Expert Assessment Study of Milking and Hygiene Practices Characterizing Very Low Somatic Cell Score Herds in France

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ABSTRACT

French dairy herds were selected on a national basis through the “Zero Mastitis Objective” Program (ZMP) to display hygiene and milking practices characterizing very low somatic cell score (SCS) herds. The herds selected were stratified in 2 groups. The first group (LOW) included 187 herds within the first 5 percentiles of herds regarding mean SCS for the 36 mo preceding ZMP (36-mo SCS). The second group (MED) included 117 herds within the 50 to 55th percentile of herds regarding 36-mo SCS. Mean milk SCS was 3.09 in the MED herds vs. 1.99 in the LOW herds, which corresponded to 265,000 and 135,000 cells/mL respectively. Moreover, LOW and MED herds did not change from one SCS category to another during ZMP. Potentially explanatory variables, collected by formally trained dairy management experts through observations from attendance at milking and farm visits, were analyzed using multistep logistic regression models. According to final model and expert observations, the probability for a herd to belong to the LOW group was maximized when: 1) winter cleanliness of dry cow shed was good; 2) use of teat spraying was carried out; and 3) California Mastitis Tests were performed at milking. Moreover, the herd probability of belonging to the MED group was maximized when: 1) air admission at teat cup attachment was observed during milking; 2) winter cleanliness of dry cow shed was poor; and 3) the milker spent time during milking to feed calves. Finally, the study highlighted milking and hygiene variables and attitudes appearing as key practices to control herd SCS through precise and safe milking and more attention paid to individual animals and cleanliness of dry cow shed.

(Key words: somatic cell score, expert assessment, dairy management, milking hygiene)

Abbreviation key: 36-mo SCS = arithmetic mean of all monthly cow SCS values determined in a herd during the 36 mo preceding the study, CMT = California Mastitis Test, LOW = very low SCS herds, MED = medium SCS herds, ZMP = Zero Mastitis Objective Program.

INTRODUCTION

Managerial and financial abilities of the dairy herdsman are key points for profitability and survivability of a dairy farm (Young and Walters, 2002). Farmers' attitudes and personal characteristics, interests, and tactics, as well as a lot of subjective technical choices constitute different facets to weigh up to highlight good management practices and motivate the producer to change hygiene routines.

Comparing management practices of high quality herds to medium or poor quality herds is a new way to highlight dairy farming procedures associated with a high degree of control of clinical and subclinical udder infections (Hutton et al., 1990; Barkema et al., 1998). Several strategies were used to describe management and hygiene variables discriminating between groups of herds experiencing different milk SCC levels. The most frequently used strategy concerns interviews with herdsmen to collect herd practices from questionnaires (Barkema et al., 1998; Barnouin et al., 2004) or milking management scoring instruments (Goodger et al., 1993). Such a method enables the collection of relevant and reliable answers, insofar as the interview 1) concerns herds with a stable dairy management including stable milking and housing systems and; 2) is conducted through clear and accurate questions covering all aspects of procedures, decisions, and attitudes playing a potential role in udder infection. Obviously, the interviews are not able to identify management defects.

Measuring specific indicators of udder conformation (Slettbakk et al., 1995), animal welfare (Rennie et al., 2003), bedding hygiene and indoor climate (Faye and Barnouin, 1985; Ward et al., 2002), psychological traits of the farmer (Young and Walters, 2002; Rennie et al., 2003), and milking machine performance can be useful

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additional information collected from farmer interviews. However, such indicators do not apply to all dairy management key-points, are not representative, and can be time and money consuming. Consequently, they cannot be always performed in field epidemiological studies including a large number of herds.

To study a herd milk SCS problem, much specialized and detailed knowledge is necessary to evaluate and compare milking practices; such expertise generally lacks in first-line dairy farm advisors (Hogeveen et al., 1995). Consequently, assessment of management practices by trained dairy management experts could help, in addition to questionnaires and indicators, to illustrate those practices and attitudes (of herdsman) that characterize a high degree of control of herd SCC. Nevertheless, as few people are formally trained to evaluate milking and hygiene practices (Goodger et al., 1988), the number of available experts appears to be a limiting factor regarding the generalization of dairy management expertise.

