Farm management factors associated with bulk tank somatic cell count in Irish dairy herds

Kelly PT[1,2], O'Sullivan K[3], Berry DP[1], More SJ[2], Meaney WJ[1], O'Callaghan EJ[1], and O'Brien B[1]

[1] Moorepark Dairy Production Research Centre, Fermoy, Co. Cork, Ireland
[2] School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland
[3] Department of Statistics, School of Mathematical Sciences, University College Cork, Cork, Co. Cork, Ireland

ABSTRACT

The relationship between bulk tank somatic cell count (SCC) and farm management and infrastructure was examined using data from 398 randomly selected, yet representative, Irish dairy farms where the basal diet is grazed grass. Median bulk tank SCC for the farms was 282,887 cells/ml ranging from 82,209 to 773,028 cells/ml. Two questionnaires were administered through face-to-face contact with each farmer. Herd-level factors associated with bulk tank SCC were determined using linear models with annual somatic cell score (i.e., arithmetic mean of the natural logarithm of bulk tank SCC) included as the dependent variable. All herd level factors were analysed individually in separate regression models, which included an adjustment for geographical location of the farm; a multiple regression model was subsequently developed. Management practices associated with low SCC included the use of dry cow therapy, participation in a milk recording scheme and the use of teat disinfection post-milking. There was an association between low SCC and an increased level of hygiene and frequency of cleaning of the holding yard, passageways and cubicles. Herd management factors associated with bulk tank SCC in Irish grazing herds are generally in agreement with most previous studies from confinement systems of milk production.

KEYWORDS: bulk tank; dairy cattle; infrastructure; management; somatic cell count

CORRESPONDING AUTHOR:

Patrick T Kelly
Teagasc, Dairy Production Department, Moorepark Production Research Centre, Fermoy, Co. Cork, Ireland.
Tel: +353 25 42222
Fax: +353 25 42340
E-mail: paddy.kelly@teagasc.ie

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INTRODUCTION

Ireland produces approximately 5,090 million litres of milk annually. In 2007, 528.5 million litres of milk were sold for human consumption and 140,400 tonnes of cheese produced (CSO 2008). Dairy cow milk was estimated to be worth €1.4 billion to the Irish economy in 2003 (CSO 2008). Given the huge economic importance of milk production in Ireland, the quality of this product is of the utmost importance. It has been shown that increased somatic cell count (SCC) adversely affects both the shelf life of milk (Barbano *et al.* 2006) and cheese yield (Barbano *et al.* 1991, Klei *et al.* 1998). Milk quality is required to be within certain thresholds according to European law (EEC 1992 Council Directive 92/46/EEC); SCC must not exceed a geometric average over three months of 400,000 cells/ml, with at least one test per month. Additionally, incentives and penalties are being increasingly applied by milk processors to help ensure high milk quality. Recent research indicates an annual increase in Irish bulk tank SCC of approximately 5,000 cells/ml, which is worrying for the dairy industry (Berry *et al.* 2006). Herd management has been shown in other international studies to be associated with bulk tank SCC (Barkema *et al.* 1998; Kiiman *et al.* 2006; Wenz *et al.* 2007). However, the management factors deemed to be important vary from farm to farm and country to country. Kiiman *et al.* (2006) concluded that the milking operator was the biggest factor affecting SCC. Wenz *et al.* (2007) documented that bedding material, housing facilities and cluster removers were all associated with bulk tank SCC. Barkema *et al.* (1998) reported that the most important factors associated with bulk tank SCC were teat disinfection after milking, the duration of clinical mastitis treatment and no drying after a wet treatment pre-milking. Rodrigues *et al.* (2005) reported differences in SCC between cows housed in forestalls and stallbarns, and Goldberg *et al.* (1992) documented that confined housing had a higher standard plate count than intensively managed rotational grazing.

Nevertheless, most research to date has been undertaken on confinement systems of milk production, whereas Ireland produces a large proportion of its milk from grazed grass with cows outdoors for the majority of the lactating period. The objective of the current study was to quantify the associations between herd management factors and bulk tank SCC in Irish, spring-calving, grass-based dairy herds. Results from this study will be useful in determining the proportion of Irish farmers undertaking different management practices and describing farm management practices associated with different levels of bulk tank SCC.

