# Dairy Herd Performance Evaluation: Mastitis Monitors

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Volumes have been written on the subject of mastitis control. Research continues to be compiled describing new, more effective measures in controlling herd mastitis. Yet application of this information has been slow. Recent analysis of Minnesota DHIA records indicates that the single most important factor accounting for milk production variation between herds was SCC (71). Since 70-80% of mastitis losses are the result of non-visable subclinical disease, it has been difficult for both educators and veterinary practitioners to convince dairy farmers of the relative magnitude of the mastitis problem.

The recent development of convenient, inexpensive mastitis monitoring techniques and recording systems coupled with the inception of milk quality premium payments by milk plants has made application of mastitis control programs more attractive to producers. The current economic pressures in the dairy industry have made improved production efficiency essential for all dairy farms.

**Surveys indicate that dairy farmers perceive veterinarians as their source of both mastitis treatment products and mastitis control information (Table 1, Table 2) (38, 81).**

TABLE 1. Current source of purchase of mastitis remedies.

| | Lactating cows | Dry cows |
|---|---|---|
| Veterinarian | 60.7% | 52.4% |
| Retail store | 38.2% | 36.4% |
| Direct-to-farm routeman | 16.8% | 16.9% |
| Mail order | 16.2% | 16.0% |
| AI technician | 4.8% | 6.1% |

* 1985 Hoard's Dairyman market study.

Ironically most veterinarians are not providing comprehensive mastitis control programs for their dairy clients. A survey of upper-midwest bovine practitioners indicates that while 99% provide routine reproductive programs for their herd health clients, only 30% provide assistance in mastitis control (Table 3) (62). Dairy practitioners need to quickly expand herd health services to fill this need.

Mastitis is a complex disease in which the interaction between the cow, the environment, and the mastitis pathogen are greatly affected by management. The statement made by Dr. Jim Jerret that "mastitis is a disease of man, the symptoms of which are seen in the cow" is perhaps overexageration, but the emphasis on management is appropriate if a solution to the problem is to be realized.

TABLE 2. Scores for sources of information that respondents indicated helped decrease the amount of mastitis in their herds.

| Source | Mean | ± 1 SD | No. of respondents using source | % |
|---|---|---|---|---|
| Local veterinarian | 3.75 | 1.17 | 124 | 95.4 |
| Farm magazines (i.e., Hoard's Dairyman) | 3.15 | 1.19 | 122 | 93.8 |
| University ext. specialist | 2.67 | 1.39 | 86 | 66.1 |
| Another dairyman | 2.61 | 1.13 | 103 | 79.2 |
| Milk plant fieldman | 2.57 | 1.21 | 104 | 80.0 |
| Farm newspapers | 2.30 | 1.32 | 98 | 75.4 |
| Drug sales representative | 1.94 | 1.15 | 72 | 55.4 |
| DHIA supervisor | 1.94 | 1.33 | 79 | 60.8 |
| Other salesman | 1.79 | 1.43 | 36 | 27.7 |
| County extension agent | 1.70 | 1.39 | 69 | 53.1 |
| Vocation agricultural instr. | 1.44 | 1.44 | 54 | 41.5 |

Other sources were mastitis consultant (1), radio (1), feed representatives (2).

| Scale = | Never useful | Rarely useful | Occas. useful | Freq. useful | Very freq. useful | Always useful |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |

In evaluating herd mastitis, all factors involved in the etiology of the disease should simultaneously be considered. Minnesota field studies in 40 mastitis problem herds verify that deficiencies in management are the greatest causes of mastitis (Table 4) (63).

Recent technology has made commonly available mastitis monitoring techniques. A clear understanding of these mastitis evaluation tools is helpful to the practitioner in providing accurate mastitis control recommendations. Complete herd mastitis evaluations includes consideration of:

1. Bulk tank and individual cow somatic cell counts.
2. Bulk tank and/or individual cow culturing.
3. Clinical treatment records.
4. Farm visit observations (stray voltage screen, milking machine analysis, milking routine and mastitis control procedure evaluation, as well as dry cow management).

Attempts to make recommendations without full consideration of the factors often leads to inaccurate assessments and ineffective results.

The purpose of this paper is to discuss in detail the use of DHI somatic cell counts records in mastitis control programs, and their effective integration with other data in

TABLE 3. Response of upper-midwest bovine practitioners indicating services provided for herd health clients.

| | 1982 | 1985 |
|---|---|---|
| Routine reproductive | 85% | 99% |
| Herd vaccination program | 87% | 91% |
| Mastitis control program (including periodic equipment analysis, evaluation of mastitis control procedure and some culturing) | 24% | 30% |
| Nutrition counselling | 31% | 36% |
| Calf and youngstock management | 56% | 63% |
| Others | 5% | 6% |

TABLE 4. Minnesota mastitis control project analysis of 40 Minnesota dairy herds with a serious herd mastitis problem.

| | % of project herds with inadequacies |
|---|---|
| Management | |
| Milking routine | 80% |
| Mastitis control (teat dipping, dry cow therapy, sanitation) | 72% |
| Equipment | |
| Milking equipment | 39% |
| Stray voltage | 45% |

the formulation of specific mastitis control recommendation.

## Factors Affecting Somatic Cell Counts

The SCC is a general indicator of udder health. High cell counts reflect udder damage regardless of cause. There are many factors that affect milk SCC; effective use of the milk depends greatly on a clear understanding of these factors.

*Infection Status*

The single most important factor affecting the SCC in milk is the infection status of the mammary gland (24, 44, 51, 66, 69). By comparison all other factors affecting the milk SCC are minor. Uninfected cows have a low SCC (X 165,000). Fifty percent of uninfected cows are under 100,000 cells with 80% under 200,000 cells (24).

Major pathogens cause higher average cell counts (1,031,000) than minor pathogens (374,000) (24). Others have found similar results (66, 69). Although there appears to be some difference in the magnitude of cellular response between pathogens, the degree of cellular response as a predictor of infectious agent is unreliable (56, 76). The magnitude and duration of the infection, the cow's history of previous exposure, and the idiosyncrasies of the immune system influence what the SCC outcome will be. Unexpectedly, coagulase negative staphs. elicit relatively high cellular response compared to other minor pathogens (9, 22, 51, 56, 69). Since coagulase negative staph. is the most frequently isolated mastitis producing organism (9, 51, 69), more attention should be given to defining its impact on production efficiency.

There is usually a clear and easily distinguishable break between SCC's in uninfected cows and cows infected with major pathogens (Table 5). Minor pathogens eliciting lower SCC levels close to threshold settings may make SCC data confusing. Depending on where thresholds are set there may be many false negative results, most of which are attributed to minor pathogens.