The present work was performed in French dairy farms selected on a national basis through the “Zero Mastitis Objective” program (ZMP). Expert observations based on management knowledge (longitudinal assessment) and unexpected attendance at milking (transversal assessment) were analyzed to underline hygiene practices and milker’s attitudes discriminating between very low SCS herds during at least 5 yr (i.e., “going beyond the objective concerning herd SCS control”) and medium SCS herds during at least 5 yr (i.e., “reaching the current objective concerning herd SCS control”).

MATERIALS AND METHODS

General Program

Data resulted from ZMP, a national mastitis control program carried out in France from February 1999 to July 2001 (Barnouin et al., 2004). The ZMP objectives were to display, through several complementary studies conducted at herd and cow levels, dairy management and treatment practices characterizing farms with a high degree of udder health control. The ZMP herds ($n = 586$) were enrolled according to the following criteria: 1) included in the national DHI database; 2) located in the departments (i.e., counties; $n = 48$) in which DHI volunteered to collaborate with ZMP; 3) at least 20 cows; 4) at least 90% of the cows belonging to the same breed (Holstein, Montbéliarde, or Normande); 5) no vaccination against mastitis; and 6) no significant change in the breeding system throughout ZMP. The enrolled herds were sampled according to previous 36-mo history of SCS (**36-mo SCS**), because SCS [$\text{SCS} = \log_2(\text{SCC}/100.000) + 3$] is a criterion not biased by milk

discarding. Two herd samples were set up and stratified by region and breed as key SCC variation factors. The very low SCS group (**LOW**) included herds belonging to the first 5 percentiles of herds regarding 36-mo SCS. The LOW Montbéliarde herds had scores ≤ 1.99 , LOW Holstein herds had scores ≤ 2.38 , and LOW Normande herds had scores ≤ 2.76 . The medium SCS group (**MED**) included herds belonging to the 50 to 55 percentiles of herds regarding 36-mo SCS. The MED herds had 36-mo SCS greater than but close to the median breed value (i.e., 2.78 for Montbéliarde herds, 3.22 for Holstein herds, and 3.32 for Normande herds). Moreover, LOW and MED herds did not change from one SCS category to another during the 30-mo study period. In each department, the herds were chosen in the ratio of 3 LOW to 2 MED, because a ZMP objective (independent of the present study) was to describe herd practices linked to clinical mastitis risk. In each department, the number of surveyed farms depended on the number of herds that each local DHI could survey.

Herd Selection

The study concerned all the ZMP herds in which an expert assessment of milking and hygiene practices could be carried out. Consequently, the herds that left ZMP ($n = 32$) for various reasons (bovine spongiform encephalopathy occurrence, DHI resignation, lack of time) or in which the expert assessment could not be performed because a trained expert was not available ($n = 240$) were not selected. Finally, 304 herds (187 LOW and 117 MED) were considered for statistical analysis, representing 57.4 and 56.2% of the ZMP total numbers of enrolled very low and medium SCS herds, respectively.

Data Collection

Ninety-two trained experts appointed by DHI collected information from February to July 2001 in LOW and MED selected herds during unexpected farm visits including expert attendance at one milking to observe milking practices and teat and udder lesions of the milked cows. A trained expert was a dairy farm advisor who 1) had an elaborate knowledge of the management practices of the surveyed herds; and 2) followed a formal training process in milking and dairy management audit including a specialist course during which milking audits were conducted to standardize expert scoring practices. The original ZMP expert procedure did not include any farmer interviews. Expert assessment data consisted of explanatory SCS variables that were validated by the consensus of a working group and pilot interviews of farmers outside ZMP. The expert assess-

ment procedure concerned 89 variables. Sixty-two variables were related to management and hygiene, and were collected through milking attendance (number of milked cows, milking time, number of milkers, premilking, milking, and postmilking practices, milking atmosphere, mastitis detection). Eleven variables were teat and udder lesion descriptors. Sixteen variables corresponded to expert advice on a farmer's ability to manage animal welfare, cow shed hygiene, milking, and feeding. Milking and hygiene practices were answered yes or no, or were continuous data (e.g., milking time, percentages of cows with teat and udder lesions). Expert advice on farmers' management practices was categorized as good, medium, or poor. In each herd, the experts completed a form to report their observations and advice. The forms were transmitted through DHI to the Animal Epidemiology Research Unit (INRA, St-Genès Champanelle, France). Data were stored in the ZMP Access 2000 relational database. Milk parameters were extracted from the national DHI database. A set of automatic logical procedures was implemented through the ZMP database to detect potential erroneous entries. Moreover, double data keyboarding was performed independently by 2 technicians to check keyboarding errors.