MATERIALS AND METHODS

Data collection

Data were obtained on annual milk supply for all farmers supplying to one of the major milk processors in Ireland, the milk processor supplied data on milk volume and bulk tank SCC on a collection basis for the years 2000 through to 2007. Milk was collected from the farms at a frequency range of one to four days. The SCC of the bulk tank was taken at almost every milk collection. Annual herd milk supply for the calendar year of 2004 was divided into strata in increments of 10,000 litres with herds supplying yields at either end of the supply distribution being merged due to small strata sizes. A total of 450 herds were randomly chosen, with the percentage selected from each stratum being weighted by the frequency of herds within strata relative to the sample population. These farms were invited to participate in a questionnaire survey, 400 of them decided to take part.

Two questionnaires were administered to each farm, one of which was undertaken during the period April to July, 2006 and the second during the period December 2006 to March 2007. In the first (summer) questionnaire, there were 70 questions relating to factors such as pre- and post-milking practices, milking machines, cleanliness of the facilities, and the practice of milk recording. The second (winter) questionnaire had 30 questions relating mainly to factors such as housing dates, housing type, cleanliness of shed and frequency of cleaning. The questions in the surveys required objective measurements and factual responses from the farmer as well as subjective measures. Bulk tank milk samples were taken during the summer visit. The sample was taken from the bulk tank after the milk was agitated, using individual sterile sample bottles. 10µl of each sample was inoculated onto blood agar plates (base no. 2; MERCK product. Manufactured in Merck KGaA 64271 Darmstadt. Germany) and incubated at 37ºC overnight (16-18h). Bacteria were identified visually from the plates after incubation, by an experienced laboratory person.

Each participating farm was visited on two occasions (summer, winter), and the questionnaires were completed during a face-to-face interview with the farmer at each visit. The questionnaires were developed following detailed discussion with specialists working in the milk quality area and examination of the main factors known to affect SCC, such as milking parlour, milking practices, housing, and hygiene. Three people were involved in the administration of the survey. Prior to the start of the study, these people standardised their approach to the scoring of farm hygiene, which was based on a visual assessment of farm yards and parlours. In addition, a scoring system for cow cleanliness was devised, based on a random sample of ten cows from each herd. Each cow was given a composite score of one (clean) to four (very dirty) based on the component score of the udder, tail and legs. An overall (herd) cow cleanliness score was calculated by combining the individual cow scores. Farms were divided into five regions based on geographical location. Farm visits within each region were alternated across time to minimise any potential temporal by spatial bias. A paper copy of each questionnaire was completed on-farm, then subsequently entered into Microsoft Excel, where the data was managed for ease of analysis. The milk processing data was supplied in electronic form and managed using Microsoft Excel. The two sets of data were combined using SAS.

Statistical analysis

Bulk tank SCC data for all milk collections in the 365 days prior to the first visit to a specific farm were obtained and the average of the natural logarithm of SCC calculated; this variable will be referred to as somatic cell score (SCS). A strong correlation (0.97) existed between mean SCS in the 365 days prior to the first farm visit and mean SCS 365 days post the first farm visit. All analyses were undertaken using linear models in PROC GLM (SAS, 2006) with SCS included as the dependent variable. Geographical location of the farm region was included in all models as a confounding effect. Initially, a series of regression models were constructed for each independent variable together with the confounding factor. Factors that were associated with SCS at a significance level of $P<0.30$, were retained for further analysis. Multiple regression models were developed using stepwise regression on the variables that fulfilled the initial selection criteria. Separate multiple regression models were generated using the questions from the summer questionnaire, winter questionnaire and from both. Statistical significance is defined as $P<0.05$ for all final multi regression models. Residual diagnostics did not indicate any concern for departures from the statistical assumptions of constant variability and normality.