*Age*

Next to infection status, lactation number has the greatest influence on SCC variation. Consistently, older cows have higher average cell counts than younger cows (56, 66, 69). One report indicated that the average milk SCC, irrespective of infection status, was 232,000 in heifers and 868,000 in cows over 7 years old (24). In equating lactation number with a progressive increase in SCC, the observation was made that the average increase per lactation was 100,000 cells (70). The preponderance of evidence concludes that the age-related increase in SCC is of bacteriologic origin. As cows increase in age, there is an increased opportunity for exposure to mastitis pathogens resulting in a gradual increase in the number of infected quarters (9, 24). Older cows tend to have infections of longer duration and more extensive tissue damage. Older cows with previous histories of infection elicit greater cellular response than uninfected cattle.

*Stage of Lactation*

The milk SCC in uninfected cows is relatively higher at freshening, lowest from peak to mid lactation, and highest at dry off. A plot of monthly SCC's would usually be the inverse of the lactation curve (16, 24, 69). The physiologic mechanism involved in uninfected udders is that of milk yield or dilution. Sheldrake et al. (66) observed that in uninfected quarters there was an increase of 80,000 cells between 35 days in milk to 265 days in milk. This degree of

TABLE 5. Summary of the mean SCC or SCC range by infection status among several studies.

| | $\bar{X}$ SCC or SCC range | | |
|---|---|---|---|
| | Uninfected | Minor | Major |
| Shultz, 1977 (69) | 170,000 | 227,000 | 998,000 |
| Eberhart, 1979 (24) | 165,000 | 364,000 | 1,061,000 |
| Natzke, 1972 (56) | 214,000 | —— | 504,000—1,470,000 |
| Sheldrake, 1983 (66) | 100,000—175,000 | 200,000—500,000 | 500,000+ |
| Andrews, 1983 (1) | 147,000 | —— | 556,000 |

variation is of no diagnostic significance in uninfected cows or those infected with major pathogens. Evidence to date does not support the idea that an elevated SCC in late lactation is less indicative of infection. In fact, the reduced milk volume of late lactation helps to reduce the number of misclassified false negatives when a fixed threshold is used.

False positives in early lactation have also been a concern. However, since DHIA rules mandate that cows be 6 days in milk prior to the first testing, this is not of great concern in DHI SCC testing programs. Although it is expected that SCC will be somewhat elevated at parturition, by 5 days postpartum SCC in uninfected cows is less than 300,000 (19). Natzke (56) reported that early lactation cell counts remained elevated for 2 weeks. However, study of that data reveals that average SCC's for uninfected cows during the first 2 weeks postpartum was 242,000 cells. Therefore, when it is understood that SCC testing is not completed on cows less than 6 days in milk and that, in fact, the average DHIA tested cattle are tested at approximately 2 weeks postpartum, then any cow with a linear score of greater than 5 (283,000) should be interpreted as being infected.

**Stage of lactation has no significant effect on correct classification of uninfected cows and those cows infected with major pathogens. Correct classification of cows with minor infections may be improved due to a decrease in milk volume at the end of lactation.**

*Season*

The highest SCC's generally occur during the summer months with the lowest counts occurring during the winter (7, 22, 25, 58, 77). Opposite trends have been reported (59, 72). Others report no consistent seasonal trend (29). Seasonal incidence of clinical mastitis parallels observed rises in the herd's SCC (61).

Speculation on whether the seasonal effect is physiological seems doubtful. Rather it is the natural result of: 1) increased bacterial contamination of teats during periods of weather that provide more optimal bacterial growth conditions; and 2) circumstances where these natural forces are not countered by sound management practices. Regardless, seasonal effects should not be considered a major cause of SCC variation.

*Stress*

A variety of stress-induced effects have been reported. Isolation, weather change, agitation (81), thermal stress (61, 77), and co-mingling of cattle (3, 41) do not significantly change milk SCC in uninfected cattle. Neither does estrus appear to effect milk SCC (31, 69). Administration of corticosteroids or adrenocorticotropic hormones have shown inconsistent effects on milk SCC (77). Overmilking has been suggested as a cause of elevated SCC in cows (68), however, thorough review of the effects of overmilking on dairy cattle (54) shows no significant increases in SCC. Stray voltage places a stress on dairy cattle and indirectly increases SCC (2).

**Cows harboring subclinical mammary infections respond to stress with significant increases in milk SCC. Uninfected cattle, however, do not appear to respond in any significant proportion. Therefore, the effects of stress do not have enough affect to alter interpretation of SCC data.**

*Diurnal Variation*

Many researchers have reported significant fluctuations in milk SCC depending on the time of sampling (15, 22, 26, 43, 73, 79). SCC's are highest in strippings and during the 1-3 h after milking, followed by a steady decline until the next milking. The effect appears to be largely that of proportional dilution relative to milking interval. Diurnal variation is of no consequence for traditional DHI sampling procedures where each sample is representative of a full 24-hour period. But for AM-PM DHI testing programs (where only one milking is collected) or for researchers and veterinarians taking samples unrepresentative of a 24-hour period and at different times during the day, diurnal variation may be very important.

It has been reported that PM milk samples have twice the number of somatic cells than AM samples (15). Closer study of these data revealed unequal milking intervals (AM-PM 7 hrs, PM-AM 17 hrs) which help explain the apparent discrepancy. Recent data (26) demonstrate that it is possible to vary the SCC in quarter milk samples 5 times in an uninfected cow depending on when the samples were taken, unless a 24-hour composite sample was used.

This fact should not be surprising since adjustment factors for fat and protein are already used to adjust for milking interval difference in AM-PM DHI sampling programs. These same considerations need to be made for somatic cells.

Although it does not appear that failure to consider diurnal variation will affect diagnosis of infections caused by major pathogens, it will lead to misclassification of uninfected cows (26). Veterinarians or others conducting SCC or doing cowside CMT tests 1-3 h after milking should anticipate false positives and confusing results if they are comparing these results to DHI SCC test results.

*Day to Day Variation*

There is increasing concern over the variation between DHI and milk plant test results. Several factors may contribute to this observation (i.e., unrepresentative sample collection, difference in test procedures, diurnal variation, etc.), but a major cause is a normal day to day variation.

The average coefficient of variation in composite samples taken at short intervals was 30-35% (15), whereas over a whole lactation it may range from 69-301% (23). Day to day variation on individual cows is considerably more in infected cows than uninfected cows (70). Therefore, a single SCC test result is relatively inconclusive and classification of infection status should be determined on the basis of a series of counts.