Statistical Analyses

The statistical procedure was conducted using SAS/STAT 8.1 (SAS Institute, 1999). The dependent variable was the group of herds based on SCS (LOW vs. MED). Herd variables shared by the whole sample were analyzed through 3 steps. First, 33 significant variables ($P < 0.25$; Table 1) were selected using χ^2 and Wilcoxon tests. In a second step, the correlations between the selected variables were analyzed, and if variables were correlated (condition index >30 or correlation coefficient >0.15), only the variable with the best fit was included in a multivariate model. In a third step, 20 uncorrelated variables were offered to a multiple logistic regression using a backward algorithm, in which the probability that a herd belonged to the LOW group was modeled. Assessment of how the models fit the data was determined using the Hosmer-Lemeshow test (Hosmer and Lemeshow, 1989), residual distribution, and deviance analysis. Five variables were significant ($P < 0.05$) through the final logistic model, which were considered the expert assessment variables discriminating between LOW and MED herds.

RESULTS

Somatic Cell Score

Mean milk SCS was 3.09 in the MED herds vs. 1.99 in the LOW herds (Table 2). These SCS corresponded to

265,000 and 135,000 cells/mL, respectively. Moreover, there were 2.75 times more ($P < 0.001$) cows with a monthly SCC greater than 800,000 cells/mL, and 1.90 times fewer ($P < 0.001$) cows with a monthly SCC lower than 50,000 cells/mL in the MED than in the LOW herds.

Descriptive Results

Milk yield per cow was higher in the LOW herds ($P < 0.01$), whereas annual milk quota did not differ among groups. Number of milked cows was lower ($P < 0.01$) in the LOW herds. Numbers of simultaneous milkers, percentages of primiparous cows, and milk protein and fat contents did not differ among groups (Table 2).

Univariate Analysis

Table 3 shows the univariate analysis of the $P < 0.05$ explanatory variables offered to multivariate analysis. Among these variables, the most discriminating ($P < 0.001$) was "winter cleanliness of dry cow shed", which was good, medium, and poor in 27.8, 51.3, and 20.9% of LOW herds, vs. 8.5, 42.7, and 48.7% in MED herds.

Multivariate Analysis

In the final logistic model (score = 57.80, $P < 0.0001$, 6 df; Table 4), the goodness-of-fit test indicated that the data fit the model well ($P = 0.893$). The deviance was 27.90 on 33 df ($P = 0.719$), the residual plots confirmed the fit of the data, and the model classified 74.4% of the herds into the correct category. According to final logistic model, the probability of a herd belonging to the LOW group was maximized when 1) winter cleanliness of dry cow shed was good ($P < 0.01$); 2) teat spraying was used ($P < 0.05$); and 3) the California Mastitis Test (CMT) was performed on at least one cow during milking ($P < 0.05$). According to the logistic model, the herd probability of belonging to the MED group was maximized when 1) air admission at teat cup attachment was observed during milking ($P < 0.01$); 2) winter cleanliness of dry cow shed was poor ($P < 0.01$); and 3) the milker spent some time to feed calves during milking ($P < 0.05$).

DISCUSSION

Data concerning the study of dairy management practices characterizing low SCC herds were collected by means of questionnaires through interviews of the farmers (Schukken, 1990; Barnouin et al., 2004) or postal surveys (Peeler et al., 2000). To assess data quality obtained from farm questionnaires, it is advisable

Table 1. Significant ($P < 0.25$) expert assessment variables ($n = 33$) through univariate analysis in very low and medium SCS groups of herds.

