ASSESSMENT OF ENVIRONMENTAL FACTORS AFFECTING OF MILK QUALITY ON ONTARIO FARMS UTILIZING VOLUNTARY MILKING SYSTEMS FOR MORE THAN ONE YEAR

D. R. MCKNIGHT[1], J. RODENBURG[2] and J. FISHER[1]
[1]KEMPTVILLE COLLEGE, UNIVERSITY of GUELPH, KEMPTVILLE, [2]OMAF, WOODSTOCK,

Abstract:
The objective of this study was to identify barn environmental factors that may affect milk quality on dairy farms using voluntary milking systems (R) in Ontario that have been installed for more than 1 year. Twenty-one R farms in Ontario were compared with a comparable twin parlor (P) farm in the same area. Farms were evaluated for water quality, barn and stall cleanliness, cow udder and teat cleanliness, milking equipment and holding pen cleanliness, dry cow treatment program and bulk tank milk quality. Farms were visited once during the winter and summer of 2003. All water samples taken were potable on all farms. R farms were more likely ($P<0.05$) to use straw bedding and had lower stall bedding ($P<0.06$) and stall cleanliness scores ($P<0.06$). Fecal consistency, alley scrape frequency, cow walkway and cow cleanliness scores were not different ($P>0.05$).Milking equipment and holding pen cleanliness was also lower ($P<0.05$) on R farms due to time of observation and less frequent cleaning, as would be expected. R farms also dry cow treated all cows and all quarters less frequently ($P<0.06$). Bulk tank bactoscan ($P<0.01$) and freezing point ($P<0.03$) measures were higher on R farms, but SCC values were not different ($P>0.05$), suggesting that lower milk quality was not due to cow mastitis but primarily due to differences in cow environment and milking system. There was more variability between farms than between milking systems, suggesting that a farm using a robotic milking system can be managed as successfully as a parlor system within existing milk quality guidelines, but environmental hygiene levels may have to exceed those normally used in parlor systems.

Introduction:
Voluntary (robotic) milking systems (VMS) have been used on commercial dairy farms in Canada since 1999. Ontario now has more than 20 dairy farms with VMS. While this number of farms may be too small a number to permit comprehensive field study, early assessments may help identify issues to be addressed with altered management or improved technology. Chief among the issues are those related to milk quality. Most reports from Europe and Canada have indicated that somatic cell and bacteria counts and mastitis have increased after introduction of VMS. Kelton et al., 2001, reported that milk from 15 Ontario herds using VMS had higher somatic cell counts, had higher bacteria counts and contained more water than milk from 30 comparatively sized free-stall herds using conventional milking parlors. Rasmussen et al., 2001, with Danish herds, reported a sudden and significant increase in new SCC at the start of automatic milking and the frequency was higher throughout the first year with VMS than the previous year with conventional milking.

In contrast Hamann and Reinecke, 2002, with a German herd, could not identify any indication (cell count, electrical conductivity, NAGase, mastitis pathogens, milk yield) that VMS would initiate any impairment of udder health. There did appear to be a slightly higher ratio of S. aureus in the control group, whereas the VMS had somewhat higher numbers of “other bacteria”.

Casirani et al., 2002, with an Italian herd, also did not find any negative impact on intramammary infection incidence, SCC and teat tissue conditions, when the initial cow health status and overall herd management were good.