Bulk tank SCC can vary considerably. The coefficient of variation in daily bulk tank contents has been reported to be 24% (78) and 23% (14). Monthly bulk tank SCC's have been reported to vary 4-46% with an average of 20% (28). Variation in bulk tank SCC will depend greatly on the herd's infection status. Those herds with higher mastitis levels generally would have greater variation in either daily or monthly SCC. Because of the innate problems associated with normal day to day variation, consideration needs to be given to averaging several SCC's for determination of quality premium payments.

*Somatic Cell Count Testing Methodology*

Sample collection, storage, transportation and differing test procedures all can influence SCC results. These technical aspects of SCC have been studied extensively (20, 31, 36, 74).

**Recently, considerable national effort is being made to standardize SCC test procedure and cell counting equipment (35).**

*Management Factors*

Mastitis is recognized as a disease intensely related to herd management (63). One report documented an inverse linear relationship between mastitis level and time spent managing the dairy herd (5). Control of mastitis by the adoption of management procedures that reduce the rate of new infections have been effective. Numerous studies have investigated the association of implementing various control procedures on SCC (6, 7, 8, 24, 30, 33, 34, 50, 55, 69).

Consistent use of an effective teat dip, dry cow therapy, individual towels to wash and dry teats, milking order, etc., have all been extensively studied. Other management factors, such as type of housing, bedding and stall maintenance, milking system design and maintenance, manure handling, etc., also have great impact on herd SCC.

*Breed Difference*

Recently there have been reports of breed diference in SCC (9, 45). As more documentation of breed difference SCC accumulates, there may be merit in the development of adjustment factors to accommodate these findings.

## Selection of an Appropriate SCC Threshold

It is obvious from studying the many factors affecting milk SCC's that the test is not perfect. Therefore, correct interpretation and use of SCC data requires good judgment.

The ideal clinical test would establish the presence of absence of disease in every case screened without any false positives or false negatives. Because of the variable nature of most biological systems there are few, if any, clinical tests that meet these ideal standards. This is even true in a test expected to be absolute in its indication of biological status. When quantitative tests are used there is always an area of overlap between positive and negative tests. It is possible to vary the positivity and negativity of these tests by changing the level at which the test is considered positive. Thus, selection of an appropriate threshold is crucial to the usefulness of any clinical test as an accurate diagnostic tool. Since mastitis is the major cause of udder damage, it is reasonable to assume that a high SCC indicates the presence of infection. Correct classification of cows into infected and uninfected groups, likewise, depends on the appropriate selection of an SCC threshold.

All DHI SCC programs in the U.S. use composite milk samples for SCC scoring. There is no question that SCC results from quarter samples are more accurate and easier to interpret. Cows mildly infected in only one quarter may easily be misclassified because of the dilution effects of 3 healthy quarters. Studies show that 70-80% of infected cows were infected in only one quarter (44, 75). Therefore, more false negative results would be anticipated when using composite samples. However, the impracticality and extra expense of quarter sample use in DHI testing programs is obvious.

The setting of an SCC threshold has little effect on the overall efficiency of the milk SCC test. But setting the SCC threshold does increase or decrease the number of false positives. Therefore, if the goal of the SCC program is treatment oriented (i.e., selective dry cow treatment), it would be appropriate to set the threshold low enough to assure that no infections are missed and thus go untreated. For example, Andrews et al. (1) determined that when SCC data was used for selection of cows for dry cow treatment, an appropriate SCC threshold was 200,000 cells. The criteria used to determine the threshold was that the number of false negatives should always be less than 15% of the number of false positives. If, however, the goal is to use the SCC information in a mastitis control program, the threshold must be set to properly express the true dynamics of the disease. Of lesser concern is the number of false negative results. It would be advisable to select an SCC threshold in a range where false positives equal false negatives (Figure 1).

Therefore, the most important criterion in the selection of a somatic cell threshold is the intended use of the information. The most recent research (44) indicates that an SCC threshold in the vicinity of 250,000 cells is reasonable for monitoring mastitis control programs. When the linear scoring system is used, the threshold should be set at a linear score of 5 (283,000 cells). This does not mean that a cow with a *single* SCC linear score of 5 absolutely has mastitis. However, the strength of that prediction increases as the number of monthly SCC tests accumulate or as the magnitude of the single SCC determination increases. This threshold level provides adequate sensitivity in herds of average mastitis prevalence to assure that most infected cows are properly classified without an excessive number of false positives. In addition, disease dynamics are sufficiently approximated to allow epidemiologic use of the data in a mastitis control program.

Figure 2 is a plot of data from Eberhart et al. (24) in relation to an SCC threshold of 283,000 (linear score of 5). Presentation of the data in this manner characterizes the distribution of the SCC in uninfected cows and heifers as

FIGURE 1. Percentage frequency distribution of mean log transformed cell counts from infected and noninfected lactations. Andrews et al. (1).

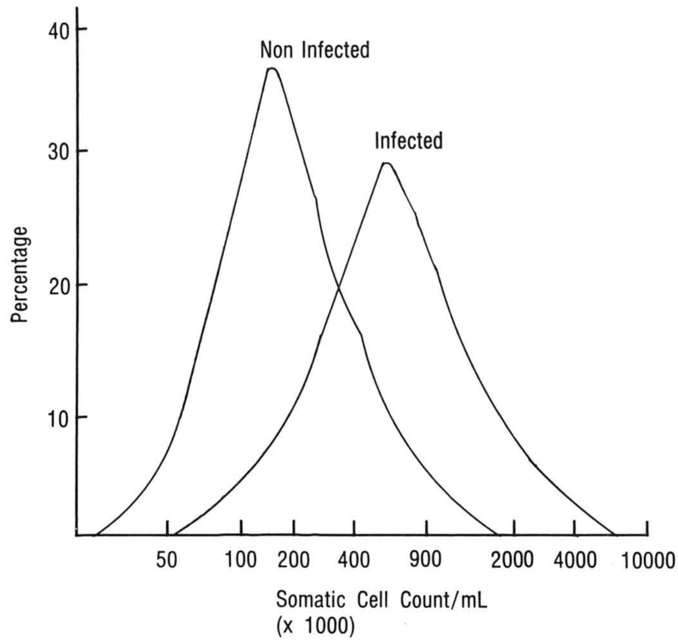
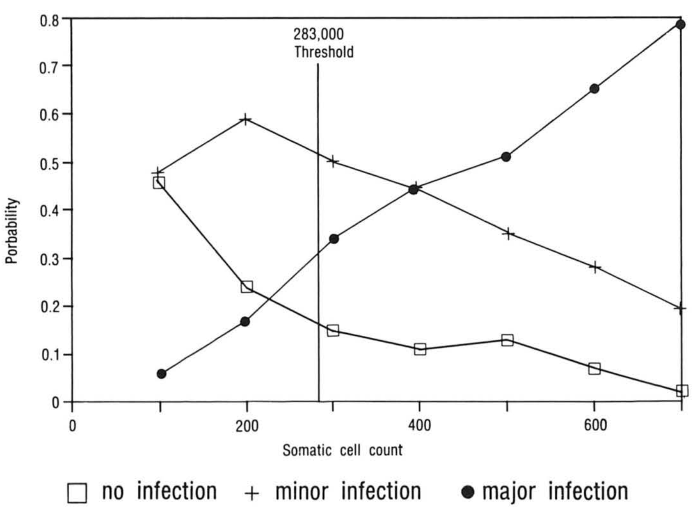



