Information and Herd Health Management Practices in Texas Dairies

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Abstract

The dissemination of information by extension agents on dairy management practices used to control mastitis and the reception and use of that information by producers are investigated. Producers are surveyed to determine current practices used. The relationship between milk yield, somatic cell count, management practices, and producer and production characteristics is estimated. Subjective probabilities are elicited from "experts," extension agents, and producers concerning the impact and cost of various management practices. Subjective marginal value products and marginal input costs are computed and compared for the respondent groups. Stochastic dominance is used to rank the relative importance of the practices as perceived by the respondents.

Key Words: information, dairy management, mastitis, subjective probabilities.

Two important responsibilities of agriculture experiment stations and Cooperative Extension Services are to develop new technologies and procedures and to disseminate information about new methods to producers. How efficiently the information is disseminated and the impact the information has on production methods are important concerns of these publicly-funded institutions.

Information about methods to minimize mastitis infections in dairy cows is important to dairy producers , consumers, and agricultural research and extension organizations and is the focus of this study. Mastitis is a general term referring to an infection in a mammary gland. Clinical mastitis is a clearly apparent infection, while sub-clinical mastitis is a non-symptomatic infection that accounts for about 70 percent of the milk loss due to mastitis. Mastitis costs the average U.S. dairy herd the dollar equivalent of approximately 1,500 pounds of milk per cow per year in milk losses, medicine costs, treatment time, and premature culling.[16] The greatest potential for decreasing the effects of mastitis lies in the early detection and treatment of clinical cases and in the reduction of the incidence of sub-clinical mastitis through improved health and herd management programs.[7,16] A substantial part of the economic benefit from improved mastitis control is passed on to consumers through improved product quality (and lower milk prices where prices are free to vary). Therefore, consumers benefit from newly disseminated information and subsequent adoption of improved mastitis control programs.[1]

The National Mastitis Council recommends a mastitis control program consisting of hygienic washing and drying of udders before milking, regular milking machine maintenance, antibiotic therapy on all cows at drying off, and culling of cows with recurrent mastitis.[17] Economic studies of these recommended practices have found them to have substantial returns over costs.[16,17] However, these

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results were from controlled experiments. It is not known if comparable results are obtained under field conditions.

An indicator of udder health is the somatic cell count (SCC), which is a recently available option on the Dairy Herd Improvement Association (DHIA) Cow Page. A low SCC indicates a healthy udder and a high SCC generally occurs when there is a high level of sub-clinical or clinical mastitis.[5,12] The SCC is a "noisy" information signal, but it is the best signal available to indicate sub-clinical mastitis. The negative relationship between milk yield and SCC is well known. Jones et al.[12] estimated that increasing SCC by 200 x 103 lowered milk yields at least 1.0 kg per day in first-lactation cows and 3.0 kg per day in multilactation cows.

The focus of this paper is on dissemination of information by area extension specialists and extension agents about herd management options for controlling mastitis and the reception and use of this information by producers. Specific objectives are to a) identify current management practices used by Texas milk producers; b) estimate the statistical relationship between management practice, somatic sell count, and milk yield; c) compare producers', extension agents', and experts' perceptions of the relationship between somatic cell count and milk yield; d) compare rankings of different management practices by the three groups; and e) compare marginal value products and marginal input costs of different management practices estimated by the three groups.

Information and communications theory as related to extension activities is briefly discussed in the following section. Data, methodology, and results of the analysis are presented next. The last section contains a summary and recommendations for further research.