Control of Staph. aureus intra mammary infections could be one of the main problems within herds with VMS. Commercial VMS make it difficult to segregate infected cows as often recommended. Moroni et al., 2002, evaluated a within herd program of dry period antibiotic therapy and adaptation of VMS management modalities. Quarter samples were taken every four months and cultured for bacteria. With a combination of dry period treatment, early (< 60 dd) treatment of infected cows and addition of Clorexidina to the teatcup washwater, Staph. aureus infections were reduced from 32.2% to 15.4% of quarters and SCC from 617,000 cfu/ml to 363,000 cfu/ml. Type of bacterial infection may indicate whether the cause is environmental or caused by the technology. Hovinen and Pyorala, 2002, reported in their VMS research herd that only 7% of the cases of clinical and subclinical mastitis were caused by environmental bacteria like Str. uberis, E. coli and Enterococcus sp. In contrast, Petermann et al., 2002, found that environment-associated pathogens were the main cause for subclinical mastitis in 3 herds studied in Germany. Late lactation cows have longer VMS milking intervals (Weiss and Bruckmaier, 2002), are likely producing less milk and this has been demonstrated to result in higher SCC (Poelarends et al., 2002). Knappstein et al., 2002, reviewed the bacteriological quality of 4 VMS herds in Germany. They state that not only total bacteria count is important but also the composition of the milk flora, e.g. the number of thermoduric bacteria, clostridia or the presence of human pathogens. They list 3 main sources of bacterial contamination as the interior of the udder, udder surfaces and milking equipment that would need to be assessed to identify prevention strategies. Identification of the type of organism found in bulk tank milk may help identify the source of contamination. Coliform counts between 10^2 and 10^3 cfu/ml in bulk tank milk are an indication of poor milking hygiene (Reinemann, 1997). As the main influences on clostridia spores in milk are the spore content in feces and the method of udder preparation (Bertilson et al., 1996) the increased number has to be attributed to failures in the automatic teat cleaning system. Thermoduric bacteria exceeding $2x10^2$ cfu/ml and coliform bacteria exceeding 10^3 cfu/ml may indicate failures in cleaning of equipment (Reinemann, 1997). Ten Hag and Leslie, 2002, suggested that maintaining a clean stall environment is of even greater importance in a robotic milking herd, since there is difficulty in cleaning teats that are covered with manure or debris. However they found no difference in teat skin bacteria between teats prepared manually or teats prepared automatically by a robotic milking system. Often significant increases in total bacterial counts are caused by a failure of the cooling system or preparation of hot water for system cleaning (Knappstein et al., 2002). Water source may also impair milk quality, especially when VMS produced milk has a greater chance of water contamination (Everitt et al., 2002). Hygiene needs to be of the highest possible standard, with clean cows with clean udders and teats and clean bedding in stalls and cubicles (Everitt et al., 2002). Many initial studies on VMS affect on milk quality have compared milk quality before and for up to a year following installation. As with any new technology it may take some time for the cows, manager and new technology to adapt to each other and make the necessary changes to maintain acceptable milk quality.

The objective of the following study was to identify barn environmental factors that may affect milk quality on VMS farms in Ontario that have been installed for more than 1 year.

Material and Methods:

VMS herds in Ontario that have been in operation for more than 12 months, and had agreed to participate in a "labor efficiency" study being conducted by J. Fisher were simultaneously used in this study as well. The "labor" study evaluated 21 VMS herds (R) compared to a similar number, size and type of conventional milked herds (P).

Herds were visited once during the winter and summer of 2003 and the following areas assessed:

1. water quality
2. barn/stall cleanliness
3. cow udder/teat cleanliness
4. cleanliness of milking equipment/cooling equipment
5. dry cow treatment program
6. bulk tank milk quality records

1. Water quality. Water samples were taken at a location as close as possible to the milking system and submitted to the University of Guelph Laboratory Services for water quality and pH testing. Due to distances involved all samples were frozen for subsequent analysis.

2. Barn/stall cleanliness was assessed at the winter and summer visits by assigning a score to 10 randomly selected stalls for criteria as follows:

A. Type of Bedding
- 0 = no bedding used
- 1 = straw
- 2 = shavings
- 3 = sand
- 4 = mixed

B Fecal Consistency Score (Larson et al., 1977)
- 1= voided feces firm but not hard
- 2= does not hold form, piles but spreads slightly
- 3= pancake batter
- 4= orange juice

C. Stall Bedding Score
- 0 = stall well bedded front and rear
- 1 = stall moderately bedded or bedded in front only
- 2 = stall poorly bedded or devoid of bedding

D. Stall Cleanliness Score
- 0 = no evidence of manure or debris in any portion of the stall
- 1 = a slight amount of manure and urine in the rear of the stall
- 2 = a moderate amount of manure
- 3 = an unacceptable amount of manure and urine in the stall

E. Cow Walkway Score
- 0 = clean and dry
- 1 = slight amount of manure and moisture

2 = moderate
3 = excessive manure and wet

F. Alley Scrape Frequency
0 = none
1 = 1-3 times daily
2 = 4-6
3 = 7-9
4 = 10-12
5 = continuous

G. Cow Cleanliness Score was assessed during winter and summer visits on 10 cows at random as documented by Ten Hag and Leslie 2002
0 = no evidence of manure or debris on udder or teats
1 = manure or debris present on either udder or teats
2 = manure or debris present on both udder and teats

3. Cleanliness of milking and cooling equipment was assessed during the summer visit by a visual inspection of overall milking equipment and holding pen and subsequent assessment of mycoplasma and bacterial types and levels found in bulk tank samples. Samples of bulk tank milk were taken at each visit, frozen, and tested through University of Guelph Laboratory Services by routine mastitis culture.

