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Management factors affecting udder health and effects of a one year extension program in organic dairy herds

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The first part of this study was a cross-sectional analysis of the impact of 29 management factors on udder health in organic dairy farms in Switzerland. All 77 farms joined the extension program 'pro-Q'. As a measure of udder health the theoretical bulk milk somatic cell count (TBMSCC) calculated by the monthly cow composite somatic cell count over a time period of 1 year was chosen. The basic udder health of the farms was determined by TBMSCC during the year prior to the start of the project (mean for all farms = 176 460 cells/ml). In the multivariable analysis, the five factors 'swiss brown breed', 'alpine summer pasturing', 'calf feeding with milk from mastitis diseased cows', 'hard bedding' and 'no post-milking' remained as significant risk factors on udder health. In the second part of the study, the development of management factors and the udder health situation affected by an extension program after 1 year was investigated. A partial improvement of the management factors on the farms but no overall improvement on udder health and no association between management changes and udder health changes were found. Improvement of udder health was more likely in farms with higher basic TBMSCC than in those farms with less udder health problems at the beginning of the project.

Keywords: management, udder health, extension effect

Implications

Disease prevention is an important means for economic and environmental improvement on dairy farms as it leads to higher milk yield and to therapy reduction. High amounts of antibiotics are used to control mastitis. Disease prevention and udder health management can be improved by extension programs. The objectives of those programs are to detect animal health risks, to develop improvement strategies and to verify effects of those implemented preventive measures. This study aims to evaluate management factors and extension effects on udder health, particularly in organic dairy farms. The results shall lead to a better effectiveness of such extension programs.

Introduction

Poor udder health is a common problem in conventional and organic dairy herds with incidences of infected udder quarters reported between 23% (Hamilton *et al.*, 2006) and 61.5% (Busato *et al.*, 2000). Both consumers' expectations and economic necessities require innovative strategies to improve udder health at the herd level. Organic farming regulation requires specific procedures to assure the health status of livestock. These procedures are: (i) animal breeding and choice of suitable animals, (ii) herd-based prevention and management, (iii) complementary therapy and lastly, resorting to (iv) chemical synthetic veterinary medicine (EC, 1999).

Surveys in a number of European countries show variable udder health in organic dairy herds (Busato *et al.*, 2000; Fehlings and Deneke, 2000) and compared to conventional systems, organic farms are not consistently better or worse, although there is a tendency for better udder health in organic herds compared to conventional herds in northern European countries (Hamilton *et al.*, 2006; Vaarst *et al.*, 2006; Fall *et al.*, 2008). A study in Switzerland found no significant differences in the incidence of mastitis between conventional and organic herds (Roesch *et al.*, 2006).

In recent decades, the local and systemic administration of antibiotics has been the most common approach to control mastitis in both conventional and organic dairy herds (except in the USA, where according to the regulations, animals treated with antimicrobial drugs lose their

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status as organic animals). However, given the principles of organic agriculture, the consumer's concern about antibiotic residues in food and the potential for pollution of the environment by residuals, interest in preventative management strategies and alternative treatments increased lately (Hertzberg *et al*., 2003).

In order to develop successful preventive strategies and extension concepts, it is important to identify factors that affect udder health under organic farming conditions. Langford *et al*. (2008) found management and disease treatment differences between organic and conventional farms in the UK. In general, the quality of management and milking technology plays an important role in udder health control (Østeras and Lund, 1988; Chassagne *et al*., 2005; Svensson *et al*., 2006). Straw yard housing was associated with reduced udder health (Peeler *et al*., 2000; Barnouin *et al*., 2005) whereas all measures improving barn and cubicle hygiene had a positive impact on udder health (Barkema *et al*., 1998; Koster *et al*., 2006; O'Reilly *et al*., 2006). Other investigations found no correlation between housing conditions and udder health (Haltia *et al*., 2006; Hamilton *et al*., 2006).