FIGURE 2. Probability that a cow is uninfected, infected with major pathogens, or infected with minor pathogens as estimated from a single SCC relative to a fixed 283,000 cell threshold. Adapted from data by Eberhart et al. (24).




well as those infected with major or minor pathogens. Of greatest concern are the false negatives SCC results. It is encouraging to note that there are few false negative SCC results in animals infected with major pathogens. However, it is bothersome to see the number of false negative SCC's among those infected with minor pathogens since the most commonly diagnosed mastitis infections are minor pathogens, in particular, coagulase negative staphs. This is particularly of concern among first calf heifers infected with minor pathogens (9). For example, in one study (24) 48% of heifers had minor infections with an average SCC mean of 190,000.

The Minnesota DHI Processing Center has been using the linear scoring system for nearly 2 years. A linear score of 5 (283,000) has been the designated somatic cell threshold. Compilation of 18 months of data (2.66 x $10^6$ SCC tests) indicates that 31% of all SCC tests completed on 230,000 cows were classified as positive. Twenty percent of all SCC tests on heifers and 36% of SCC tests on older cows were positive (>283,000). Although simultaneous bacteriology was not completed to verify this level of mastitis in Minnesota DHI herds, the figures are comparable with other mastitis prevalence assays (Table 6).

It appears that estimates of mastitis prevalence based on somatic cell counts using the SCC threshold of 283,000 are realistic.

TABLE 6. Summary of recently reported mastitis prevalence in dairy cattle.

| | **Mastitis prevalence** |
|---|---|
| Lindstrom et al., 1980 (44) | 23.6% |
| Wilson and Richards, 1980 (82) | 28.0% |
| Dohoo et al., 1981 (22) | 34.0% |
| McDermott et al., 1982 (48) | 24.0% |
| Bakken, 1984 (4) | 31.0% |

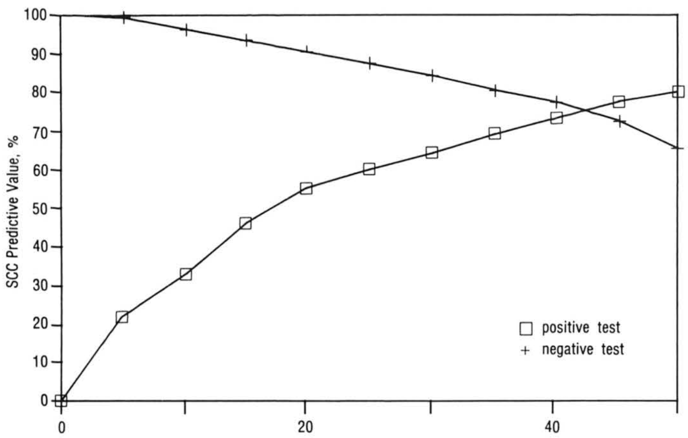
*Herd Prevalence Considerations*

Herd prevalence must be considered in the interpretation of SCC reports. Herd mastitis prevalence is probably the most important but least understood factor affecting the accuracy of the "positive" SCC test. It should be kept in mind that as the prevalence of mastitis within a herd increases, the accuracy of correctly predicting the presence of mastitis on the basis of SCC also increases (48, 69).

Sheldrake (67) stated "from our study, selection of a common threshold for diagnosis of mastitis in all herds will result in a large number of false positive predictions in some herds and a similar proportion of false negatives in others."

This is graphically represented in Figure 3 taken from the work of McDermott, Erb and Natzke (48). Note that as mastitis prevalence increased, the accuracy of the positive SCC test also increased, while the accuracy of the negative negative test decreased. Overall efficiency, that is, the percentage of cows classified correctly relative to infection status, stayed the same and was 75-80%. Because of the variation in herd mastitis prevalence which greatly affects the accuracy of predicting infected cows, it is essential to make SCC report interpretation and the formulation of mastitis control recommendations on an individual herd basis (45, 48). If dependable criteria could be developed, then establishing relative thresholds for herds of differing mastitis prevalence may merit consideration. Regardless, those using SCC data should clearly understand the effects of herd prevalence on SCC interpretation.

FIGURE 3. Effect of prevalence on predictabilities of somatic cell count for intramammary infections. McDermott et al. (48).




### Use of SCC Linear Score on DHIA Reports in Milk Yield Loss Estimates

The greatest advantage of expressing raw SCC data in the linear score format is its linear relationship with milk yield (21, 41, 68). The Wisconsin and Virginia data show that each increment increase in the linear score is associated with a doubling of raw SCC and a 1.5 lb per day or 400 lb per lactation loss in milk production. The milk yield loss in first lactation cows is approximately one-half that of older cows (Table 7). Canadian research (21) indicates a similar linear relationship between the linear SCC score and milk yield. However, the production losses were greater. With each increment change in SCC score there was a 1.44 kg per cow per day milk yield loss.

TABLE 7. Linear SCC score and its relationship to daily and lactational milk yield losses.

| | | Daily yield lost | | Lactation yield lost | |
|---|---|---|---|---|---|
| Linear SCC | Avg. SCC | First lactation | Older cows | First lactation | Older cows |
| 0-2 | — | 0 | 0 | 0 | 0 |
| 3 | 100 | 0.6 | 1.3 | 200 | 400 |
| 4 | 200 | 1.3 | 2.6 | 400 | 800 |
| 5 | 400 | 2.0 | 3.9 | 600 | 1200 |
| 6 | 800 | 2.6 | 5.2 | 800 | 1600 |
| 7 | 1600 | 3.3 | 6.6 | 1000 | 2000 |
| 8 | 3200 | 3.9 | 7.9 | 1200 | 2400 |
| 9 | 6400 | 4.6 | 9.2 | — | — |

Objections have been raised about the accuracy of loss estimates using the linear SCC system. This is particularly true in herds with low prevalence of mastitis or in estimating milk yield losses on individual cows with low cell counts (50,000-200,000). It is understandable that objections are raised since there is insufficient research data to satisfactorily explain the observed linear reductions in milk yield, even at cell counts less than 200,000. A recent study by Fox et al. substantiates that loss of milk production in counts less than 200,000 is associated with milk compositional changes consistent with mammary inflamation. There is limited evidence that the presence of the so-called commensal or minor pathogens *(C. bovis, Staph epi.)* may explain milk yield losses at low SCC levels (55). Others would challenge the idea that the minor pathogens have any significant effect on milk production yield (12). Further research is necessary.