Topic	No. of variables	Variable (abbreviated wording)
Expert advice on dairy management	14	Animal welfare regarding climatic conditions Animal welfare: awareness Cow flanks and back humidity Cow shed surroundings: maintenance Cow shed ventilation Dry cows: winter cow shed cleanliness Feeding: awareness Cow bedding area humidity Milking cows: winter cow shed cleanliness Milking hygiene Milking technique Protection at pasture against bad weather Selection for udder conformation Straw stock humidity
Milking practices and attitudes	16	Air admission at teat cup attachment California Mastitis Test performed on at least 1 cow Cluster disinfection after mastitic cow End of milking: control system High-SCC/mastitic cows milked last High-SCC cows milked using special milking unit Milker spends time to feed calves during milking Milking atmosphere: quiet Music in milking parlor Postdipping: spraying Predipping: drying interval >30s Teats washed: shower Udder palpation before milking Udder washed: shower Udder washed: single cloth Whole teat predipped
Teat and udder lesions	3	Percentage of cows: compression rings Percentage of cows: cracks Percentage of cows: vaccines

to test the repeatability of the questionnaires and implement double data keyboarding to estimate and locate the errors (Barnouin, 1980; Schukken, 1990), 2 data management practices that were performed in ZMP. Moreover, rigorous training of the interviewers might improve data reliability, particularly in epidemiological

studies concerning mastitis management (Schukken, 1990). Nevertheless, inadequate or faulty milking management and hygiene practices cannot be reasonably detected through information collected from the farmer, who cannot be his own judge. Consequently, an original assessment procedure based on trained experts (which

Table 2. Milk parameters [mean (SD)] in very low (LOW) and medium (MED) SCS herds.

Variable	All herds ($n = 304$)	LOW herds ($n = 187$)	MED herds ($n = 117$)	P
No. of milked cows	38.7 (13.0)	36.8 (13.0)	41.6 (12.5)	**
No. of simultaneous milkers	1.4 (0.6)	1.4 (0.7)	1.4 (0.5)	NS
Primiparous cows, % of herd	29.0 (3.6)	29.0 (3.7)	29.2 (3.6)	NS
Milk cellular score	2.40 (0.25)	1.99 (0.27)	3.09 (0.21)	***
Milk SCC, % of monthly results				
<50,000 cells/mL	46.3	56.7	29.9	***
>800,000 cells/mL	4.0	2.4	6.6	***
Annual milk quota, $\times 10^3$ L	274 (112)	269 (117)	282 (105)	NS
Milk yield, kg/cow per yr	7256 (962)	7397 (1011)	7030 (834)	**
Milk protein content, g/L	32.1 (1.0)	32.1 (1.0)	32.0 (1.1)	NS
Milk fat content, g/L	40.3 (2.7)	40.4 (2.8)	40.2 (2.6)	NS

NS $P > 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 3. Univariate analysis of the $P < 0.05$ variables offered to the final logistic regression model to study expert assessment management practices in herds with very low (LOW) and medium (MED) SCS.

Variable	Herds with the practice (%)		P
	LOW (n = 187)	MED (n = 117)	
Air admission at teat cup attachment	35.8	54.7	**
Postdipping: spraying	21.4	9.4	**
California Mastitis Test on at least 1 cow at milking	31.5	20.5	*
Milker: spends time to feed calves during milking	12.3	21.4	*
Quiet milking atmosphere	95.2	88.0	*
Dry cow shed cleanliness in winter			
Good	27.8	8.5	
Medium	51.3	42.7	
Poor	20.9	48.7	***

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

did not include farmer interviews) was implemented in a subset of ZMP herds to complete the significant risk factors highlighted from questionnaire surveys (Barnouin et al., 2004). Among the 5 management variables which were more frequently observed in the MED herds according to expert assessment study, 3 of the variables (“poor cleanliness of dry cows cow shed in winter”, “milker spending time to feed calves during milking”, and “air admission at teat cup attachment”) were not available from information collected through farmer interviews. Moreover, the milking practices concerning untimely displacements of the milker and teat cup attachment were not previously described in any study that compared herd samples through SCC level.