Quality and quantity of roughage, concentrates and minerals in the dairy cows' rations can influence udder health (Barkema *et al*., 1998; Nyman *et al*., 2007). Feeding of the young stock influences their udder health as primiparous cows (Svensson *et al*., 2006). It is still controversial whether giving infected milk to calves plays a role in the development of subsequent persistent infections in these heifers after parturition (Barto *et al*., 1982). Herds where calves were fed with milk bearing high somatic cell counts (SCC) had a higher risk of high bulk milk somatic cell counts (BMSCC) (Barkema *et al*., 1998).

This cross-sectional study was performed to investigate (i) the influence of management factors on udder health in organic dairy farms under Swiss milk production conditions (small herd sizes, mostly family farms) and (ii) the effects of extension on management practices and udder health. All involved farms participated in the Swiss organic dairy farm network 'pro-Q' (Ivemeyer *et al*., 2007). Management improvements were investigated in terms of udder health development. The results should provide the basis for specific herd health improvement concepts for organic dairy farms.

Material and methods

Project framework and herd selection

The first part of the study investigated the impact of management factors on udder health. A total of 77 farms out of the Swiss organic dairy farm network 'pro-Q' were included in this study. As inclusion criterion, milk recording data and cow somatic cell count (CSCC) data from the year before project start (11 months) had to be available. Joining the 'pro-Q' network was the farmer's decision. All those farms had joined the 'pro-Q' network between April 2004 and December 2005 and had received advice and guidance for at least 1 year after. At project entrance of each farm, milking management was recorded by standardized observation and duration of milking procedures was recorded using Noldus Pocket-Observer 2.1 software (Noldus Information Technology, Wageningen, The Netherlands). Milking technology and housing were surveyed and measured and a questionnaire on feeding and general farm issues was filled in. Milking technology was assessed by the same expert on all farms. All management factors were assessed by four researchers of the 'pro-Q' team. They were trained by the project manager and they all used the same recording methods. Basic udder health was assessed by analyzing retrospective CSCC of the whole year before project start in order to exclude seasonal effects. Clinical udder investigations were performed, accompanied by milk samples from all lactating udder quarters. The quarter milk samples of the entire lactating herd were taken before milking. Analysis of bacteriology, using standard bacteriological culture methods and cell count measurement (SCC) with flow cytometry (FOSSOMATIC; Foss Electric, Hilleröd, Denmark) were carried out on all samples. All milk samples were analyzed by a certified commercial veterinary laboratory in Switzerland.

After 1 year, the assessment of the management factors and the quarter milk samples were repeated. In the 12 months between the two investigations, 4 to 6 regular advisory meetings were held between the farmers, their veterinarians and one member of the project team. Management weak points were discussed and optimization concepts, including the long-term goal of reducing antibiotic input, were carried out. A follow-up meeting was conducted after 1 year to evaluate the progress in herd health management and udder health. The first aim of the extension program was the prevention of mastitis through improvement of management practices. Antibiotics were used for therapies as needed where appropriate, but were not used preventatively. A thorough description of the approach within the 'pro-Q' project can be found in Ivemeyer *et al*. (2007).

In the second part of the study the extension effect on management practices and on udder health was evaluated. Sixty-four farms out of 77 initial farms were examined again after one year (83%). The other 13 were excluded because of incomplete datasets due to the lack of compliance by farmers or due to them leaving the program (17%).

Analysis of udder health variables

The theoretical bulk milk somatic cell count (TBMSCC) of each farm throughout 1 year was used to assess the status of udder health. It was calculated using the monthly milk recording data of the breeding company: all CSCCs were multiplied by individual milk yields on sample days. These values were added up for 1 year and this sum was divided by the whole herd milk yield of the same year. In order to identify management factors influencing udder health significantly the variables recorded at the initial investigation were correlated with the TBMSCC over the year before the start of the project (TBMSCC_0).

