Health of dairy cows milked by an automatic milking system

A preliminary report

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Information

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Abstract

A study on the impact on cow and herd health when changing from conventional, usually parlour, to automated milking (AM) is underway in Denmark, the Netherlands and the UK. Farms have been recruited to allow 15 to be studied in each country, approximately 1000 cows per country. The study is examining general aspects of herd health including milk quality, veterinary interventions, and veterinary costs. Specifically, cow studies are being made on individual cow milk cell count, mastitis incidence and treatments, teat condition, lameness, body conditions and reproductive performance. The aim is to gather data for 6-12 months pre-installation and then for 12 months after conversion to AM.

This brief report contains very preliminary information limited to those farms where data collection has been completed and data validated. It is being used to indicate areas and issues that may warrant more detailed investigation when all of the data sets are complete. This is essential as an extremely large database is being constructed. This project will only be able to examine the obvious key indicators of improved or impaired health. The whole database will be available as a research resource.

The preliminary indications are that body condition is not affected overall in the transition to AM, and that in all three countries farm management controls these well. Lameness, assessed as locomotion score, increased slightly in the Netherlands and the UK. No concerns have been raised but this will be investigated further including examination of changing risk factors including comparison of zero-grazed and part-grazed systems.

Early data suggest a large variation between farms, but that overall, fertility is not affected. Breeding success may be more difficult or lactations may be being extended with AM as the time to conception and the calving interval may be lengthening. These are not primary health issues that aaffecfg the well-being of the cows *per se*.

It is clear in the Netherlands and the UK that bulk milk cell count increases, at least in the short term, on installation of AM. However, the mastitis and teat health studies so far show no indications of a change in the incidence of infection. Substantial further investigation of this issue will be required to determine the involvement of infection and the extent of physiological variation in more frequent and/or irregular milking frequency.

Overall, there are few indications of general health problems on conversion to AM. Individual farms often have their own unique problem(s). These appear to be related to management, expectations and facilities rather than the milking system.

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1 General introduction

Automatic milking offers dairy cows significantly greater choice in daily routines according to individual choice. The herding instinct will still apply but individuality is allowed and management of animals by gross batches for milking or feeding is not part of the system. Some choice of behaviour and pattern of activity lies with the individual cow that favours cows lower in social ranking. Perhaps, more importantly, great choice is available to the manager, especially in time-tabling husbandry and management tasks.

Many of the variables of cow and herd health that affect welfare and herd productivity are related to risks associated with fixed routines including short-term activities such as feeding or milking, medium term influences of housing or grazing, and longer term effects such as breeding cycles.

Successful dairy farming requires control of and minimising the impact of cow health in its broadest sense with particular emphasis on the main disease categories of fertility, mastitis and lameness. This trio are considered to incur the greatest losses. The welfare of individual cows and the well being of the farming system depend on the quality of management of such potential problems.

Within any herd there is variation in the prevalence and incidence of disease. Information on the health of the herd comes mostly from regular monitoring of animals usually associated with the regular milking routine. That allows close observation of individual animals and all animals in milk. With automated milking such opportunities are lost. This may be a disadvantage if other facilities and monitoring opportunities are not used. However, optimisation of these is far from understood. It is likely that there may be different appreciations of herd health when milking automatically.

The impact of fully automated milking on individual animal's and herd health may be seen clearly and quickly for some conditions, especially acute disease, but many factors, especially in reproduction, require more specialist monitoring. As well as short-term deviations in herd performance, development of longer-term problems and evaluation of better management practices require more detailed study. Predictions have been made that any number of health problems may occur with automated milking but these ignore the fundamental interests and abilities of animal carers. The transition from conventional to automated milking is highly complicated and the two systems hugely different. It is important that good observations are made to determine what, when and why parameters of animal health may change. Changes are likely to be highly variable between and within farms according to previous practice, training and management philosophy. An extensive study is necessary.

2 Study aims

Work package 8 of the project *Implication of the introduction of automatic milking on dairy farms* seeks to study the health of a number of dairy herds over the transition from conventional to automated milking. It has defined objectives:

1. To calculate the incidence of infectious and production diseases in herds using automatic milking, relating these to particular risks and management practices,
2. To show areas of risks in animal health created when cows are not milked using direct human help such that different management strategies are necessary,
3. To identify those areas of particular advantage to health from allowing cows choice of milking frequency and timing,
4. To identify changing risks and best management practices necessary when using automated milking to reduce the disease burden and safeguard milk quality,
5. To identify and specify the possible effects of automatic milking on teat condition and thus udder health.