Information Theory

The term "information" has at least four definitions in the literature.[4] Topics of papers dealing with information have ranged from the costs and benefits of the search for information[22] to the effect of information on prices and market structure[9,20] and the information required for empirical research and for measuring economic well-being.[2] Information in this paper is defined as the product of screening, editing, and evaluating data, and it only has value if it affects actions in a decision-making process.[3] More information (or better information) always makes a producer at least as well off,[11] but there is always the risk that the value of the new information may not be worth its acquisition cost to the producer[a]. Throughout this study it is assumed that producers are aware of the uncertain value of new information, but that some early adopters search out information and adopt new technologies with apparent value. Middle and late adopters of new technologies follow as new procedures are proven.[8] A full mathematical exploration of information and decision making can be found in Marschak and Radner.[14]

Information and communication are given rigorous theoretical and mathematical examinations by Shanon and Weaver.[21] If an information signal is originated at point A and that signal is desired at and sent to point B, the transmission of that signal is a form of communication. The signal faces three kinds of communication problems. First are technical problems such as typographical errors and radio transmission interference, which are problems best left to the engineers. Second is the semantic problem, which is often referred to as the problem of "noisy" information.[13] If the conditional probability is equal to one that x is occurring given the information provided in y (i.e. $P(x|y)=1$), then y is a noiseless information signal. At the other extreme is a signal that gives a probability distribution no different from one's prior beliefs; such information is worthless. Most information is noisy to some extent.

Information has value only if it affects decision-making: if actions with the information are different from actions without the information, then the information has value. This leads to the third problem—effectiveness. If the information affects actions in the desired way, then it is effective. One must ask if the information disseminated by extension agents is noiseless, effective information. That is, do producers adopt the recommended practices, and if so, do the results equal their expectations?

Producers will acquire new information only if the expected value of the information is at least as great as its cost. Likewise, they will adopt a new method only if the expected benefits from the new method are greater than its expected costs. Noiseless information that generates clear and accurate expectations can benefit producers through lower production costs and society through lower commodity prices.

Methodology and Results

Texas dairy producers were surveyed to determine current management practices. The survey data were combined with the respective DHIA herd milk data to estimate the relationship between milk yield, SCC, and management practices for the sample herds. Milk loss functions and subjective probability distributions (SPD) were elicited from experts, extension agents, and producers to see if they shared the same beliefs about the importance and impact of various management practices on milk yield. Stochastic dominance was used to rank the different practices. The estimated marginal value products and marginal input costs for the various practices were compared across respondent groups

[a] In the content of this paper, the risk of the SCC option to producers is that the information contained in the SCC may not be worth the $.12 per cow per month charged by the Texas DHIA. It is assumed that monitoring udder health through the SCC is worth the cost of the producers using it.

Management Practices in Texas

A total of 138 producers in Texas was surveyed in October and November, 1985. This group was identified because they chose the SCC option on the DHIA program. Because of this choice, the potential for selection bias exists. This group's expressed interest in SCC may be an indicator that they are more aware of mastitis and mastitis control methods than is the population of all producers. There is also a potential bias since they are on DHIA, which in itself is optional. However, enrollment in DHIA programs is so common that any bias by being on DHIA is likely unimportant.

Table 1 lists the use of selected practices in the surveyed group. The majority of producers follow many of the

TABLE 1. Description, frequency, and Mean of selected management practices and production characteristics, Texas Dairy Farms, 1985.

Variable	Description	Frequency (%)	Mean
Washing Practices:			
S1	Prep-stall or automated pre-wash used	5.8	
S2	Hand-held sprayer used	70.3	
S3	Combination of hand-held sprayer and prep-stall or automated pre-wash	16.7	
S4	Combination of hand-held sprayer and bucket and sponge	8.7	
S5	Sanitizer used in the washing solution	45.7	
Drying Practices:			
S6	Udders allowed to drip dry (i.e., not hand dried)	25.4	
S7	Single -use paper towels used to dry udders	58.7	
S8	Udder never wet when claw is attached	35.5	
Other practices:			
S9	Pre-milking check on every cow	42.0	
S10	Hospital string milked last	35.5	
S11	Dip teats after milking	94.2	
S12	Dry cow treatment on all cows	77.5	
S13	Antibiotics changed on a regular basis	10.9	
S14	Milking machines inflations changed on a regular basis	25.4	
S15	Milking system checked every six months or less	50.0	
S16	Veterinarian visits on a regular basis	36.2	
S17	Clinical mastitis a basis for culling	71.0	
Production and Producer Characteristics:			
P1	Stated SCC level a cow consistently has for culling		6.56
P2	Owner does most of milking	32.6	
P3	Age of owner/operator		40 years
P4	Years owner/operator in dairying		18 years
P5	Years managing own farm		13 years
P6	Years of schooling of owner		college graduate[iii]
P7	Owner/operator frequently attends dairy extension seminars	42.8	
P8	Lactation number		2.52
P9	3rd 5th month of lactation	36.5	
P10	6th and later month of lactation[i]	45.0	
P11	Number of cows in herd		204.1
P12	Herd milk yield average less than 14,300/lb./yr.	50.3	
P13	Herd milk yield average greater than 16,940/lb./yr.[ii]	11.2	