Laboratory analyses were used to group the quarter secretion of all cows, according to the DVG/IDF (Deutsche Veterinärmedizinische Gesellschaft/International Dairy Federation) mastitis definition (Hamann and Fehlings, 2002), into the following categories (a) normal secretion (NORMAL; quarter somatic cell count (QSCC) $<$100 000/ml), (b) non-specific SCC increase (NON-SPECIFIC; QSCC exceeded 100 000/ml, but were culturally negative) and (c) mastitis quarters (MASTITIS; QSCC $\geqslant$ 100 000 and culturally positive).

Analysis of management factors

The selection of 29 management factors was based on investigations performed by Goodger (1996), but those not relevant for small farms under Swiss conditions were excluded from this study. Five areas of management were examined: general aspects (breed, alpine pasturing), housing, feeding, milking management and milking technology. Variables of numerical character were divided into two categories. If there was no biologically relevant threshold available to do so, the median was used as delimiter. The categories of management factors and the frequencies of their assessment are shown in Table 1.

For the assessment of the lying space the Swiss standard-dimensions were used as reference values (FAT, 2005). For on-farm measured dimensions, acceptable width and length of the lying space were related to breed-based cow size (e.g. Jersey cows require smaller lying space dimensions). The lunge space was measured from shoulder flange to wall or, in head-to-head design, to the dividing construction rail. The diagonal dimension of the cubicles was measured from neck rail to rear end.

The preparation time per cow during milking was measured from first touch of the cow until applying the milk unit. Post-milking was defined as the time of manual support during machine milking at the end of the milking procedure.

In order to evaluate the effects of the extension program for each farm the number of management factor improvements between start of the project and end of the first project year was counted. The definitions of improvements of the 17 changed management factors are listed in Table 4 (under the section 'Results'). The other twelve factors, for example breed or housing system, remained stable in the farms and were not included in the analysis of management development.

Statistical analysis

For the univariable statistical analysis, one-way ANOVA procedures were performed. Tukey–Kramer *post hoc* comparison was added for identification of differences between the respective levels of the variables. Distribution of data had been evaluated graphically by normal-qq-plots. For multivariable modeling all variables with $P < 0.20$ in the univariable ANOVA were included in an initial linear model with stepwise backward elimination of not significantly associated factors with the dependent variable (threshold for elimination: $P = 0.05$). Model diagnostics were done by a graphical evaluation of the residual distribution and the residual-by-predicted-values plot. Multicollinearity was checked up by testing for interaction between the factors.

In order to calculate the association between management changes and TBMSCC development (TBMSCC_1-0; difference between TBMSCC of project year (TBMSCC_1) and TBMSCC_0) the former were categorized into five groups (0, 1, 2, 3 and $\geqslant$4 management changes per farm) and the TBMSCC_1-0 of those groups were compared using ANOVA. The correlation between TBMSCC_0 and TBMSCC_1-0 was tested by performing linear regression. In all analyses levels of significance were $\alpha = 0.05$. All statistical analyses were carried out using JMP 5.0.1.2 (SAS Institute Inc., Cary, USA).

Results

Descriptive statistics of herds and farms

The mean herd size of farms in the survey was 20 cows (range: 8 to 65 cows). Most of them ($n = 49$, 63.6%) were herds of Swiss Brown cattle breed, 17 (22.1%) were herds of Swiss Fleckvieh, five were Holstein Friesian herds, two were Jersey herds and four herds were of mixed breeds. About 92.2% of the herds ($n = 71$) were certified organic farms, the other six (7.8%) practiced integrated productions (which is a certified conventional farming standard in Switzerland, including some ecological requirements). More characterizations of the investigated farms can be found in Table 1.