The cleanliness of the dry cow shed, particularly in winter, would be an important parameter to achieve the main goal (from an udder-health perspective) of the dry period, which is to minimize the number of quarters infected at the next calving (Dingwell et al., 2003a). The (observed) better cleanliness of the dry cows’ shed in the LOW herds could be compared with 2 questionnaire variables that characterized very low SCC herds, i.e., “dry cows not housed in cow shed of milking cows”

($P < 0.05$ variable through multivariate analysis) and “cow shed of the dry cows regularly disinfected by a specialist company” ($P < 0.05$ variable through univariate analysis). These 2 housing practices would illustrate the fact that the nonlactating cows were housed in poorer facilities in MED SCC herds.

Recent research (Bradley and Green, 2000) indicated that *Escherichia coli* and *Streptococcus uberis* can persist within the udder for longer periods than was previously thought. This suggests, in agreement with the present results, that dry cows need to be kept clean (Ward et al., 2002), a practice whose interest was pointed out by Albright (1983) through a discussion on direction of animal welfare in the future. Concerning clinical mastitis, the risk for specific pathogens increased if the same species of bacteria that had caused mastitis was isolated in the late dry and postcalving periods. Moreover, clinical cases associated with dry-period infections occurred earlier in lactation than cases not associated with dry-period infections (Green et al., 2002). Consequently, it is crucial to ensure the cleanliness of dry cows and improve their housing hygiene, especially as nonlactating cows are often housed in ob-

Table 4. Final logistic regression model for milk cellular score in French dairy herds with very low and medium milk SCS (expert assessment variables sorted by decreasing probability for positive and negative odds ratios).

Variable	Odds ratio (OR)	95% Confidence interval for the OR	P
Characterizing very low cell score herds			
Dry cow shed cleanliness in winter: good	3.093	1.406–6.807	**
Postdipping: spraying	2.548	1.190–5.453	*
California Mastitis Test on at least 1 cow at milking	1.909	1.046–3.486	*
Characterizing medium cell score herds			
Air admission at teat cup attachment	0.470	0.281–0.785	**
Dry cow shed cleanliness in winter: bad	0.395	0.226–0.690	**
Milker: spends time to feed calves during milking	0.420	0.208–0.846	*

* $P < 0.05$; ** $P < 0.01$.

solete facilities. Farmers could improve udder cleanliness by feeding cows in such a way that feces were as dry as possible (Ward et al., 2002). Moreover, drinking from a river or pool involves mud, dung, and water splashes incompatible with udder cleanliness, and such a practice should be limited to control herd SCC level (Barnouin et al., 2004).

The “air admission at teat cup attachment” and “milker spending time to feed calves” variables, which were not previously described as discriminating between medium and low SCC herds, appeared to be key practices, indicating less capability for careful milking in the MED herds. Defects in the milking machine and faulty milking management are thought to have great influence on udder health. Vacuum level in the milking system can vary through air admission into the system during teat cup attachment. Undesirable vacuum losses and subsequent milking unit fall-offs could be detrimental to udder health (Tan et al., 1993). Moreover, Capuco et al. (2000) stated that the keratin content of teats, which is important in udder resistance to infection, is proportional to liner tension. Reverse pressure gradients across the teat canal are sufficient to transfer bacteria or bacteria-contaminated milk through the teat canal at teat cup attachment or detachment for various reasons (diameter of the mouthpiece orifice, liner position at attachment, reserve capacity level), but no fully safe method of attachment has been identified (Rasmussen et al., 1994). The smaller number of cows at milk in the LOW herds must prevent milkers from developing inappropriate milking practices, such as spending time during milking to feed calves. Moreover, such a practice could involve a less quiet milking atmosphere (significant $P < 0.05$ variable through univariate analysis), more stress on cows, a global lack of milking control, and could lead to udder infection. Overmilking could be a consequence of the milker's exit from the milking parlor to feed calves, but overmilking was not more frequently observed in the MED herds than in the LOW herds.

The variables “use of teat spraying” and “CMT performed at milking”, which characterized the LOW herds, concerned udder management practices about which the ZMP farmers were questioned from interviews conducted by the DHI technicians.