There is some evidence that the milk loss is not linear at the higher cell count levels (18). Upon reevaluation of the Wisconsin and Virginia data, this finding was not verified (17, 40).

The accuracy of production loss estimates based on the linear score computation is sufficient to document the relative economic magnitude of the herd mastitis problem. For those working with individual dairy farmers, the ability to document economic impact is an essential motivating factor in achieving adoption of herd health management procedures (52). However, it should be emphasized that loss estimates on individual cows are weak, especially when based on a single SCC test. Accuracy is greatly improved if the average lactational linear score is used (17). Care must be taken to properly interpret loss estimates relative to herd mastitis prevalence. This is particularly true in low prevalence herds realizing that those estimates may be somewhat inflated. Therefore, the cost benefit of recommended mastitis control procedures should always be considered in the light of individual herd record interpretation.

### Using SCC Reports for Treatment Guides

SCC reports should never be used as the sole criterion for antibiotic treatment of subclinical mastitis. It has been clearly documented (37) that treatment based on high cell counts is not profitable. Recent data (49) indicates that when cows with subclinical mastitis having an SCC of 400,000 or above were treated, there was an average net loss of $19.65 per cow.

In a similar study (75), average cost per animal was $38.19 (antibiotics and discarded milk). There was a mere 23.3% cure rate and no significant decrease in SCC.

If antibiotic therapy for cows with subclinical mastitis is contemplated, the SCC report can be used to select high cell count cows for individual culturing. Only in cases where cows are infected with *Streptococcus agalactiae* has lactational therapy for subclinical mastitis proven economically beneficial. Even in the specific situation, economical benefit is unlikely on cows beyond 150 days in milk.

The question of complete or selective dry cow therapy continues to be debated. This debate has recently been revived by a New Zealand report (46) that cows dry cow treated had 6.4% more clinical cases in their subsequent lactation than did the untreated controls. However, milk production was significantly less (572 lb) in the untreated group. Of interest was the suggestion that the depressed production was most pronounced among untreated cows with high cell counts.

It is well recognized that dry cow treatment and teat dipping effectively lower the prevalence of gram positive infections (*Staph aureus, Staph epi., Strep ag., C. bovis*), resulting in a lowered SCC (10, 11, 57). It has also been demonstrated that cows with low cell counts are more susceptible to acute coliform mastitis (13, 38, 65). There has been recent research interest in the possible protective role of *C. bovis* and *Staph epi.* against acute mastitis. Moderate SCC levels stimulated by the presence of these so-called minor pathogens may be of some physiologic benefit (11). However, whether the cost of subclinical gram positive infection outweighs the risk of development of clinical mastitis, particularly acute coliform mastitis, must be questioned. This is obviously another area of needed mastitis research.

Certainly, the strategy of complete dry cow therapy is not questioned in problem herds. Herds with herd average cell counts of greater than 500,000 cells or with a herd prevalence of greater than 25% should dry cow treat all quarters of all cows. In herds of low prevalence, selective dry cow therapy based on high SCC's may be a valid strategy as long as dry cow sanitation is emphasized.

## Epidemiologic Considerations in Reporting Somatic Cell Count Information

Usefullnes of DHI somatic cell data as a mastitis management tool requires that expression of the SCC data relates to the epidemiology of the disease. Measures of the herd mastitis level (prevalence), new infection rate (incidence), and analysis of mastitis patterns within the herd over time are essential. As a mastitis control program is implemented, it is crucial to the success of that program that the mastitis level be monitored. Measurements of mastitis level over short run or long run are valuable. However, mastitis level (prevalence) is a relatively static measure of herd mastitis and because of relative slow changes may be discouraging to the farmer.

New infection rates (incidence), on the other hand, are sensitive indications of the cause and effect relationship of either recently implemented mastitis control procedures or a breakdown in those procedures. It is, therefore, necessary to focus the farmer's attention on this information as a meaningful monitor of current mastitis control effectiveness.

Classical epidemiological analysis is the study of patterns within or across populations over time. Comparison of mastitis patterns between groups of cows by age, stage of lactation, etc., may help identify possible management or mastitis control deficiencies specific to either the groups or the period of time being considered.

When all of these epidemiologic factors are considered and expressed in an easily understood and useable format, the SCC report becomes an extremely valuable mastitis control tool. Epidemiologic characterization will help identify management shortcomings enabling the recommendation of effective herd specific control procedures.

## Interpretation of DHI SCC Herd Summaries

The Minnesota SCC report has five herd summaries (64). The Current SCC Summary, Herd Avg SCC, and the Problem Cow List are reasonably self-explanatory and will not be discussed in detail in this presentation (see Figure 9).

The trend summary categorizes the infection status of heifers and older cows, comparing the percentage of SCC positive heifers and older cows from a current sample with samples from last month and a year ago. This herd summary is useful for monitoring progress in mastitis control over both the short and long term as well as consideration of seasonal effects.

The heifers in the trend summary shown in Figure 4 have remained free of mastitis, indicating that control procedures preventing cow-to-cow spread of mastitis are working well. Progress also may have been made by successful dry cow therapy or the culling of chronically infected old cows.

FIGURE 4. Sample somatic cell count trend summary.

| SCC TRENDS | | | |
|---|---|---|---|
| Lact | PCT Positive | | |
| No | Current | Last Mo | Year Ago |
| 1st | 0 | 0 | 0 |
| Other | 9 | 13 | 18 |
| All | 6 | 10 | 14 |

Drastic increases in the percentage of infected cows from one month to the next (Figure 5) should raise questions and initiate an investigation into what is happening:

1. Is there an equipment problem such as a loose belt on the vacuum pump, a stuck vacuum regulator, a plugged vacuum line, or any other equipment defect that might have a detrimental effect on the milking characteristics of a machine?
2. Is a different person doing the milking?
3. Has there been a sudden and severe change in the weather, with lots becoming muddy and cows becoming wet and dirty and/or developing frozen teats or other teat problems?
4. Has there been a sudden onset of a disease process such as pseudo cowpox or ulcerative mammillitis that might be causing teat end damage?