The mean TBMSCC_0 for all farms was 176 460 cells/ml (95% CI: 159 040 to 193 880 cells/ml; normal distribution). Of the 5528 quarters analyzed at the beginning of the project, 71% were NORMAL, 12% showed a NON-SPECIFIC QSCC increase and 14% were diagnosed as MASTITIS quarters. In 141 quarters (3%), measurement of QSCC was not possible; so they could not be classified. The microbial distribution of these 794 MASTITIS quarters is shown in Figure 1. *Staphylococcus aureus* (35%) and *Staphylococcus ssp.* (33%) were the most frequent pathogens followed by *Streptococcus uberis* (16%).

Multivariable analysis of impact of management factors on udder health

In univariable analysis, seven factors had a significant effect ($P < 0.05$) and one factor had a tendential effect ($P < 0.20$) on the TBMSCC_0 (Table 2). These eight factors were included in a multivariable regression model.

After backward elimination and stepwise regression procedures the remaining factors 'breed', 'alpine pasturing', 'calf feeding method', 'bedding deformability' and 'post-milking' showed significant effects ($P < 0.05$) on the TBMSCC (Table 3). The whole model had a P-value of < 0.001 with an R^2 of 0.406 and an adjusted R^2 of 0.354. The model was valid according to the model diagnostics.

Development of udder health and management factors affected by the extension program

In 17 out of 29 different management factors, an improvement was recorded on at least one of the 64 farms at the

Table 1 *Included 29 management factors and frequency of farms (n = 77) related to the variable level*

Area	Factor	Level	No. of farms (%)
General	Breed	Brown Swiss	49 (64%)
		Swiss Fleckvieh	17 (22%)
		Other (Holstein, Jersey, mixed breeds)	11 (14%)
	Alpine pasturing during the summer months	Yes (1500 m to 2500 m pasture altitude)	33 (43%)
		No	44 (57%)
Feeding	Concentrates in milking parlor	Yes	10 (13%)
		No	28 (36%)
		No milking parlor	39 (51%)
	Feeding of milking cows	Ration without silage (for hard cheese production)	23 (30%)
		Silage in ration	54 (70%)
	Feeding milk for rearing calves	From udder health cows only	13 (17%)
		From cows with intramammary infections and mastitis milk	64 (83%)
Housing	Housing system	Stanchion barn	33 (43%)
		Loose housing systems	44 (57%)
	Climate concept of the stable	Warm	42 (55%)
		Cold closed	19 (25%)
		Cold open	16 (21%)
	Type of cubicles	High cubicle (without rear end flange)	11 (14%)
		Deep cubicle (with rear end flange)	31 (40%)
		No cubicles	35 (45%)
	Assessment of the lying space based on length and width compared with standard-dimensions	Amply	43 (56%)
		Narrow	34 (44%)
	Lunge space in cubicles[1]	⩾60 cm	13 (17%)
		<60 cm	29 (38%)
		No cubicles	35 (45%)
	Diagonal-dimension of cubicles	<190 cm	21 (27%)
		⩾190 cm	16 (21%)
		No cubicles or no neck rail	40 (52%)
	Bedding deformability	Soft	38 (49%)
		Hard	39 (51%)
Milking	Number of milk units per milker	1 or 2	25 (32%)
		3 or more	52 (68%)
	Pre-milking	Into strip-cup	47 (61%)
		On the floor	17 (22%)
		No pre-milking	13 (17%)
	Preparing time per cow (median)	<90 s	66 (86%)
		>90 s	11 (14%)
	Manual aid of post-milking	Yes	70 (90%)
		No	7 (9%)
	Post-disinfection of teats	Teat dip	48 (62%)
		Teat spray	11 (14%)
		No post-disinfection	18 (23%)
	Assessment of post-disinfection (time between removal of the milk unit and post-disinfection)	<30 s	51 (66%)
		>30 s or no post-disinfection	26 (34%)
	Removal of single teat cups	No	13 (17%)
		Yes	64 (83%)
	Pre-milking and cleaning	Pre-milking before cleaning	39 (51%)
		Cleaning before pre-milking, no pre-milking or no Cleaning	38 (49%)
	Milking order depending on udder health	Yes	20 (26%)
		No	57 (74%)
	Special milk unit for mastitis cows	Yes	25 (32%)
		No	52 (68%)
	New cleaning material for each cow	Yes	46 (60%)
		No	31 (40%)