i 18.5 percent of the cows were in the 1st or 2nd month of lactation.

ii 38.5 percent of the herds reported herd milk average of 14,000-16,490 pounds per year.

iii Years of schooling were measured discreetly (i.e., some high school, some high school graduate, some college, college graduate, graduate or professional school).

practices recommended by the National Mastitis Council, but only 30 percent of them employ all five recommendations practices (washing and drying udders before milking, regular milking machine maintenance, teat dipping, dry cow treatment, and culling cows with recurrent mastitis). There are still 5.8 percent who do not teat dip, 22.5 percent who do not treat their cows with an antibiotic at the end of the lactation period (dry cow treatment), and 29.0 percent who do not consider mastitis as a culling criterion. These percentages are somewhat surprising for a group that one would expect to have a high level of awareness about mastitis prevention and control.

Statistical Model

It is well documented that a high SCC affects milk yeild[12] and that certain management practices affect SCC,[16,17] but for the most part these results have been from controlled experiments. Often there is a difference between experimental results and the results producers obtain in the field. To verify the relationship between milk yield and SCC under field conditions and to see if producers receive the expected results from recommended mastitis control practices, a three stage least squares model was used to analyze data for February, 1986, from 22,998 cows in the 138 Texas dairy herds. Milk yield and SCC were estimated as a system because it is known that a relationship exists between milk yield and SCC, but that relationship is not clearly understood.

The milk yield equation was estimated as a cubic function of SCC and six production characteristic variables. The cubic form was used to facilitate comparing results with the Jones et al.[12] study, and also to allow for increasing and decreasing responses[b]. The SCC in the model is the score reported to the producer and is measured in log base 2. The SCC score equation was estimated as a linear function of 17 management practices and 13 production and producer characteristics. The SCC score is a jointly dependent variable, so instruments for it were estimated using the management practices and producer and production characteristics.

A description of the management practices and production characteristics is provided in Table 1. The management practices and production characteristics included in the model are those identified in the, literature as most likely to affect milk yield and SCC. The management practiced entered the model as binary variables (i.e., $S^i=1$ if the dairy employs the i^{th} practice, otherwise $S_i=0$). Continuous producer and production variables entered at their respective values. The average daily milk yield and production characteristics came from DHIA records for the herds surveyed. The management practices and producer characteristics were obtained from the survey[c].

[b] Nested tests on the quadratic and cubic log SSC terms yielded t–statistics of 17.11 and 6.44, respectively (significant at the 1 percent level). Jones et al. did not publish their parameter tests.

[c] Most dairy production studies account for unobservable differences across herds with binary dummy variables. The mix of management practices and herd and producer characteristics was assumed to account for most of the differences across herds that are usually unobserved. Consequently, herd dummy variables were not included in this model.

TABLE 2. Estimated three stage least square recursive model of milk yield and somatic cell counts, Texas dairy farms, 1985 1986.