A. Milking Equipment Cleanliness was scored as
0 = very clean
1 = moderately clean
2 = dirty

B. Milker Holding Pen Cleanliness was scored as
0 = very clean
1 = clean
2 = moderately clean
3 = dirty

4. Dry cow treatment program, if any, was documented. Information recorded included whether the cow was cultured prior to treatment, timing of administration relative to dry off and expected calving date, method of administration and product used. A percentage of cows dry treated was assigned in cases where all cows were not treated and this data was analyzed statistically.

5.Bulk tank milk quality measures of SCC, bactoscan and freezing point from DFO records were requested from the producer for the previous 12 month period during the summer visit.

Data was analyzed using PROC GLM procedures in SAS (SAS Institute,1999). Means were compared by least significant difference.

Results and Conclusions:

Twenty-one farms with robotic milking systems (R) agreed to go on the study in the winter of 2003 and were paired up with a comparable parlor system (P) in the same vicinity. One of the R farms withdrew from the study prior to the summer visit. Two of the R farms had both R and P milking systems necessitating removal of the milk quality data, as all milk was stored in the same bulk tank.

1. Water quality.

All water samples were found to be potable on all farms. Samples were tested for coliforms and E. Coli. In contrast, DFO and other surveys have reported that up to 35% of dairy farms may be using non-potable water. The farms evaluated in this study tend to be larger in size and are newer facilities with more current water supply systems. It is also possible that the freezing of water samples prior to testing lowered the counts. In any case, if milk quality from R farms is of lower quality than P farms, it does not appear to be due to differences in water quality supplied to the R milking system.

2. Barn/stall cleanliness (Table 1).

A. Type of Bedding.

There were differences ($P<0.05$) in type of bedding used. Two out of 20 R farms used little or no bedding and R farms were more likely to use straw than P farms. Lack of bedding and use of straw may be associated with the lower stall bedding scores found in C. below.

B. Fecal Consistency Score.

There was no significant difference ($P>0.51$) between milking systems in fecal consistency. Eighty-six % of farms scored either 1 or 2. Fecal consistency is largely a reflection of diet, and the thinking was that systems with more liquid manure might lead to dirtier cows and lower quality milk.

C. Stall Bedding Score.

Fifty-one percent of farms were observed to have well bedded stalls. However significantly ($P<0.06$) more R farms had poorly bedded stalls and fewer moderately bedded stalls than P systems. This may be related to type of bedding chosen but may also be associated with time spent in stall maintenance.

D. Stall Cleanliness Score.

Significantly ($P<0.06$) more stalls were clean and dry on P systems than R systems (21. vs 8.6% for P and R respectively). This suggests that R farms spend less time maintaining stall cleanliness, or that the type of bedding system chosen is more difficult to maintain. No unacceptable stall conditions were recorded reflecting the overall high level of management exhibited during visits. Leslie, 2002, suggested that maintaining a clean stall environment is of even greater importance in a robotic milking herd, since there is difficulty in cleaning teats.

E. Cow Walkway Score.

Ninety-five percent of farms were scored as 1 or 2 category, suggesting adequate frequency of alley scraping. There was no difference ($P>0.35$) between milking systems, although there was a tendency for R systems to have cleaner, drier walkways, possibly a refection of frequency of alley scraping.

F. Alley Scrape Frequency.
There was no significant difference (P>0.21) in overall frequency of alley scraping between R and P farms, although more P farms scraped form 1-3 times daily than R farms. This may account for the trend to cleaner drier alleys noted in E.

G. Cow Cleanliness Score.
There was no significant difference (P>0.66) between milking systems in cow cleanliness score. Forty-six percent of herds scored 0 and only 14% of herds scored at 2. If milk quality is lower in R herds it does not appear to be due to cow cleanliness. The lower level of stall cleanliness observed in R farms did not translate into reduced cow cleanliness.

3. Cleanliness of Milking Equipment.

A. Milking Equipment Cleanliness.
There was a significant difference (P<0.05) between R and P systems in equipment cleanliness with R farms more often observed to be moderately dirty. This was not unexpected as parlors are completely cleaned after each milking, and this was when the observations were taken, while voluntary milking systems are used throughout the day, cleaned less frequently and therefore observed as dirty more often during visits. Although unavoidable, it may be that this sanitation level, and the opportunity for pathogens to grow over time, could have an impact on milk quality.

B. Milking Holding Pen Cleanliness.
As with milking equipment, cleanliness of the milker holding pen was also significantly (P<0.05) poorer for R than P systems.