Table 1 *Continued*

Area	Factor	Level	No. of farms (%)
	Cleanliness of teats before milking	Clean	30 (39%)
		Not clean	47 (61%)
	Air adsorption during application of teat cups	Much	28 (36%)
		Medium	36 (47%)
		Few	13 (17%)
	Interim cleaning of milk units	Yes	22 (29%)
		No	55 (71%)
	Cleanliness of milking place	Clean	26 (34%)
		Not clean	51 (66%)
Milking technology	Type of milking system	Tie	39 (51%)
		Side-by-side	6 (8%)
		Tandem	12 (16%)
		Fishbone	20 (26%)
	Type of milk transport system	Evacuation	57 (65%)
		Bucket	20 (26%)

[1]Standard dimensions according to FAT (2005).

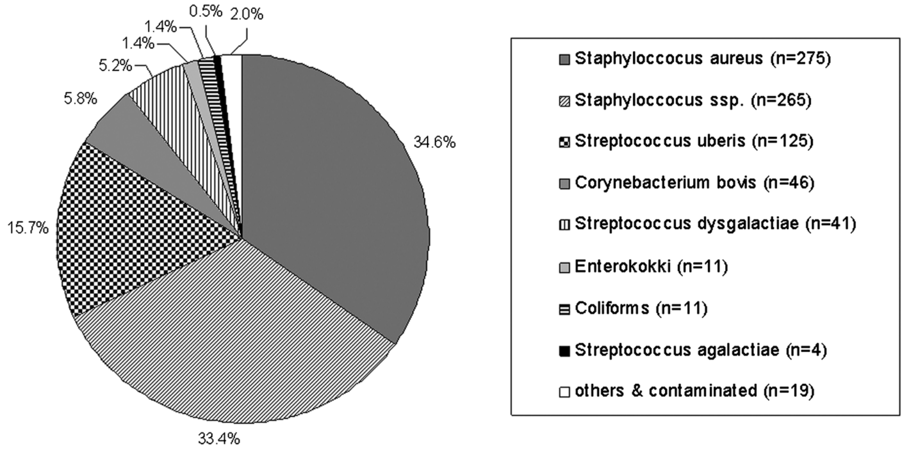

Figure 1 Distribution of basic bacteriological profile of all MASTITIS quarters in the 77 investigated farms at the time of beginning of the project ($n = 794$ quarters).

end of the first project year (Table 4). In seven farms there was no improvement of any factor (zero improvements) while 17 farms improved one factor, 16 farms improved two factors, 13 farms improved three factors and 11 farms improved four or more factors. The maximum number of management improvements per farm was seven. There was no statistical difference in TBMSCC_1-0, as a measure for udder health assessment between these categories (ANOVA, $P = 0.904$).

Overall, TBMSCC_1-0 showed no significant development over the year with a slight TBMSCC increase of 11 885 cells/ml (95% CI: −3324 to 27 094 cells/ml). Anyway, 34 (44%) of the 77 farms showed a decline in TBMSCC. Figure 2 shows the TBMSCC_1-0 relative to TBMSCC_0, with negative values representing farms showing improvements. Linear regression indicated an association between TBMSCC_0 and TBMSCC_1-0 (TBMSCC_1-0 = 50 122–0.217 TBMSCC_0, $R^2 = 0.062$, adjusted $R^2 = 0.049$, $P = 0.030$). In farms with higher TBMSCC_0, improvement of udder health was more likely than in farms that initially showed fewer udder health problems.