Variable[a]	Parameter Estimate	Standard Error
Dependent Variable: Average Daily Milk Yield (lbs.)		
Independent Variables		
Intercept	64.992	0.861*
SCC[b]	0.010	0.351
SCC^2	- 0.555	0.032*
SCC^3	0.027	0.004*
P8	1.753	0.109*
P9	- 8.588	0.353*
P10	- 21.134	0.410*
P11	- 0.015	0.001*
P12	- 8.985	0.264*
P13	11.200	0.390*
Dependent Variable: Somatic Cell Count Score		
Intercept	2.790	0.171*
S1	0.577	0.079*
S2	- 0.071	0.052
S3	- 0.180	0.091**
S4	0.001	0.098
S5	0.143	0.033*
S6	0.181	0.060*
S7	0.193	0.055*
S8	- 0.001	0.037
S9	0.221	0.036*
S10	0.221	0.034*
S11	- 0.479	0.067*
S12	0.018	0.034
S13	0.006	0.053
S14	0.421	0.038*
S15	- 0.080	0.041*
S16	0.092	0.039**
S17	- 0.008	0.035
P1	0.016	0.009
P2	- 0.052	0.036
P3	0.002	0.002
P4	0.004	0.002
P5	- 0.015	0.003*
P6	- 0.096	0.015*
P7	- 0.157	0.033*
P8	0.266	0.008*
P9	0.405	0.037*
P10	0.763	0.036*
P11	- 0.001	0.0001*
P12	0.021	0.034
P13	0.076	0.542

Weighted R^2 for System = 0.2600.
[a] See Table 1 for definitions of variables.
[b] SCC score is a log base 2 score.
* Significant at the = .01 level.
** Significant at the = .05 level.

Parameter estimates and standard errors for the model are reported in Table 2. The model explained 26 percent of the variation in milk yield and SCC. Milk yield and SCC are clearly negatively related over observed SCC levels. Jones et al.,[12] using data for Virginia, also estimated a negative relationship, but with much different magnitudes. An increase in the SCC score to 5 from 0 decreased milk yield 5.5 percent for a first-lactation cow and 13 percent for later-lactation cows in the Jones et al.[12] study, and 16 and 15 percent respectively, in the present study. The greater impact of SCC on milk yield estimated from the Texas data indicates an increased importance of the SCC score as an information signal.

Among the expected results from the second equation (Table 2) is that use of a pre-stall or automated pre-wash (S1) has a strong positive effect on SCC. Previous research has indicated that the savings in labor cost from a prep-stall may be offset by increased udder problems.[23] Washing with a hand-held sprayer (S2) lowers SCC. A hand-held sprayer combined with a prep-stall (S3) has the second largest negative impact on SCC in this model, but combining a hand-held sprayer with a bucket and a sponge raises the SCC slightly (S4). Teat dipping after milking (S11) is a recommended and widely adopted practice that is expected to lower SCC, and it does so significantly, with the largest negative impact on SCC in this model. It is expected and confirmed in this model that allowing the udder to drip dry (S6) increases SCC while always having udders that are dry when the claw is attached (S8) lowers SCC, but not significantly (10% level). Servicing the milking system every six months or less (S15), regular (as opposed to emergency only) visits by a veterinarian (S16), and using clinical mastitis as a basis for culling (S17) all lower the SCC, but the last is not significant. The expectation that SCC increases with later lactations (P8) and with the stage of lactation (P9, P10) is confirmed in this model.

Increased information and experience appear to lower the SCC. When the owner does most of the milking (P2) the SCC decreases, but not significantly. Lower ownership and management of a farm (P5), more education (P6), and regular attendance at dairy extension meetings (P7) are associated with lower SCC.

Unexpected results occurred for some recommended and widely used practices. Using a sanitizer in the washing solution (S5) and drying udders with single-use paper towels (S7) are recommended, but both practices were associated with increased SCC. Dry cow treatment (S12) is also widely used and recommended but appears to have a small but significant positive impact on the SCC. Using a pre-milking gross check (S9) and milking a separate hospital line last (S10) show an increased SCC. It is possible that some of these relationships could be spurious since producers may adopt these practices when a problem develops; thus. a high SCC may cause introduction of these practices rather than vice versa.