RESULTS

The average number of cows per herd was 55, ranging from 12 to 293 cows. The average number of heifers per herd was 12 and ranged from 0 to 67. There was a wide range in milk volume supplied to the processor in the 365 days prior to the farm visit varying from 17,087 to 1,324,474 litres. Farm SCC ranged from 82,209 to 773,028 cells/ml; the median SCC was 282,887 cells/ml. From the 303 bulk tank milk samples taken, 51% of the samples tested positive for the presence of *Staphylococcus aureus*, varying from 1 CFU to 'numerous' (i.e., 40 to 100 CFU); 11% of all milk samples had >40 CFU. No other bacteria were isolated.

Tables 1 to 6 describe the univariate association between bulk tank SCC and milking process infrastructure, teat preparation, herd management, winter housing, parlour and roadway hygiene and the hygiene of winter housing, respectively. Not all milking parlour infrastructure variables were associated with bulk tank SCS (**Table 1**). Farmers that milked with a recorder jar plant had lower (P<0.001) SCS than farmers that milked using a direct pipeline. The presence of cluster removers and heated water in the parlour were also associated (P<0.05) with lower SCS. Separating milk from infected cows by way of the milking jar was also associated (P<0.01) with lower SCS than when a dump line or a churn was used. The number of milking units and the parlour design were not associated with herd bulk tank SCC.

Approximately half of the farms surveyed in this study practiced some form of teat preparation (**Table 2**), but there was no association between teat preparation and SCS. However, lower (P<0.05) SCS was observed on farms that disinfected teats after every milking. Farmers that used a dry cow therapy programme had lower (P<0.01) bulk tank milk SCS (**Table 3**) as had the 49% of farms that milk recorded (P<0.001).

Cleanliness of the farm, housing and milking parlour were strongly associated (P<0.05) with lower herd SCS (**Tables 4, 5 and 6**). Bulk tank SCS was lower in herds with clean facilities and/or that cleaned the housing area more frequently; herds that bedded cows on paper or sawdust bedding had the lowest (P<0.001) SCS. There was no association between bulk tank SCC and hygiene of calving area or let-in and out date of the cows. Furthermore, the overall dirtiness score of the cow was not associated with SCS. **Tables 7, 8** and **9** summarise the factors from the summer, winter and combined questionnaires, respectively that were significantly associated with bulk tank SCS in the multiple regression models. The solutions for the different levels of the factors were similar to those estimated from the

Table 1: Factors associated with milking process infrastructure on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10^3/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Parlour design	Side by side	45	12.49(266)	0.024	ns
	Herringbone	48	12.56(285)	0.023	
	Abreast, stall, byre	7	12.51(272)	0.061	
Number of milking units	≤5	13	12.50(269)	0.044	ns
	6	33	12.55(282)	0.027	
	7 and 8	24	12.53(278)	0.032	
	9 and 10	16	12.47(260)	0.040	
	12 to 30	14	12.54(279)	0.042	
Pipeline system	Direct pipeline	62	12.58(292)	0.020	***
	Recorder plant	38	12.43(250)	0.027	
Automatic cluster removers	Yes	5	12.37(237)	0.068	*
	No	95	12.53(278)	0.016	
Heated water in parlour	Yes	40	12.45(255)	0.025	***
	No	60	12.58(290)	0.020	
Frequency liners change	≤once a year	64	12.52(274)	0.020	ns
	>than once a year	36	12.53(278)	0.027	
Procedure to isolate milk from mastitic cows	Churn/milking bucket	55	12.53(277)	0.021	**
	Through the milk line	16	12.63(307)	0.038	
	Dump line	5	12.52(273)	0.069	
	Into the milking jar	24	12.43(251)	0.034	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Table 2: Factors associated with teat preparation on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10^3/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Teat preparation spring	Wash only	22	12.54 (279)	0.034	ns
	Wash and dry – paper towel	5	12.52 (273)	0.070	
	Wash and dry– common cloth	3	12.48 (263)	0.087	
	Dry wipe	24	12.50 (267)	0.032	
	None	46	12.54 (279)	0.023	
Summer	Wash only	16	12.55 (283)	0.039	ns
	Wash and dry – paper towel	2	12.34 (228)	0.111	
	Wash and dry – common cloth	2	12.50 (268)	0.104	
	Dry wipe	26	12.50 (270)	0.031	
	None	54	12.53 (278)	0.021	
Winter	Wash only	22	12.55 (282)	0.033	ns
	Wash and dry – paper towel	7	12.53 (275)	0.061	
	Wash and dry – common cloth	4	12.46 (257)	0.076	
	Dry wipe	22	12.50 (269)	0.034	
	None	45	12.53 (277)	0.023	
Disinfecting after milking	Never	22	12.61 (298)	0.033	*
	Intermittently	9	12.55 (281)	0.052	
	Every milking	69	12.50 (267)	0.019	
Foremilking practiced	At each milking	34	12.51 (270)	0.027	ns
	Once a day	3	12.57 (288)	0.089	
	If filter/sock has cruds	12	12.51 (272)	0.046	
	If SCC increases suddenly	8	12.52 (272)	0.055	
	Other	10	12.64 (308)	0.051	
	Never	33	12.52 (273)	0.027	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Table 3: Factors associated with herd management in summer on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*103/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Is milk recording practiced?	Yes	49	12.46 (259)	0.022	***
	No	51	12.58 (292)	0.022	
Mastitis cows milked?	At start	3	12.63 (305)	0.098	ns
	At end	28	12.54 (280)	0.030	
	Anywhere in herd	69	12.52 (273)	0.019	
Dry cow therapy applied?	Never and selected cows	4	12.74 (342)	0.083	**
	All cows	96	12.52 (273)	0.016	
Gloves worn during milking?	Yes	37	12.49 (266)	0.026	ns
	No	63	12.54 (281)	0.020	
Tail management (tail hair clipping)	Cut > once a year	48	12.51 (270)	0.023	ns
	Cut ≤once a year	39	12.55 (283)	0.025	
	Ringed	13	12.51 (271)	0.043	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