Discussion

Study design

The presented study was performed to evaluate which management factors influence udder health as a basis for extension concepts for organic dairy farmers. It differed from others in the pre-selection of interested farms via the 'pro-Q' network, since most comparable studies worked with stratified random samples of farms (Busato *et al.*, 2000; Green *et al.*, 2007). This pre-selection of motivated farmers inhibited a randomized choice, but it was welcome

Table 2 *Significant and tendency effects of management factors on udder health in univariable analysis with theoretical bulk milk somatic cell count mean and confidence interval*

Factor	Level	TBMSCC (1000/ml) mean	Lower and upper 95% CI	*P*
Breed	Swiss Brown	195	175 to 215	<0.05
	Swiss Fleckvieh	118	83 to 152	
	Other	186	143 to 228	
Alpine pasturing during the summer months	Yes	198	172 to 224	<0.05
	No	160	138 to 183	
Feeding milk for rearing calves	Of udder healthy cows only	116	76 to 156	<0.05
	Of cows with intramammary infections and mastitis milk	189	71 to 207	
Assessment of the lying space based on length and width compared with standard dimensions	Amply	158	135 to 180	<0.05
	Narrow	200	175 to 225	
Bedding deformability	Soft	158	134 to 182	<0.05
	Hard	194	170 to 218	
Manual aid of post-milking	Yes	170	152 to 187	<0.05
	No	244	188 to 299	
Cleanliness of teats before milking	Clean	145	118 to 171	<0.05
	Not clean	197	175 to 218	
Interim cleaning of milk units	Yes	158	125 to 190	0.076
	No	184	163 to 204	

TBMSCC = theoretical bulk milk somatic cell count; CI = confidence interval.
The *P*-values are results from ANOVA and *post hoc* Tukey–Kramer test (<0.05).

Table 3 *Management factors with significant effects on theoretical bulk milk somatic cell count (TBMSCC_0) in multivariable linear regression model (whole model:* R^2 *adj. = 0.354, F-ratio = 7.96,* $P < 0.001$*)*

Variable	Estimate	s.e.	F	*P*
Intercept	203.54	16.01		<0.001
Breed SB (compared to SF)	21.18	9.30	5.19	0.026
Breed others (compared to SF)	29.51	12.07	5.98	0.017
Alpine summer pasturing	18.94	7.53	6.33	0.014
Feeding milk from diseased cows	33.15	9.59	11.96	0.001
Herd bedding	16.10	7.32	4.84	0.031
No manual aid of post-milking	38.17	12.75	8.97	0.004

SB = Swiss Brown cattle, SF = Swiss Fleckvieh.

to have such a group of farms, since in extension programs farmers' motivation is needed to get any improvement effects (Ivemeyer *et al*., 2008).

The theoretical bulk milk somatic cell count calculated from milk yield and CSCC based on 1-year milk recording data was chosen to describe the udder health for a number of reasons. A 12-months overview offers independence to seasonal variations, without the lengthy time span of 36 months used by Barnouin *et al*. (2004). Furthermore, in contrast to the (absolute) BMSCC of delivered milk, the TBMSCC is not biased by discarded milk. In contrast to a recent intervention study (Green *et al*., 2007), this study investigates udder health on the basis of all kinds of mastitis including sub-clinical infections and not primarily on clinical mastitis.

Comparison of the results of the present study with those reported previously

The proportion of 29% quarters with SCC higher than 100 000/ml agrees with the spectrum of udder health status described in literature for organic dairy herds in Switzerland. A screening of 152 Swiss organic farms primarily based on the California Mastitis Test (CMT) came to a similar result (Busato *et al*., 2000). In that study, out of a total of 9775 quarters, 2918 (30%) showed an elevated SCC, defined by a positive CMT. There is no comparable study published which investigates TBMSCC on organic farms.