Concerning teat spraying, according to the ZMP questionnaire survey, 23.0% of very low SCC herds vs. 9.1% of medium SCC herds stated they performed the practice, whereas according to the experts' observations in the current study, 21.4% of LOW milkers vs. 9.4% of MED milkers practiced teat spraying. Moreover, from the subset of herds surveyed in the present study, 26.2% of LOW herds vs. 11.1% of MED herds declared through ZMP questionnaire survey that they regularly used teat

spraying, percentages that were close to those displayed from expert observations. As through questionnaire survey, when teat dipping was practiced, the teat cups were more frequently cleaned in very low SCS herds vs. in medium SCS herds, we hypothesized that teat dipping is not less effective than teat spraying per se, but it is through less teat cup hygiene (Barnouin et al., 2004). Inadequate teat cup hygiene could depend on the regular replacement of dipping solutions and the regular cleansing of teat dip cups with a strong disinfectant to eliminate infection transfer from one cow to another. In presence of organic matter, the performance of chlorine disinfectants against *Staphylococcus aureus* was reduced (Rodgers et al., 2001). Organic materials added to disinfectants lead to the formation of disinfection by-products and bacterial proliferation. Moreover, povidone-iodine and chlorhexidine were ineffective when challenged with 2% fat milk (Best et al., 1990), a result indicating that traces of milk on the teat surface, in addition to fecal and other organic materials, could play a role in decreasing teat disinfectant efficacy.

Concerning CMT use at milking, 30.7% of very low SCC vs. 24.5% of medium SCC herdsmen declared through ZMP questionnaire survey that they performed the practice, whereas the experts reported in the present study, that 31.5% of LOW vs. 20.5% of MED milkers performed the test. Consequently, some discrepancy concerning the frequency of CMT use in the herd SCC groups was observed between the questionnaire survey and the expert assessment study. Nevertheless, from the subset of herds surveyed in the present study, 39.6% of LOW vs. 26.5% of MED farmers stated they performed the CMT in the questionnaire survey. Consequently, 20.5% of LOW and 22.6% of MED farmers who declared they performed the test through the questionnaire survey did not perform CMT on the day of the expert visit, probably because CMT was not useful at this time according to the current mastitis status of the milked cows. The different percentages of LOW and MED herds practicing CMT in the expert study and in the questionnaire survey could be explained by the lack of available experts in 8 departments that did not perform CMT in any herd. This would suggest that CMT use in a herd would partially depend on expert dairy management advice. The farmers of low bulk milk cell count herds worked precisely rather than quickly and paid more attention to individual cows (Barkema et al., 1999), and such a management style could explain why LOW farmers used CMT more frequently at milking to detect mastitis-suspected cows and control response of infected cows to curative antibiotherapy. Moreover, farmer's precision was highlighted as a variable characterizing the very low SCS herds (Barkema et al., 1998; Barnouin et al., 2004). In a study conducted in organic

farms, a lower risk of subclinical mastitis was observed in dairy farms where CMT was performed regularly (Busato et al., 2000). Finally, CMT would play a useful role in herd monitoring programs as a screening test to detect fresh cows experiencing intramammary infections caused by major pathogens and contribute to control herd SCC level (Dingwell et al., 2003b).

CONCLUSIONS

Assessing dairy management practices that characterize top quality herds regarding udder health requires the collection of information independently of the farmer, as farmers' psychological characteristics and working attitudes are implicated in their capability to efficiently control herd health problems (Bigras-Poulin et al., 1985), especially high SCC (Barkema et al., 1998). Consequently, expert opinions on farm dairy management must be fully considered, when formally trained experts are available, to detect faulty management practices, whatever difficulties are inherent in evaluating an activity such as management (Goodger et al., 1988). Expert opinions from a standardized audit that included a farmer's full cooperation could persuade the farm manager to correct detrimental attitudes and practices concerning milking and hygiene management. Improving attitudes would be particularly important, as interactions between attitudes and management practices (Bigras-Poulin et al., 1985) suggest that attitudes would act as effect modifiers on the management practices—herd performances relationship. According to the present study, the expert procedure of dairy management assessment completed or confirmed the previously published factors characterizing very low SCS herds through farmers' interviews (Barnouin et al., 2004). Finally, safe milking, more attention and time paid to individual animals, and cleanliness of the dry cow shed should be considered key points for optimal SCS control in bovine dairy herds.

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