analyses where the factors were individually included in the model. Cleanliness of the housing and milking parlour were factors that remained significant in all models as well as bedding type, the use of dry cow therapy and whether or not heated water was available in the milk parlour.

DISCUSSION

Milk production, and thus milk quality, is of economic importance to Ireland and therefore herd management factors that are associated with milk quality need to be accurately quantified. Hence, the objective of this study was to quantify the association between herd management factors and bulk tank SCS. Because of the design of the study, it should be noted that the associations reported within do not imply cause and effect, and should not be interpreted as such. Nonetheless, this study provides an insight into the proportion of a random, but representative sample of Irish farmers that undertake different management practices as well as describing farm management practices associated with bulk tank SCS. Median SCC of the farms in the present study was 282,887 cells/ml, which is similar to the geometric mean of 250,937 cells/ml accounting for an annual increase of 5,000 cell/ml reported by Berry *et al.* (2006) for a large number of Irish dairy herds in 2004.

Rodrigues *et al.* (2005) documented that from the bulk tank milk samples taken on Wisconsin farms there was a small prevalence of contagious pathogens, and the type of facility was not associated with types of pathogens recovered. In contrast, Barkema *et al.* (1999) documented that there was a relationship between different pathogens and management practices. Backema *et al.* (1999) also reported that factors associated with bulk tank somatic cell count were related to the incidence rate of clinical mastitis caused by *S. aureus*. Also, Rodrigues *et al.* (2005) reported that many pathogens were identified from those farm bulk tank samples, while not to a single pathogen was identified from the bulk tank milk samples in the current study. Pitkälä *et al.* (2004) also identified many pathogens from milk samples of cows within confinement systems of either stanchion barns or loose housing. Barkema *et al.* (1999) showed that the incidence rate of *S. aureus* clinical mastitis was related to factors associated with bulk milk SCC. *S. aureus* cure rates are variable with a decrease in cure as SCC, duration of infection, number of quarters infected and age of the cow increase (Barkema *et al.* 2006).

Herd management

The lower SCS observed in herds that practice milk recording is possibly due to increased farmer knowledge on individual cows and its importance as a factor associated with SCC was substantiated by its persistence in the multiple regression model. Hutton *et al.* (1990) also reported that farmers that were more aware of the mastitis status of the herd had lower SCC.