It is generally believed that larger herds have a higher SCC6, but this model shows larger herds (P11) have a slightly lower SCC. This result is especially important since the average dairy herd in Texas is increasing in size. Finally, it is usually thought that higher producing herds have a higher SCC because of the stress of higher production, but this study shows no significant difference in the SCC between low (P12), medium, or high (P13) producing herds.

The statistical model confirms the negative relationship between SCC and milk yield and supports the effectiveness of proper washing, teat dipping, assuring dry udders at milking, frequent milking system servicing, and regular veterinarian visits. It shows the benefits of experience and formal and continuing education of the operator. It raises questions about the benefits of prep-stalls and pre-washes, the use of sanitizers in the washing solution, single-use paper towels, and dry cow treatment. It challenges the common beliefs about large herd size and high production levels being associated with a high SCC.

Subjective Probability Distributions

Methods: To determine whether the information signal sent by the experts is the same signal that is received by the producers, beliefs about the relationship between milk yield and SCC (i.e., the milk loss function) and subjective probability distributions of a herd's SCC given various management scenarios were elicited from "experts," extension agents, and producers. "Experts" were identified as current and past members of the National Mastitis Council and persons recommended by members of the Council. Extension agents were Texas-area dairy specialists and agents in Texas counties where dairying is a major agricultural enterprise. Producers were randomly selected from Texas dairy producers who enrolled in DHIA's SCC option as of July, 1986. Eight experts, eight extension agents, and eleven producers were interviewed in July and August, 1986. Respondents were asked to participate by telephone, and then surveys were sent to them. The respondents' milk loss functions and subjective probability distributions were elicited during a second phone call.

Milk Loss Functions: To elicit the subjective milk loss functions, respondents were asked to think of a hypothetical second-lactation cow in her second month of lactation, producing 100 pounds per day with a "perfect" SCC score of zero. The respondents were asked how many pounds per day they thought the cow would produce as her SCC score increased, *ceteris paribus*[d]. The mean and standard

[d] 100 pounds was used as a starting point to make it easy to state a percent reduction. This yield occurs with some frequency. The cows in the sample with a daily yield of 90 pounds or more is 3.6 percent, which is not infrequent for a single month, especially considering that most calvings are from September to December, resulting in a small proportion of the herd being in peak production in February. Also, February is traditionally not a peak production month.

deviation for the three groups' milk loss functions and the statistical model's predictions are given in Table 3.

TABLE 3. Average milk yields for specified SCC scores predicted by experts, extension agents, producers, and the statistical model.

SCC score	Experts	Agents	Producers	Model
	Estimator			
	- - -milk yield (lbs.)- - -			
0	100.00	100.00	100.00	100.00
	(–)	(–)	(–)	(–)
1	99.12	99.06	98.04	99.23
	(1.81)[a]	(1.70)	(2.94)	(0.35)[b]
2	98.25	96.97	95.91	96.92
	(3.61)	(3.32)	(5.78)	(0.35)
3	95.78	95.81	91.32	93.38
	(4.91)	(4.77)	(8.35)	(0.35)
4	94.49	91.50	87.00	89.08
	(5.90)	(7.48)	(10.01)	(0.35)
5	90.14	88.62	79.50	83.85
	(5.86)	(8.72)	(15.80)	(0.35)
6	83.04	81.75	74.09	78.15
	(11.81)	(15.65)	(18.83)	(0.35)
7	76.30	76.62	69.32	72.31
	(15.14)	(19.65)	(20.75)	(0.35)
8	68.45	71.62	64.64	66.61
	(21.14)	(22.9)	(21.70)	(0.35)
9	64.90	66.00	59.95	60.92
	(23.91)	(25.46)	(22.67)	(0.35)

a Standard deviations of the responses are in parentheses.
b The standard error of the estimates for the model is computed from Var(a + b + c) = var(a) + var(b) + var(c) + 2cov(ab) + 2cov(ac) + 2cov(bc).