4. Dry Cow Treatment Program.
Ninety-five percent of P farms and 75% of R farms dry cow treated all cows and all quarters, which is a significantly different proportion (P<0.06). 15% of R farms either did not dry cow treat or only treated 50% of the cows, which could be a factor in milk quality, although there was no difference in somatic cell count levels.

5. Bulk Tank Milk Quality Measures.
Only one bulk tank sample was positive for mycoplasma so no statistical analysis was completed. The single positive was isolated from an R farm system. There was no difference between R and P farms in average SCC levels (P>0.63). Hamann and Reinecke, 2002 and Casirani et al., 2002 also did not find any negative impact on intramammary infection and SCC when the initial cow health status and overall herd management was good. However this is in contrast to many other studies and a previous study in Ontario by Kelton et al., that reported increased levels of SCC, bacteria counts and freezing point, in a study conducted in a similar fashion to the one reported here using many of the same R farms. Perhaps over the 2 year interval between studies, the level and type of management applied on the R farms has adapted to better control mastitis. In this study only 1 R farm had reached SCC penalty level of >499,000 and that occurred 5 X's during the twelve month period. Because SCC were not different between milking systems also suggests that the source of lower quality milk is not from the cow but rather the environment or milking system itself. From personal communication with DFO staff that have continued to monitor milk

quality levels, pre and post VMS installation, it is known that milk quality indicators post installation are still higher than pre installation. Bactoscan ($P<0.01$) and freezing point ($P<0.03$) levels were significantly increased in R versus P herds. Thirteen tests on 9 out of 20 R farms exceeded the 121,000 Bactoscan penalty level over the 12 month test period compared to 4 tests on 3 out of 20 P farms. The higher freezing point on R farms is most likely a result of the milking system, but the higher bactoscan levels could be a combination of milking system and environment.

In conclusion, stall bedding use, stall cleanliness and milking equipment cleanliness were found to be significantly lower on robotic versus parlor milking system farms. However cows were equally clean in both systems. These differences in stall and milking equipment cleanliness may have resulted in lower milk quality, however only bacteria levels and freezing point levels were significantly increased. The higher freezing point and bactoscan levels appear to be primarily due to the type of milking system. There was more variability between farms than between milking systems, suggesting that a farm using a robotic milking system can be managed as successfully as a parlor system within existing milk quality guidelines, but environmental hygiene levels may have to exceed those normally used in parlor systems.

Acknowledgments: Support of the participating farms and technical support of A. KoekKoek and A. Willoughby was much appreciated. Financial support was provided by the Ontario Ministry of Agriculture and Food.

Table 1 Assessment of environmental factors affecting milk quality in dairy herds using robotic or parlor milking systems

	Robotic (R)		Parlor (P)		Probability
Type of Bedding	#*	%**	#	%	0.05
0 none	2	10	0	0	
1 straw	5	25	3	15	
2 shavings	11	55	12	60	
3 sand	2	10	3	15	
4 mixed	0	0	2	10	
Stall Bedding Score					0.06
0 well bedded	20	50	21	52.5	
1 moderately bedded	11	27.5	17	42.5	
2 poorly bedded	9	22.5	2	5.0	
Stall Cleanliness					0.06
0 very clean	7	17.5	17	41.5	
1 slightly dirty	28	70.0	21	51.2	
2 moderately dirty	5	12.5	3	7.3	
3 excessively dirty	0	0	0	0	
Cow Cleanliness					0.66
0 none on udder/teats	20	50	17	42.5	
1 either udder or teats	14	35	18	45.0	
2 both	6	15	5	12.5	
Scraping Frequency					0.21
0 none	10	24.4	7	17.1	
1 1-3 x's daily	2	4.9	8	19.5	
2 4-6	12	29.3	6	14.6	
3 6-9	6	14.6	10	24.4	
4 10-12	4	9.8	4	9.8	
5 continuous	7	17.1	6	14.6	
Walkway Score					0.34
0 clean/dry	1	2.5	1	2.6	
1 slightly dirty	33	82.5	25	65.8	
2 moderately dirty	5	12.5	11	29.0	
3 excessively dirty	1	2.5	1	2.6	

Fecal Consistency					0.51
1 solid pile	9	22.5	13	32.5	
2 flat pile	26	65.0	21	52.5	
3 pancake batter	5	12.5	6	15.0	
4 orange juice	0	0	0	0	

Table 1 ***(cont'd)*** Assessment of environmental factors affecting milk quality in dairy herds using robotic or parlor milking systems