The yearly summary considers the percentage of SCC "positive" cows or heifers relative to their stage of lactation. Determination of when the most infections occur during the lactation and in which group (heifers or cows) they are most often occurring enables identification of which management

FIGURE 5. Examples of drastic increases in percentage of infected cows.

| SCC TRENDS | | | |
|---|---|---|---|
| Lact | PCT Positive | | |
| No | Current | Last Mo | Year Ago |
| 1st | 15 | 7 | 3 |
| Other | 21 | 7 | 9 |
| All | 20 | 7 | 7 |

Drastic increase

| SCC TRENDS | | | |
|---|---|---|---|
| Lact | PCT Positive | | |
| No | Current | Last Mo | Year Ago |
| 1st | 29 | 0 | 5 |
| Other | 50 | 17 | 15 |
| All | 45 | 12 | 12 |

factors that are the most likely cause(s) of the herd mastitis problem.

There is concern that false positives during early lactation may be misleading. National DHI rules dictate that cows may not be sampled until 7 days post partum. Because of this ruling, most cows will not actually be tested until 2 weeks post partum. Research using simultaneous SCC counts and bacteriologic cultures indicates that uninfected cows have counts well below 300,000 by five days post partum (16, 19). Therefore, a cutoff of 30 days post partum will better reflect mastitis problems caused by deficiencies in springing heifer and dry cow management.

Mastitis control in the herd described in Figure 6 is good. Heifers are freshening free from mastitis and are remaining free of it throughout the lactation. There are a few older chronic cows in the herd that probably are being milked last. The management techniques being used to control the spread of mastitis in this herd probably include good milking equipment, recommended milking procedures, general sanitation, effective teat dipping, and dry cow therapy.

The herd described in Figure 7 is experiencing a high incidence of mastitis in heifers soon after calving. Some possible reasons would include unsanitary heifer maternity facilities, udder edema, and calf sucking problems. In general, the level of mastitis in this herd, except for heifers fresh less than 30 days, is relatively good.

**In such a case, searching for deficiencies in milking equipment, milking procedures, teat dipping, or dry cow therapy probably would be unproductive. Emphazing heifer management should solve the problem.**

FIGURE 6. A herd in which mastitis is being controlled effectively.

| Yearly SCC Summary | | | |
|---|---|---|---|
| | PCT Positive | | |
| Lact | <30 | 30-220 | >220 |
| No | Dim | Dim | Dim |
| 1st | 0 | 0 | 0 |
| Other | 10 | 7 | 13 |
| All | 7 | 6 | 12 |

Yearly Average Percent SCC Positive = 9

—First lactation cows clean
—Some older chronic cows

FIGURE 7. A herd experiencing a high incidence of mastitis in heifers soon after calving.

| Yearly SCC Summary | | | |
|---|---|---|---|
| | PCT Positive | | |
| Lact | <30 | 30-220 | >220 |
| No | Dim | Dim | Dim |
| 1st | 42 | 1 | 0 |
| Other | 14 | 15 | 21 |
| All | 32 | 9 | 8 |

The herd described in Figure 8 demonstrates the typical pattern that develops when there are poor milking practices, marginal milking equipment, or the failure to teat dip or use dry cow therapy consistently. Any one of these circumstances or any combination of them can result in this type of pattern.

Note that the heifers in this herd begin their lactation, as expected, with no infection. As the lactation progresses, however, seemingly small deficiencies (failure to use separate towels to wash and dry, failure to teat dip constantly, allowing too many air slips, etc.) have the cumulative result of increasing the level of mastitis. By the

FIGURE 8. Typical pattern of increasing mastitis prevalence when management practices during lactation are poor.

| Yearly SCC Summary | | | |
|---|---|---|---|
| | PCT Positive | | |
| Lact | <30 | 30-220 | >220 |
| No | Dim | Dim | Dim |
| 1st | 0 | 46 | 60 |
| Other | 20 | 34 | 37 |
| All | 11 | 39 | 42 |

FIGURE 9. John Dairyman herd SCC Summary.

JOHN DAIRYMAN 101 HAECKER HALL ST PAUL MN 55108

| HERD CODE | MAIL DATE |
|---|---|
| 41-00-0052 | 07-10-84 |

# SCC SUMMARY

SOMATIC CELL COUNT
AN EFFECTIVE TOOL
IN MASTITIS CONTROL

| SAMPLE DATE | PAGE |
|---|---|
| 07-02-84 | 1 |

**CURRENT SCC SUMMARY**

| LACT NO | NUMBER COWS | NUMBER OF COWS ON SAMPLE DAY: 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1ST | 10 | | 3 | 3 | | 3 | | 1 | | | |
| OTHER | 21 | | 2 | 10 | 3 | 1 | 3 | | 1 | 1 | |
| ALL | 31 | | 5 | 13 | 3 | 4 | 3 | 1 | 1 | 1 | |

**HERD AVG SCC**

| | |
|---|---|
| CELLS | 328,000 |
| LINEAR | 3.0 |

**SCC TRENDS**

| LACT NO | PCT POSITIVE: CURRENT | LAST MO | YR AGO |
|---|---|---|---|
| 1ST | 10 | 8 | 0 |
| OTHER | 24 | 10 | 6 |
| ALL | 19 | 9 | 4 |

**YEARLY SCC SUMMARY**

| LACT NO | PCT POSITIVE: ≤30 DIM | 30-220 DIM | >220 DIM |
|---|---|---|---|
| 1ST | 0 | 5 | 3 |
| OTHER | 17 | 16 | 18 |
| ALL | 11 | 11 | 12 |

**LIST OF PROBLEM COWS WITH PERCENT HERD SCC**

CRISCO 54
CB.... 14

DAIRY HERD IMPROVEMENT
DHI 222 9/83

ESTIMATED DAILY MILK YIELD LOST = 39 LBS

YEARLY AVERAGE PERCENT SCC POSITIVE = 11

PREVIOUS SAMPLE DAY MILK POUNDS AND SOMATIC CELL COUNTS (LINEAR SCALE - - - SEE BACKSIDE)