Analysis of potential risk factors in this study showed influences of management practices on udder health. The link between Brown Swiss cattle and udder health problems compared to Swiss Fleckvieh is not in agreement with another study in Switzerland (Busato *et al*., 2000). Alpine pasturing is a specific issue of mountainous regions; approximately 15% of all Swiss dairy cows are fed on pastures between 1500 to 2500 m above sea level for 2 to 5 months during the summer. Often, cows from a number of different herds are gathered on the same alpine pasture, which leads to social stress in the newly socialized herd and to a higher risk of cross infection. Also the change of milking personnel, milking technology, climate and feedstuff could result in a higher infection risk, particularly for high-performance breeds. All these factors could lead to a high SCC both in

Table 4 *Improved management factors within the first project year, definition of improvement and number of farms that realized the improvement (farms* n = *64)*

Management factor	Level defined as improvement	No. of farms showing improvement
Concentrates in milking parlor	No	1 (1.6%)
Feeding milk for rearing calves	Milk of healthy cows only	17 (26.6%)
Number of milk units per milker	⩽3	2 (3.1%)
Pre-milking	Into strip-cup	8 (12.5%)
Preparing time per cow (median)	<90 s	6 (9.4%)
Post-milking	Yes	3 (4.7%)
Post-disinfection of teats	Teat dip	11 (17.2%)
Time from milk unit removal to post-disinfection	<30 s	10 (15.6%)
Removal of single teat cups	No	8 (12.5%)
Range of pre-milking and cleaning	Pre-milking before cleaning	11 (17.2%)
Milking order depending on udder health	Yes	7 (10.9%)
Special milk unit for mastitis cows	Yes	7 (10.9%)
New cleaning material for each cow	Yes	8 (12.5%)
Cleanliness of teats before milking	Clean	10 (15.6%)
Air adsorption during application of teat cups	Less	13 (16.9%)
Interim cleaning of milk units	Yes	8 (12.5%)
Cleanliness of milking place	Clean	9 (14.1%)

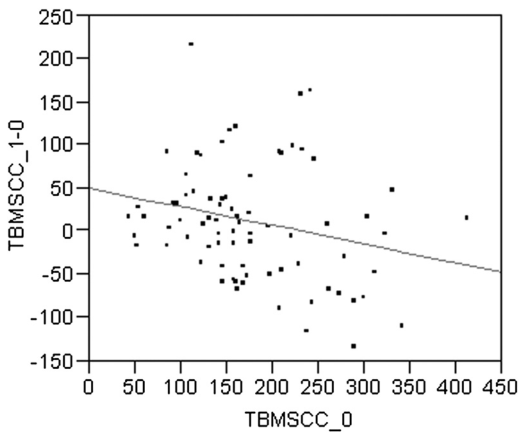

Figure 2 Regression function of udder health development (measured as difference between theoretical bulk milk somatic cell count (TBMSCC) in the year before project start and the project year – TBMSCC_1-0) in dependence of TBMSCC in the year before project start (TBMSCC_0) in 1000/ml ($n = 77$ farms, $P = 0.030$).

initial quarter and cow composite milk (Lamarche *et al.*, 2000; Walkenhorst *et al.*, 2005). However, Swiss Brown herds may be more likely to be exposed to the risk factor 'alpine summer pasturing'. Although there is no statistical correlation between 'alpine summer pasturing' and 'breed' (χ^2 test, $P = 0.159$), 76% of the Swiss brown herds spent their summers on alpine pastures.

Feeding of milk from infected cows to pre-weaning calves is correlated with a higher TBMSCC in the herds. An explanation for the correlation between waste milk feeding and high TBMSCC could be a higher rate of heifers with infected quarters. Another possible explanation is that farms with poorer udder health use to feed more infected milk to their calves in order to avoid discarding of milk. Although there are no investigations demonstrating a correlation between feeding milk pathogens and later infections after the first birth, some studies show indirectly that this calf feeding practice can result in a higher mastitis risk of primiparous cows (Barto *et al.*, 1982; Roberson *et al.*, 1994 and 1998; Barkema *et al.*, 1998). Further investigations are necessary to study this correlation in order to find causal relationships.