The beneficial association between the use of dry cow therapy and lower SCC is probably due to minimising the carry over effect of subclinical mastitis across lactations (MacMillan *et al.* 1983). Smith *et al.* (1985) also showed that dry cow therapy reduced the rate of streptococcal infections during the early dry period but had no effect during the prepartum period. Wenz *et al.* (2007) showed a trend between the use of dry cow therapy and low bulk tank SCC.

Teat preparation and hygiene

In agreement with most previous studies (Barkema *et al.* 1998; Chassagne *et al.* 2005) clean farms, houses and milking parlours were strongly associated with lower SCS. The importance of cleanliness and hygiene was substantiated by these factors remaining in the multiple regression model. Nonetheless, no significant association was observed in the present study between cow cleanliness and SCS, which disagreed with Reneau *et al.* (2003) who reported lower SCC in cleaner cows in The Netherlands. Schreiner and Ruegg. (2003) also reported an increase in SCS and prevalence of intramammary environmental pathogens as udder hygiene score increased within a scale of one to four, four indicating dirty cows. The cleaner the roadway and holding yard; the less chance of dirt splashing on the cow's udder both before and after milking which may reduce the exposure of the teat ends to manure. Schreiner and Ruegg (2003) reported that the primary sources of exposure for environmental mastitis pathogens to the cow are the presence of moisture, mud, and manure. The more sanitised the machine, the fewer bacteria transmitted to the first line of cows from the last line of cows in the previous milking. This is increasingly important in herds with high milk SCC and mastitic cows at the end of milking. A higher frequency of passageway cleaning and cubicle cleaning and also specific bedding material types were associated with bulk tank SCC. In

Table 4: Factors associated with the winter housing on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10^3/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Cubicle bedding	Sawdust and other	11	12.40 (244)	0.049	***
	Shredded paper	4	12.37 (236)	0.082	
	Straw	4	12.55 (283)	0.076	
	Lime	17	12.62 (301)	0.038	
	Mats and lime	34	12.40 (242)	0.027	
	Mats	19	12.51 (271)	0.035	
	None	11	12.61 (301)	0.049	
Cubicles cleaned	Twice a day	37	12.43 (250)	0.027	**
	Once a day	46	12.49 (265)	0.023	
	Every second day	7	12.65 (313)	0.063	
	Weekly	5	12.60 (297)	0.073	
	Never	5	12.61 (299)	0.070	
How is the passage cleaned?	Mechanical scrapers	55	12.46 (257)	0.022	***
	Tractor	23	12.59 (294)	0.033	
	Hand scraper	6	12.57 (288)	0.069	
	Slats	11	12.49 (265)	0.050	
	Mixture	5	12.31 (221)	0.068	
How often is the passage cleaned?	Twice a day	16	12.51 (271)	0.043	***
	Once a day	24	12.61 (301)	0.035	
	Every 1/2 hrs	11	12.44 (253)	0.051	
	Every 3/4 hrs	32	12.39 (240)	0.030	
	Every 5/7 hrs	12	12.49 (267)	0.048	
	Twice a week	4	12.62 (303)	0.088	
	Never	1	12.69 (324)	0.176	
Calving area	Calving box	85	12.48 (264)	0.018	ns
	Cubicles house	4	12.55 (283)	0.084	
	Paddock	4	12.60 (307)	0.084	
	Stalls	3	12.53 (269)	0.091	
	Other	4	12.45 (256)	0.076	
How often is the calving area cleaned?	Daily	23	12.43 (251)	0.034	***
	Twice a week	17	12.63 (305)	0.039	
	Weekly	11	12.38 (237)	0.047	
	Three times a season	15	12.45 (256)	0.041	
	Twice a season	24	12.48 (264)	0.032	
	End of season	10	12.53 (276)	0.050	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Table 5: Factors associated with parlour and roadway hygiene on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10^3/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Cleanliness of the parlour	Clean	43	12.45 (255)	0.024	***
	Slightly dirty	48	12.57 (288)	0.023	
	Dirty	9	12.60 (297)	0.054	
Cleanliness of claw piece	Clean	42	12.45 (256)	0.024	***
	Slightly dirty	45	12.55 (282)	0.024	
	Dirty	13	12.67 (317)	0.043	
Condition of the liners	New	81	12.58 (269)	0.018	**
	Slightly cracked	12	12.69 (291)	0.048	
	Cracked	7	12.47 (324)	0.062	
Collecting yard cleaning frequency	After every milking	17	12.44 (253)	0.038	*
	Daily	37	12.50 (267)	0.026	
	Weekly	15	12.57 (289)	0.041	
	Every second day	13	12.55 (283)	0.044	
	Every third day	6	12.56 (285)	0.063	
	Slates	6	12.58 (291)	0.063	
	As required and other	6	12.66 (313)	0.064	
Cleanliness of yard	Clean	26	12.47 (261)	0.032	*
	Slightly dirty	43	12.53 (278)	0.025	
	Dirty	31	12.58 (292)	0.031	
Cleanliness of road	Clean	25	12.50 (269)	0.031	**
	Slightly dirty	51	12.49 (265)	0.022	
	Dirty	24	12.62 (302)	0.038	
Condition of road way	Very good	17	12.49 (265)	0.038	ns
	Good	59	12.51 (272)	0.021	
	Poor	24	12.56 (286)	0.032	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