| COMPUTER NUMBER | LACT NUMBER | DAYS IN MILK | CURRENT SAMPLE 7-02-84 MILK | SCC | SCC CODE | BARN NAME | JUN 3, 29 DAYS AGO MILK | SCC | MAY 1, 62 DAYS AGO MILK | SCC | APR 2, 91 DAYS AGO MILK | SCC | MAR 3, 121 DAYS AGO MILK | SCC | FEB 2, 151 DAYS AGO MILK | SCC | JAN 3, 181 DAYS AGO MILK | SCC | DEC 1, 214 DAYS AGO MILK | SCC | NOV 4, 241 DAYS AGO MILK | SCC | OCT 4, 272 DAYS AGO MILK | SCC | SEP 5, 301 DAYS AGO MILK | SCC | AUG 2, 335 DAYS AGO MILK | SCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0069 | 2 | 270 | 21 | 3 | | APACHE | 32 | 4 | 36 | 2 | 40 | 3 | 52 | 1 | 56 | 2 | 61 | 2 | 75 | 1 | 77 | 2 | | | | | | |
| 0077 | 2 | 122 | 60 | 7 | C | CB | 59 | 5 | 73 | 1 | 77 | 2 | | | | | | | | | | | | | | | | |
| 0049 | 4 | 180 | 70 | 8 | NP | CRISCO | 78 | 4 | 67 | 5 | 73 | 3 | 95 | 0 | 103 | 1 | | | | | | | | | | | | |
| 0070 | 2 | 250 | 44 | 2 | | DEANNA | 61 | 3 | 52 | 1 | 53 | 2 | 61 | 0 | 61 | 1 | 73 | 2 | 74 | 7 | 63 | 4 | | | | | | |
| 0043 | 4 | 215 | 63 | 3 | | EFFIE | 71 | 2 | 66 | 2 | 68 | 2 | 76 | 1 | 78 | 1 | 89 | 1 | | | | | | | | | | |
| 0042 | 4 | 174 | 72 | 2 | | ELSIE | 86 | 3 | 84 | 1 | 96 | 2 | 99 | 0 | 90 | 0 | | | | | | | | | | | | |
| 0033 | 5 | 190 | 59 | 2 | | GYPSY | 79 | 3 | 74 | 2 | 78 | 2 | 84 | 2 | 97 | 1 | 69 | 2 | | | | | | | | | | |
| 0061 | 3 | 311 | 22 | 5 | N | HOLLY | 40 | 4 | 42 | 3 | 40 | 3 | 46 | 3 | 58 | 2 | 59 | 3 | 60 | 2 | 74 | 4 | 75 | 3 | 68 | 3 | | |
| 0062 | 3 | 162 | 55 | 2 | | IRIS | 61 | 1 | 70 | 3 | 72 | 1 | 76 | 0 | 70 | 0 | | | | | | | | | | | | |
| 0056 | 3 | 275 | 48 | 5 | C | JILL | 64 | 4 | 61 | 6 | 59 | 5 | 73 | 3 | 84 | 5 | 78 | 4 | 79 | 5 | 85 | 4 | | | | | | |
| 0060 | 3 | 194 | 61 | 4 | | KIM | 73 | 3 | 58 | 7 | 72 | 2 | 76 | 5 | 93 | 4 | 83 | 5 | | | | | | | | | | |
| 0078 | 2 | 149 | 55 | 1 | | LORI | 62 | 1 | 60 | 2 | 69 | 4 | 74 | 7 | | | | | | | | | | | | | | |
| 0076 | 2 | 100 | 63 | 3 | | MAMIE | 57 | 2 | 79 | 2 | 60 | 3 | | | | | | | | | | | | | | | | |
| 0040 | 4 | 152 | 68 | 2 | P | MANDY | 86 | 1 | 77 | 4 | 90 | 5 | 69 | 2 | | | | | | | | | | | | | | |
| 0083 | 1 | 347 | 40 | 1 | | MARLO | 48 | 1 | 44 | 1 | 43 | 2 | 51 | 0 | 52 | 0 | 47 | 1 | 44 | 2 | 44 | 3 | 39 | 0 | 51 | 4 | 43 | 4 |
| 0081 | 2 | 18 | 75 | 2 | | MIKKI | | | | | | | | | | | | | | | | | | | | | | |
| 0064 | 3 | 84 | 77 | 2 | | MOLLY | 91 | 1 | 76 | 1 | | | | | | | | | | | | | | | | | | |
| 0059 | 3 | 227 | 60 | 2 | | NICKY | 75 | 2 | 66 | 2 | 63 | 2 | 79 | 1 | 85 | 1 | 95 | 0 | 85 | 2 | | | | | | | | |
| 0065 | 3 | 72 | 69 | 1 | | PLUTO | 85 | 1 | 65 | 1 | | | | | | | | | | | | | | | | | | |
| 0073 | 2 | 161 | 63 | 2 | | RITA | 74 | 2 | 77 | 1 | 78 | 2 | 87 | 0 | 77 | 2 | | | | | | | | | | | | |
| 0001 | 7 | 287 | 49 | 5 | CP | UNA | 67 | 5 | 63 | 6 | 70 | 6 | 83 | 6 | 88 | 4 | 86 | 4 | 101 | 4 | 96 | 3 | 71 | 7 | | | | |
| 0087 | 1 | 217 | 47 | 2 | | VANESA | 66 | 3 | 56 | 2 | 52 | 3 | 60 | 1 | 59 | 1 | 55 | 1 | | | | | | | | | | |
| 0091 | 1 | 153 | 60 | 4 | | VELMA | 66 | 3 | 65 | 2 | 70 | 3 | 78 | 2 | | | | | | | | | | | | | | |
| 0054 | 3 | 243 | 49 | 2 | | VENUS | 59 | 2 | 52 | 2 | 55 | 2 | 69 | 1 | 69 | 0 | 83 | 1 | 79 | 1 | | | | | | | | |
| 0086 | 1 | 256 | 47 | 1 | | VERA | 63 | 2 | 52 | 1 | 48 | 2 | 59 | 1 | 61 | 1 | 68 | 1 | 65 | 1 | 55 | 3 | | | | | | |
| 0085 | 1 | 251 | 41 | 4 | | VIENNA | 52 | 3 | 47 | 3 | 46 | 2 | 53 | 4 | 57 | 4 | 60 | 2 | 58 | 3 | 50 | 4 | | | | | | |
| 0090 | 1 | 179 | 41 | 2 | | VIOLET | 43 | 2 | 45 | 2 | 48 | 3 | 55 | 2 | 64 | 2 | | | | | | | | | | | | |
| 0092 | 1 | 146 | 33 | 6 | C | VISTA | 40 | 5 | 39 | 5 | 42 | 5 | 41 | 4 | | | | | | | | | | | | | | |
| 0088 | 1 | 215 | 32 | 4 | | VIXEN | 42 | 4 | 37 | 4 | 39 | 3 | 44 | 2 | 42 | 2 | 46 | 2 | | | | | | | | | | |
| 0089 | 1 | 191 | 37 | 1 | | VONNIE | 44 | 2 | 41 | 1 | 39 | 2 | 45 | 1 | 45 | 1 | 39 | 1 | | | | | | | | | | |
| 0094 | 1 | 127 | 37 | 2 | | VYRNA | 44 | 2 | 41 | 2 | 44 | 2 | | | | | | | | | | | | | | | | |

***** NUMBER OF NEW INFECTIONS = 2 COWS ( 6 PCT OF COWS IN MILK) end of the lactation, 60 percent of the heifers in this herd are infected. The owner of a herd with such a pattern needs to analyze milking equipment performance, milking procedures, teat dipping, sanitation, and dry cow therapy.