The experts and agents appear to have similar milk loss functions, while the producers have one that is larger, but the differences between the functions are not significantly different from zero. All of them believe that milk yield decreases as a cow's SCC increases. Experts generally have the smallest standard deviations of the three sets of respondents and producers the largest. This indicates that there is more consistency among the experts' and the agents' beliefs than among the producers' beliefs. However, the producers' milk loss function is the closest to the statistical model's predicted values for five of the nine SCC scores. Close agreement between the producers' milk loss function and the statistical model fit to field data suggests that as a group these producers accurately understand the relationship between the SCC information signal and the expected milk loss, but the large standard deviations indicate that individual produces are troubled by noise in the signal.

Probability Distributions: Subjective probability distributions (SPD) were elicited by giving each respondent a hypothetical 100-cow dairy with a specific management scheme and then requesting estimates of the number of cows that would be in each of the ten SCC score classifications[e]. The management schemes were changed, one practice at a time, and new SPD's were elicited. The cost of each practice, or the savings realized by not following the practice, was also elicited. The six scenarios are presented in Table 4.

TABLE 4. Scenarios used to elicit SPD from Texas dairy farmers, 1986.

Scenario	Management Practices
1	Washing udders with a water/sanitizer solution and a hand-held sprayer, drying udders with single-use paper towels, teat dipping all quarters of all cows after milking, treating all quarters of all cows with an antibiotic at drying off, having the milking system serviced every year, and culling "problem cows."
2	Eliminate the teat dipping.
3	Eliminate antibiotics at drying off.[a]
4	Eliminate sanitizer from the washing solution.[a]
5	Eliminate drying with paper towels.[a]
6	Service milking system every six months instead of once a year.[a]

a Previously eliminated practices are included.

The expected dollar value per cow per lactation of each scenario is computed by multiplying the SPD by the milk loss function and multiplying the result by the current milk blend price in Texas ($13.09 per cwt.). The marginal

e This method does not explicitly elicit a probability distribution for one cow, but the probability is given that a cow randomly chosen from the herd has a specific SCC score. In effect, the elicited distribution is a probability distribution.

TABLE 5. Subjective marginal value products (MVP) and marginal input costs (MIC) of selected management practices of experts, agents, and producers, and predicted marginal value products from the statistical model.

Practice	Experts MVP	Experts MIC	Agents MVP	Agents MIC	Producers MVP	Producers MIC	Model MVP
	$/cow/lactation						
Teat dip	77.49[a]	12.87	135.64	8.24	119.17	16.06	53.54
	(76.39)[b]	(4.70)	(176.31)	(4.91)	(98.60)	(13.68)	(7.50)
	(1.30)[c]		(1.14)		(0.72)		
Dry cow treatment	80.57	6.00	141.75	4.69	132.36	5.73	1.96
	(74.73)	(2.20)	(135.16)	(2.66)	(112.09)	(1.95)	(3.70)
	(1.18)		(0.38)		(0.76)		
Sanitizer	0.76	4.19	116.27	5.60	37.64	4.58	15.18
	(2.14)	(3.19)	294.04)	(6.06)	(75.50)	(3.25)	(3.49)
	(2.83)		(2.82)		(2.82)		
Paper towel	33.94	7.74	210.23	10.50	91.84	11.84	20.42
	(63.11)	(3.27)	(287.92)	(9.68)	(103.42)	(13.54)	(5.78)
	(2.69)		(2.58)		(1.17)		
System servicing	14.41	0.96	54.66	0.77	24.51	0.72	7.91
	(24.33)	(0.43)	(93.91)	(0.45)	(43.16)	(0.43)	(4.42)
	(2.46)		(2.34)		(2.85)		

[a] Based on a 305 day lactation.
[b] Standard errors are in parentheses below the MVP.
[c] Third moments (skewness) of the distributions are in parentheses below the standard errors.

value products (MVP) are computed by setting scenario 1 as a benchmark and comparing the expected values of the different scenarios. The marginal input costs per cow (MIC) are the costs of the practices as given by the respondents. The subjective MVP's from the statistical model are presented in Table 5. All the subjective MVP's are positive and are far greater than the subjective MIC's, except for the experts' beliefs about sanitizers in the washing solution. The experts as a group do not believe sanitizers have a benefit greater than their cost. The MVP's computed from their statistical model are positive only for teat dipping and servicing the milking system more often.