agreement, Chassagne *et al*. (2005) showed that cleaner dry cow sheds were observed more frequently in the lower SCC category. Also, Barkema *et al*. (1998) reported that the cleanliness of cubicles and a greater frequency of cubicle cleaning were associated with lower bulk milk SCC. Wenz *et al*. (2007) documented that both the bedding material and the housing facility for cows were associated with bulk tank SCC.

Teat preparation is well researched for its association with SCC and intramammary infection rate but the results differ slightly, with the current study finding no association between pre-milking teat preparation and SCS, which is in agreement with Hutton *et al*. (1990) who reported that there was no significant difference in numbers of herds using teat preparations in the study between high and low SCC groups. However, in contrast it has also been shown that the utilisation of pre-milking teat preparation compared with no teat preparation is significantly associated with lower bulk tank SCC (Goodger *et al*. 1993), reduced presence of bacteria (Pankey 1989) and reduced incidence of new intramammary infections (Galton *et al*. 1988, Neave *et al*. 1969). Goldberg *et al*. (1992) concluded that insufficient hygiene prior to milking may repress the effect of improved management practices. The difference in results between the current study and previous studies may be due to cows in the present study being milked while at pasture and therefore being less dirty and under less pathogenic load, with the subsequent effect of reducing any potential benefits of teat preparation as may be observed in confined cows. Barkema *et al*. (1998) found the use of teat disinfection to have a reducing effect on bulk milk SCC and Chassagne *et al*. (2005) showed that teat spraying was more predominant in the low SCC group, both of which support the current study.

Table 6: Factors associated with cow housing and degree of cow hygiene on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10³/ml in parentheses) after controlling for region

Variable	Level	%	SCS (SCC)	SE	P
Cleanliness of loafing area	Clean	43	12.46 (267)	0.024	**
	Slightly dirty	43	12.48 (268)	0.024	
	Dirty	14	12.64 (312)	0.041	
Condition of cubicle shed	Very good	9	12.46 (257)	0.054	**
	Good	85	12.47 (262)	0.018	
	Poor	6	12.68 (322)	0.067	
Cleanliness of cubicles	Clean	56	12.43 (249)	0.021	***
	Slightly dirty	35	12.54 (281)	0.027	
	Dirty	9	12.66 (315)	0.053	
Total dirt score of the cow (worst score 120)	<40	19	12.49 (269)	0.037	ns
	<60	65	12.47 (270)	0.019	
	≥60	16	12.58 (296)	0.039	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Table 7: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during summer, based on a multiple regression model

Variable	Level	SCS (SCC)	SE	P
The pipeline system	Direct pipeline	12.65 (313)	0.044	***
	Recorder plant	12.53 (277)	0.049	
Heated water in the pit	Yes	12.54 (279)	0.046	***
	No	12.64 (310)	0.045	
Cleanliness of parlour	Clean	12.53 (276)	0.047	**
	Slightly dirty	12.63 (307)	0.047	
	Dirty	12.61 (300)	0.061	
Use of dry cow therapy	Never	12.69 (324)	0.082	*
	All cows	12.49 (267)	0.022	
Is milk recording practiced?	Yes	12.56 (285)	0.047	*
	No	12.62 (304)	0.045	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Milking parlour