Herds with mastitis problems due to multiple management or equipment deficiencies throughout the dry period and lactation may not show any of these typical patterns. In such cases, all aspects of mastitis control need serious consideration.

The yearly average percent SCC positive number (see Figure 9), indicates the accumulated percent of all sample day tests conducted during the past year that had a linear score of 5 or higher. It reflects the average situation in the herd during the past 12 months.

*Individual Cow Data*

Individual cow data is listed on the Minnesota SCC Report beneath the herd summaries (Figure 9). When combined with herd summary information, it is useful information in adding the detail necessary to developing mastitis control recommendations and monitoring their effect.

The number of new infections is listed after the last line of cow data. Knowing the rate of new infections each month is a critical monitor of mastitis control. The level of mastitis is dependent on the number of cows presently infected, the duration of the infection, as well as the rate at which new infections are occurring. Therefore, any significant rise in the new infection rate may indicate a breakdown in mastitis control procedures or may indicate improperly functioning milking equipment.

Individual cow cell count data are useful in identifying problem cows and as an aid in making culling decisions. When possible, changing milking order so that high cell count cows are milked last is another means of reducing the spread of contagious mastitis.

Monitoring the SCC's of individual cows at the end of lactation may aid in anticipating potential flare-ups during the early dry off period. Certainly the cow with a consistently high SCC late in lactation needs close observation during this critical period. When individual culturing is deemed necessary, individual cow SCC data can be used to develop a list of those cows to be sampled.

The Minnesota SCC Report lists monthly milk weights and somatic cell scores on individual cows for an entire lactation. A characteristic pattern observed in herds where "environmental" mastitis pathogens predominate is a pattern of intermittent rise and fall of somatic cell scores within individual cows.

**Proper interpretation of herd SCC summaries, as well as individual cow SCC data, facilitates an epidemiological evaluation focusing attention on the most likely management cause (10) of the herd's mastitis problem(s). Combining SCC test results with bacteriological culturing and farm observations will result in the formulation of effective herd specific recommendations. Monthly monitoring of SCC reports provides early warning of management breakdowns and/or effective evaluation of the success or failure of newly initiated mastitis control procedures.**

## Conclusion: Is the SCC a Good Test for Mastitis

Clinical pathologists have suggested the following criteria of a "good" clinical test (28).

A good clinical test should:

- provide correct diagnosis
- provide data to aid in prognosis
- provide an indication of subclinical disease
- provide for monitoring the effects of treatment
- provide data that may indicate possible reoccurrence of chronic disease.

Using 283,000 cells as a threshold, the SCC is 80% efficient in correctly classifying infected and uninfected animals. SCC data is a good indicator of the seriousness of the mastitis problem, offering a prognosis of the biological and economic impacts of the herd problem. SCC programs develop awareness of subclinical disease and are recognized as motivators of mastitis control programs (24). SCC also enables monitoring of udder health as well as the effectiveness of treatment and prevention measures. SCC data provides evidence of chronic mastitis, which may alter considerably the mastitis control strategies. Lastly, an important consideration for a herd health screening test is the test's relative availability and expense. Considering these criteria, the SCC is an excellent screening test for the presence of mastitis.

**However, it needs to be emphasized that the SCC is not a "stand alone" diagnostic procedure. It is only one of the scientifically valid diagnostic screening procedures used to evaluate udder health. The evaluation of a series of SCC's, SCC herd averages, and SCC trends within herds are extremely useful in assessing the mastitis status of the herd. When combined with other data, for example bulk tank or individual cow cultures and the observations of a herd visit, accurate herd specific recommendations can be made.**

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## Questions & Answers:

*Question:*

*Answer:* . . . How we're doing that is if a cow freshens with a linear score of 5 or above, of course she's counted as a new infection and any cow that has a previous score of less than 5 for two months and then has a linear score of 5, we're counting her as a new infection. So it is possible. It's a little game we are playing with the computer. You and I know that a few of those cows that have 5 and then go down to 4 for a couple months and then come back to 5 have probably been infected all along. But on the other side of the coin there are some situations where we have environmental infections that come in for a month, They're out for a couple of months, come back in for a month. That's how we're counting it. I know there are some fallacies in that but that's the way we think that it is strong enough.

*Question:* In blitz treatments for *Strep. ag* what level are you using? Are you doing it in every herd?

*Answer:* We do not recommend blitz treatment in all herds. There are some herds that I've worked with that I wouldn't dare do. I would rather see them correct the problems that are causing the mastitis to be there in the first place, and then begin to possibly institute a treatment program. The reason for that is, there are some producers, as you well know, as soon as you hand them a syringe, they forget everything you've told them about prevention. And all they want to do is treat, treat. If you have a herd that's in trouble and they have a high cell count and they have to get down to legal levels, then I think that's a different situation all together. But we don't make a blanket. We approach every herd individually.

*Question:* In the last herd you gave as an example, was there an attempt to encourage the use of backflush system to reduce the spread that obviously was occurring in this herd, and much of it was a Staph problem.

*Answer:* The answer is, no we did not. The reason is that that is a stall barn and it's difficult for us . . . that's one of the problems we have in the upper midwest, to use some of that technology in our stall barn. And so we didn't. We did try to recommend some strong culling. I think the best quote I ever heard anybody say about a Staph herd, was: "What you need when you've got *Staph. aureus* is lots of gasoline in a long trailer!" But one of the real problems that you have, and you can see in this herd, is you've built up such a massive pool of infection, 80 percent of the cows infected, I think, and my experience is, that when you get a herd up to 50 percent or more and it's a Staph. problem with a herd in a stall barn, you've got almost an impossible task because you've got this immense pool. Every other cow has it, and it is almost impossible to keep that spread down. I wish I did have some better answers for a herd like that which is really in trouble other than culling, because obviously you can't cull everything. You've got to have some cash flow.

*Question:* In a bulk tank sampling, are you considering that all the *Staph. aureus* are coming from the udder?

*Answer:* I thing that brings up a good point. When you're doing any bulk tank analysis, in specific to your question, I would say we are more likely to consider that *Staph. aureus* are coming from the udder than some of the other things. For instance, the environment when we have environmentals in a bulk tank, that does not necessarily mean that they came from the udder. They are in the milk. They came from inside the udder at least, from the outside, or a teat or something. And the feeling with a bulk tank is, if it is in the milk, then it was on the teat and then the opportunity to establish an infection because of an air slip or some other thing is there. Therefore the predominance of the mastitis problem in that herd, if you had, for instance, all non-ag Stephs, is probably due to that organism.