	Robotic (R)		Parlor (P)		Probability
Milker Cleanliness	#	%	#	%	0.01
0 clean	6	30.0	21	100	
1 moderately clean	13	65.0	0	0	
2 dirty	1	5.0	0	0	
Holding Pen Cleanliness					0.01
0 very clean	1	5.0	21	100	
1 clean	17	85.0	0	0	
2 moderately clean	1	5.0	0	0	
3 dirty	1	5.0	0	0	
Dry Cow Treatment					0.06
0 none	1	5.0	0	0	
0.5 50%	2	10.0	0	0	
0.8 80%	1	5.0	0	0	
0.9 90%	1	5.0	1	5.0	
1.0 100%	15	75.0	19	95.0	
SCC (000's)	207		200		0.63
Bactoscan (000's)	37.56		23.9		0.01
Freezing point	-0.539		-0.541		0.03

* # of observations within milking system type
** % of observations within milking system type

References:

Bertilsson, J., Lingvall, P. and Gyllensward, M. 1996. Factors affecting the contamination of bulk tank milk with clostridia spores. Proc. IDF Symp. Bacteriological quality of raw milk, Wolfpassing, Austria, pg. 33.

Casirani, G., Piccinini. R., Migliorati, L. and Zecconi, A. 2002. The effects of voluntary milking system on teat tissues, intramammary infections and somatic cell counts. Proceedings of the 1st North American Conference on Robotic Milking. pg. IV-49.

Everitt, B., Ekman, T. and Gyllensward, M. 2002. Monitoring milk quality and udder health in Swedish AMS herds. Proceedings of the 1st North American Conference on Robotic Milking. pg. V-72.

Hamann J. and Reinecke, F. 2002. Machine milking effects on udder health-comparison of a conventional with a robotic milking system. Proceedings of the 1st North American Conference on Robotic Milking, pg. IV-17.

Hovinen, M. and Pyorala, S. 2002. Observations on udder health of automatically milked cows in Finland. Proceedings of the 1st North American Conference on Robotic Milking. pg. IV-71.

Kelton, D. F., Rodenburg, J. and Hand, K. 2001. Udder health and milk quality on Ontario dairy farms utilizing voluntary milking systems. Proceedings of the 2nd International Symposium on Mastitis and Milk Quality, pg. 410.

Knappstein K., Reichmuth, J. and Suhren, G. 2002. Influences on bacteriological quality of milk in herds using automatic milking systems and experiences from selected German farms. Proceedings of the 1st North American Conference on Robotic Milking. pg. V-13.

Larson, L. L., Owen, F. G., Albright, J. L., Applemean, R. D., Lamb, R. C., and Millar, L. D. 1977. Guidelines toward more uniformity in measuring and reporting calf experimental data. J. Dairy Sci. 60:989-991.

Moroni, P., Cattaneo, M., Casula, A., Ruffo, G. and Bronzo, V. 2002. First study on prevalence and control of Staph. aureus intramammary infections in an Italian dairy farm with automatic milking system. Proceedings of the 1st North American Conference on Robotic Milking, pg. IV-60.

Petermann, M., Wolter, W., Rittershaus, C., Kloppert, B., Seufert, H. and Zschock, M. 2002. Automatic milking systems: udder health and milk flow profiles. Proceedings of the 1st North American Conference on Robotic Milking. pg. IV-75.

Poelarends, J., Willemsen, D. J. and de Koning, K. 2002. Relationship between milking interval and somatic cell count. Proceedings of the 1st North American Conference on Robotic Milking. pg. IV-82.

Rasmussen, M. D., Blom, J. Y., Nielson, A. H. and Justesen. P. 2001. Udder health of cows milked automatically. Livestock Prod. Sci. 72:147-156.

Reinemann, D. 1997. Troubleshooting high bacteria counts in farm milk. Porc. 36th Annual Meeting, National Mastitis Council, Inc., Albuquerque, New Mexico, pg. 65.

SAS Institute Inc. SAS/STAT® User's Guide, Release 8.02 Edition, Cary, NC: SAS Institute Inc., 1999-2001.

Ten Hag, J. and Leslie, K. E. 2002. Preliminary investigation of teat cleaning procedures in a robotic milking system. Proceedings of the 1st North American Conference on Robotic Milking. pg. V-55.

Weiss, D. and Bruckmaier, R. M. 2002. Influence of the milking interval in automatic milking systems. Proceedings of the 1st North American Conference on Robotic Milking. pg. IV-78.