This study showed a difference between recorder plants and direct pipelines with regard to SCS, the explanation of which requires additional information on the parlour design, as it is unknown if the vacuum was affected or the milk line height was different on these farms. The farms with automatic cluster removers had lower SCS, potentially due to consistent cluster removal at a specific milk yield and less chance of over milking. Natzke *et al*. (1982) showed that the increase in new infections from over milking is due to an increase in the number of quarters infected in an already infected cow rather than the number of newly infected cows increasing. Hutton *et al*. (1990) reported that cluster removers were less frequent on high SCC herds than low SCC herds. Wenz *et al*. (2007) also documented that the use of automatic cluster removers was associated with lower bulk

Table 8: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during winter, based on a multiple regression model

Variable	Level	SCS (SCC)	SE	P
Cleanliness of cubicles	Clean	12.43 (251)	0.041	*
	Slightly dirty	12.51 (272)	0.047	
	Dirty	12.58 (292)	0.058	
Cubicle bedding of cows	Sawdust and other	12.47 (260)	0.064	**
	Shredded paper	12.36 (234)	0.090	
	Straw	12.55 (281)	0.084	
	Lime	12.61 (302)	0.050	
	Mats	12.53 (276)	0.051	
	Mats and lime	12.45 (255)	0.047	
	None	12.60 (295)	0.057	
How often is the calving area cleaned?	Daily	12.42 (249)	0.048	**
	Twice a week	12.64 (308)	0.051	
	Weekly	12.45 (256)	0.059	
	Three times a season	12.50 (267)	0.054	
	Twice a season	12.50 (270)	0.050	
	End of season	12.54 (280)	0.062	
How often is the passage cleaned	Twice a day	12.58 (290)	0.047	*
	Once a day	12.61 (299)	0.037	
	Every 1-2 hrs	12.52 (274)	0.055	
	Every 3-4 hrs	12.46 (257)	0.039	
	Every 5-7 hrs	12.50 (268)	0.052	
	Twice a week	12.45 (254)	0.108	
	Never	12.46 (258)	0.205	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

Table 9: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during summer and winter, based on a multiple regression model

Variable	Level	SCS (SCC)	SE	P
Cubicle bedding of cows	Sawdust and other	12.51 (270)	0.062	***
	Shredded paper	12.47 (260)	0.082	
	Straw	12.57 (288)	0.086	
	Lime	12.71 (330)	0.057	
	Mats	12.62 (303)	0.054	
	Mats and lime	12.55 (282)	0.048	
	None	12.71 (331)	0.060	
The pipeline system	Direct pipeline	12.65 (313)	0.044	***
	Recorder plant	12.53 (276)	0.049	
Heated water in the pit	Yes	12.54 (280)	0.047	**
	No	12.64 (308)	0.045	
Use of dry cow therapy	Never	12.72 (335)	0.082	**
	All cows	12.46 (258)	0.025	
Cleanliness of the parlour	Clean	12.56 (284)	0.048	*
	Slightly dirty	12.64 (310)	0.048	
	Dirty	12.57 (288)	0.061	

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

tank SCC. In agreement with the present study, Hutton *et al.* (1990) also reported that milking clinically infected cows last was more common in low SCC herds.

CONCLUSIONS

This study described the facilities and work practices of a representative sample of Irish dairy farms. It also indicated different management practices and farm infrastructure associated with milk SCS. Some of the management practices associated with low SCS included the use of dry cow therapy, participation in a milk recording scheme, and the use of teat disinfection post-milking. An association between low milk SCS and an increased level of hygiene and frequency of cleaning of the holding yard, passageways and cubicles was also observed. Additionally, when a regression model was used on the data, the cumulative effect of best practices, such as use of dry cow therapy on all cows, having a clean parlour, heated water in the parlour, a recorder jar pipeline milking system and shredded paper for bedding cows, was calculated as 246,984 cells/ml, i.e., milk SCC was lower by 246,984 cells/ml when these best practises were in place compared to the poorest alternative in each case.

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