For all the practices, agents have the largest MVP's and the largest standard errors, indicating that they believe these practices have a large economic impact, but there is a large difference of opinion about that impact. Experts have the smallest MVP's. The very large standard deviations for all the groups' MVP's are due to highly skewed distributions. Except for the producers' MVP distribution for dry cow treatment, all the MVp's have a positive skewness parameter (third moment), which indicated the distribution is skewed to the right. This positive skewness reflects the fact that the MVP's range from zero to very large positive numbers.

Ranking Practices: Stochastic dominance was used to rank different management practices for each respondent. The different scenarios can be ranked by ordering the MVP-MIC = marginal net returns, but such a ranking is based on only the first moment of the subjective distribution. Stochastic dominance can be used to determine which scenario dominates, or is preferred, over the full range of moments. Given two cumulative SPD's of income-generating practices, f(y) and G(y)m, they can be compared using first and second degree stochastic dominance (FSD, SSD), or stochastic dominance with respect to a function (SDF).[10,15] FSD states that F(y) dominates (is preferred to) G(y) if $[F(y)-G(y)] < 0$ for all y. SSD is weaker than FSD and allows for the two distributions to be equal or cross at one or more points

(i.e., $\int_{-\infty}^{y} [F(y) - G(y)]dy < 0$ for all y).

SDF takes into account the utility function or risk preferences of the decision maker;

$$\int_{-\infty}^{y} [F(y) - G(Y) \mu(y)\, dy < 0 \text{ for all y.}$$

A decision maker with a given set of risk preferences may prefer F(y) to G(y, while another decision maker with different risk preferences may prefer G(y). It was assumed that the decision maker is not a risk preferrer. The Pratt risk aversion parameter, r(x), was varied from zero to $2(\mu)/\sigma^2$; $2(\mu/\sigma^2 = r(x)$, is equal to a certainty equivalent of zero[f]. Thus, the decision makers' risk preferences were ranged from risk neutral to risk averse, however, the degree of risk aversion did not change the rankings. The STODOM algorithm[19] was used to obtain the rankings.

The scenarios for each respondent ranked from most preferred to least preferred are reported in Table 6. The experts are most consistent as a group, and the agents are least consistent. Sixty–three percent of the experts rank scenario #4 (deleting sanitizer from the washing solution) first. Eighty-eight percent of them rank plain water over a water/sanitizer solution (#4 over #1). The statistical analysis also shows an unfavorable relationship between sanitizers and SCC. one half of the experts rank #3 (no dry cow treatment) as the worst scenario and 37 percent rank #2 (eliminate teat dipping) as the worst one. Dry cow treatment is a strongly recommended practice in all publications, but has a small, positive relationship with SCC in the statistical analysis. Teat dipping is also strongly recommended and has the largest estimated negative effect on SCC in the statistical analysis.

Table 6. Ranking of the six scenarios by experts, agents, and producers, from most preferred to least preferred.

Respondent number	Expert	Agent	Producer
1	6/1/4/2/5/3	1/4/6/5/3/2	5/4/6/1/3/2
2	4/1/6/3/2/5	1/4/2/3/5/6	1/6/4/2/3/5
3	4/6/1/5/3/2	6/1/4/2/5/3	6/1/4/2/3/5
4	5/4/1/6/3/2	1/5/2/3/6/4	4/5/1/6/2/3
5	4/5/1/6/2/3	2/4/1/6/5/3	6/4/1/5/2/3
6	5/4/1/6/2/3	4/1/2/3/5/6	2/3/1/4/6/5
7	4/1/6/5/2/3	6/1/2/3/4/5	4/2/3/6/1/5
8	4/1/6/5/3/2	2/4/3/1/6/5	6/4/1/2/5/3
9			4/1/3/2/6/5
10			4/1/6/2/5/3
11			6/1/5/2/3/4

