25. This interaction failed to remain significant (at the p=.05 level) when the c1 and c12 main effects were forced in the model, along with the interaction; both main effects were also nonsignificant.

The model selected using the March-April data had the single main effect c10 and the four interactions between c1 and c10, c1 and c12, c3 and c12, and between c10 and c12 (R-squared=.35). The interaction between c10 and c12 was the only interaction that remained significant when these three interactions and all corresponding main effects were forced in the model. C10 was the only main effect which was significant. No model was selected based on the May-June data. Table 3 gives the coefficients of the 3 models identified.

Table 3: Regression Coefficients (P-value) for selected models relating BTSCC and category scores.

Nov-Dec	
Intercept	7.96(.0001)
C1	-.0767(.0008)
C1 squared	.000692(.004)
C10	-.00890(.014)

Jan-Feb	
Intercept	5.82(.0001)
C1 and C12	-.000129(.0004)

March-April	
Intercept	7.19(.0001)
C10	-.0548(.002)
C1 and C10	.000479(.01)
C1 and C12	-.000675(.0035)
C3 and C12	-.000302(.0002)
C10 and C12	.000874(.0001)

Discussion

The results indicate that the category "general sanitation practices" appears to be an important explanatory variable for BTSCC level in almost every time period, either through main effects or interactions with other variables. Studies have shown that high amounts of moisture from muddy cow yards allow bacteria to grow in large numbers, exposing the teat end to large numbers of bacteria.[2,3] Also, cows need more washing on dairies, where corral effluent drains into traffic lanes that are not cleaned before milking.[4,5] The effectiveness of udder washing, in keeping dirt and bacteria off of the teat orifice, is then very dependent on the state of cleanliness of the udders when cows enter the parlor. Recent research suggests that if cows can be managed in a way that maintains clean udders and teats, then udder washing can be limited to washing only visibly dirty teats without affecting milk quality.[6,7,8] Washing only visibly dirty teats has been shown to reduce new mastitis infection rate and improve teat condition.[9,10,11] It would also encourage dairy operators to leave teats alone that are clean and dry, thus giving less opportunity for water laden with bacteria to drain into teat cups during milking.[12] This result could mean that management energies should be focused on making general dairy sanitation as clean as possible and that good milking management begins outside of the parlor with attention to farm laneways and gateways.

The category mastitis treatment (c10) is significant during November-December and March-April). The significant effect on BTSCC may occur as procedures on large-scale dairy farms become more efficient in recognizing clinical mastitis, its treatment, and preventing its spread. First, the importance of checking the foremilk of each cow cannot be overemphasized, because the most probable cause of elevated somatic cell counts is mastitis. Second, managing treatment procedures in an efficient manner can remove major obstacles which limit the success of a mastitis control program on a large-scale dairy. This management may begin with management-level employees performing treatment procedures to avoid any confusion. In a recent study on milking management practices, when dry cows were treated by the owner as opposed to the manager or milker, the cull rate for mastitis was lower.[13] Also, these treatment procedures should include the use of FDA approved or extra-label approved commercial preparations instead of multiple-dose containers of "homemade medicine". Moreover, treatment procedures used when treating cows should follow the same course of aseptic techniques as used for dry cow treatment.[14]

The significant interaction between mastitis treatment (c10) and record use (c12) in the March-April results moderates the impact of the negative mastitis treatment linear effect discussed above. The net effect, however, was a decline in BTSCC, with an increase in mastitis treatment (c10). A similar net effect was reported in results from a recent study that found that only 35% of the dairy managers kept mastitis treatment records.[15] But, in that study, those herds keeping records of mastitis cases had lower mean somatic cell counts than herds that did not. Thus, if more dairy operators kept records on mastitis treatments, the results from their treatments might improve and be reflected in lower BTSCC. Also, it has been shown in a recent study that when equipment records were kept, the number of the cows culled for production or mastitis decreased.[13] Encouraging producers to keep adequate records may thus have an indirect impact on udder health; the manager who keeps good records may be more carefully monitoring the entire operation and may thus be better able to take actions to reduce mastitis.

The reliability of the instrument has been shown in other studies[1], therefore, the observed variation over time probably is not due to variation in scorer, instrument error, or measurement error. Rather, the results of the MANOVA indicates a significant time period effect existed, in that the instrument documented that management did change over time. General sanitation practices (c1), milking procedures (c8), and mastitis control (c11) scores became progressively higher between the November-December and May-June periods (Table 2). Sanitation scores may have become higher in relation to the seasonal change from the rainy to the dry summer environment, whereas milking procedures and mastitis control scores may be related to our visits. It was intended that management not be informed of the results until after the survey was completed, but these policies became increasingly difficult to adhere to as the study progressed. In addition, the multiple interviews over a short period of time, within essentially a 30 mile radius and the interactions with herd veterinarians, probably served to make dairy operators more conscious of their milking management practices. The milker performance scores (c6) were biphasic and might represent the variety of different milkers observed over time (Table 2). The condition of cows score (c4) became progressively lower over the study period (Table 2) and might reflect current market conditions in the short run related to feed availability and the price of cull cows.

In summary, the instrument can be used as a clinical tool because the instrument tracks changes in management that reveal improving or declining udder health over time. But it appears that the relationship between management practices and udder health is difficult to model over time. MANOVA suggested that there was an effect over time, but the effect was not simple to model, meaning that to demonstrate associations with a response variable may require higher-order terms or interactions. The linear regression analysis documented this fact in that resulting significant models had main effects, squared terms, and interaction terms in the models.

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