Ample lying space (larger than the Swiss standard dimensions) was associated with a lower TBMSCC in the study farms. Housing conditions are a common issue of different studies, whereas the lying space has not been considered as an impact factor on udder health before. An adequate laying space has been recognized in recent reviews as a crucial aspect of cow comfort to avoid injuries and to increase welfare and thus performance of dairy cows (Cermak, 1988; Cook *et al.*, 2005), yet this may be compromised since many dairy breeds have increased in size during the last decades. The deformability of the bedding also had a positive impact on udder health. A high deformability is normally associated with deep litter cubicles that are dry and often have a high hygienic standard. Barkema *et al.* (1998) identified a low BMSCC in herds where the thickness of bedding in cubicles of lactating cows was more than 1 cm. The bedding in the deep litter cubicles of most investigated barns in this study was in excess of 10 cm.

This study reveals some further aspects of milking routine influencing udder health. Manually supported machine post-milking is a very common practice by milkers in Switzerland due to the small size of many herds. This was determined to have a positive impact on udder health, possibly due to less residual milk that could act as a substrate for new and existing infections in the udder. On the other hand the importance of this factor is still questionable, because only seven farms (9%) did not conduct any manual aid of post-milking. In agreement with other investigations, teat cleanliness can be an indicator of hygiene in the cows' environment and good cubicle and barn hygiene were found to be correlated with good udder health (Bartlett *et al*., 1992; O'Reilly *et al*., 2006; Breen *et al*., 2009).

In other studies, aspects of milking technology such as less frequent technology check, automatic cluster removal, high milking vacuum and cleanliness of milking parlor have been reported to have a negative influence on udder health (Østeras and Lund, 1988; Barkema *et al*., 1998), whereas in general, the factors of milking technology and feeding of lactating cows in the presented investigation show no significant association to udder health. It is important to know that under Swiss conditions the milking technology is of a high standard because the milking equipment has to be tested annually. On the other hand, feeding parameters might show no effects on udder health because most of the investigated herds were fed by a roughage-based ration with a small amount of different components. This consequently led to a low feeding variability between the farms.

Effects of the extension program

Extension-based effects on udder health over the first year under advice were limited in the presented project. One reason could be that improvement of sub-clinical mastitis is often combined with the dry-period of the cow. Hence, herd-level extension effects on udder health may become obvious after a longer time than 1 year. A recent study showed a remarkable effect of reduced clinical mastitis following an intervention program on farms with a high incidence of mastitis, compared to increased mastitis incidences on control farms (Green *et al*., 2007). The design of the present study does not include control farms and the main focus of the investigation is sub-clinical, rather than clinical mastitis. As our results show, an improvement of udder health is more easily achieved in herds with compromised udder status. This result is quite weak in this study (according to the low R^2-value), but it is getting stronger when a 2-year development is analyzed (Ivemeyer *et al*., 2008). Indeed two-thirds of the herds showed a TBMSCC lower than 200 000/ml prior to the project, which is moderate by international standards, so, this may be a reason for the slight changes in udder health during one extension year on all farms. In the first year, only management factors that can be classed as short term or dynamic changes can be altered. The long-term management factors often take longer than 1 year to implement (e.g. breed or alpine summer pasturing) or are associated with high investment (e.g. rebuilding of the stable). They are unlikely to be altered in 1 year by an extension service based on animal health support. Furthermore, effects of extension may need more than 1 year because the confidence between the farmer and the advisor is developing slowly and often depends on positive results (Ivemeyer *et al*., 2008).

Conclusions

A set of management factors associated with reduced udder health in Swiss organic dairy herds can be identified. The management factors with significant influence on udder health are in agreement with comparable previous studies. The results support the extension concept but there may be further relevant factors for advising in individual farm situations that cannot be determined as significant on all farms. Not all identified risk factors were changed in the first year of extension. Udder health improvement was achieved only on some of the farms within 1 year, especially on those with poorer basic udder health status.

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