[f] The certainty equivalent (CE) is a guaranteed payoff that would make an individual indifferent between a risky proposition, $X = P(\mu,\sigma^2)$, and the CE. The CE takes into account the variance of the risky proposition and the risk aversion of the individual (i.e., $CE = \mu - 1/2\ \sigma^2\ r(X)$). A risk aversion parameter of zero indicates a risk neutral individual. As r(X) increases, the level of risk aversion increases, with CE = 0 as the upper limit.

Thirty-six per cent of the producers rank #6 (service milking system every six months or less) first; 27 percent rank #4 (no sanitizer) first. There is no majority, but 91 percent of them do rank #4 or #6 as either first or second. The statistical analysis shows a small, negative parameter for #6. Plain water is ranked over a water/sanitizer solution by 64 percent of the producers. There is no majority opinion on the worst scenario. Forty-five percent rank $5 (no single-use paper towels to dry udder) as worst; 36 percent rank #3 (no dry cow treatment) worst. Both of these practices have small, positive parameters in the statistical analysis.

The agents exhibit no consensus. Thirty-seven percent rank scenario #1 (all recommended practices) first. Scenarios #2 (no teat dipping) and #6 (increased servicing of milking system) are ranked first by 25 percent of the agents. A water/sanitizer solution is preferred over plain water by 37 percent of the agents, and plain water is preferred over water/sanitizer by 63 percent. The worst case is spread out over all scenarios except #1.

The lack of consistency both among the extension agents and with the other groups of respondents is noteworthy. It is possible that the agents had a cognitive problem, or that they did not understand the questions or the scenarios, but the other two groups were given the same survey under the same conditions and had more consistency in their answers. The subjective MVP's show that the agents believe the practices discussed are important. They do not agree with the experts or the producers, however, about the order of importance.

Summary and Recommendations

The survey of Texas dairy producers shows that the majority of them are using most of the mastitis control practices recommended by the National Mastitis Council, but only about one third of them use all five recommended practices. The statistical analysis supports the use of some of the recommended practices (e.g., washing udders with a hand-held sprayer and teat dipping after milking) and shows that producers with the lowest SCC are those who pay explicitly for information in the form of regular visits by a veterinarian and implicitly for information by regularly attending extension seminars.

The statistical analysis also raises questions about the use of sanitizers in the wash water, the use of prep-stalls and pre-washes, single-use paper towels, and dry cow treatment. Further study of these practices is required, especially on use of paper towels and dry cow treatment, to determine why results from field data are different from controlled experiments.

All the groups believe that the SCC is an informative signal about the milk yield, but the experts and agents do not expect increases in SCC to depress milk yield as much as the model predicted. Large standard deviations for subjective milk loss functions indicate the SCC score is a confusing information signal. This confusion as to what the SCC score means decreases its effectiveness as an information signal.

Experts and producers show some consistency in ranking the six management scenarios, but agents have widely different rankings. Agents expect the impact of the recommended practices on milk yield to be greater than experts and producers expect them to be. All respondents believe the MVP of the practices is much greater than the MIC of the practices, except that the experts do not believe that adding a sanitizer to the washing solution id cost effective. The MVP;s have large standard deviations and highly-skewed distributions.

Inconsistency among the agents could lead to credibility problems. Their information is that the SCC is a good signal and the recommended mastitis control practices are good, but as a group they appear to suffer from the "salesman's belief." In this case it is the belief that the recommended management practices will have an impact greater than the users, the experts, or the statistical model estimates them to have. The agents have "sold" the practices as shown by the number of producers employing the practices, but there is confusion among the agents about the relative importance of the different practices and the amount of noise in the SCC information. Producers may receive conflicting signals if they want to adopt new practices one at a time starting with the practice that has the largest impact on net expected returns.

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