This project is collecting, collating and making available data on dairy cow health, and much background farm and staff information, for a number of months prior to starting automatic milking until one year after the introduction of automatic milking in herds in Denmark, the Netherlands and the UK.

The project started in early 2001 with discussions between research teams from the three countries to agree key health parameters, means of their assessment, areas of responsibility and a timetable. The different resources, interests and access to dairy farms meant that all partners would not carry out identical studies but that there would be a basic core related to fertility, animal physiology, mastitis and lameness. More detailed study of all aspects was planned for the UK. In the Netherlands the work includes some specialisation on cow teat health.

The project as planned has varied by necessity and in response to circumstances out-with the control of the team. The first major influence was the 2001 outbreaks of Foot-and-mouth disease in the UK and the Netherlands that severely restricted early access to farms and disrupted many farm plans. The market demands for automated milking and the responses of the manufacturers and suppliers have varied hugely, often far from their initial predictions. Not all suppliers supply to all markets. Interest and sales are not evenly distributed geographically or seasonally. Farm interest and enthusiasm has varied with the economic status of dairy farming. It has been possible to recruit all the farms needed for the study but not to include all the machine types intended and not to sustain all farms through the whole project. The main problems encountered that appear to be an accurate description of provision of automated milking include an insistence of farmers to install within a very short time of deciding to change milking system. This has meant that many farms were poorly prepared in facilities and management. A few farmers procrastinated and eventually never installed whilst another few did not complete 12-months of milking automatically.

The project will be completed within the agreed timetable but this interim report has been made with only limited access to complete data sets. The data are representative of each country but use a limited number of farms for which data have been validated. This interim report looks at key areas of fertility, lameness and mastitis to indicate any immediate areas of concern. This will allow focussing of the analyses of the full data sets to better describe any

problems encountered, their magnitude, universality, risk factors and successful management solutions.

3 Data priorities

The study was projected to use 15 herds in each of 3 different countries (UK, The Netherlands and Denmark); also including automated milking systems from up to three different companies. Country, type of animals, machine, level of production are variables to be accounted for in the study. Each herd, or sub-herd enrolled had 35-120 cows. This varied between the countries and also on farms where installations varied from one- to nine-milking units. Some 1000 cows were studied in each country.

Herds were recruited on advice from machine manufacturers of significant interest by farmers. The farms were visited to explain the project; the amount of data, access and assistance required; and to agreed protocols and confidentiality arrangements. The aim was to obtain 6 months of study when the farm was still using the conventional milking system with access to an earlier 6-months (minimum) of herd performance and animal health records. Then data are to be collected for at least one year of use of the automated system.

The herds, where possible, used standardised health-recording schemes although the methods of recording varied according to local demands. The data were retrieved from herds by regular submission of paper or computer records.

The basis of the study was to aim for a programme of visits to each farm a minimum of three times before installation of automated milking and at least one, three, six and twelve months after installation. This allowed collection of farm records on all infections, disease and conditions likely to affect milk quality and production. At each visit a programme of inspection of animals was undertaken that included

(a) body condition scoring of a minimum of 50% cows being milked,
(b) locomotion scoring of a minimum of 50% cows being milked,
(c) teat condition scoring (NL and UK) of a minimum of 40 cows in conventional milking and a minimum of 25 cows with AM.

Standardised methods for each of these were used and will be included as appendices in the final report. Prior to farm visits joint training sessions were held with appropriate staff to agree methods and scores.

The main areas of interest are:

Body condition	- determination of body condition score
Lameness	- determination of locomotion scores and treatments
Fertility	- calving interval, number of inseminations to conception, days to conception
Udder health	- bulk milk somatic cell count, individual cow cell counts, incidence of clinical mastitis, treatments, veterinary attention
Teat condition	- using Teat Club International protocols (NL and UK)
Milk production	- 305-day production, length of dry period, fat and protein composition, milk quality
Veterinary assistance	- records of veterinary input and medicines used.

4 Progress report

4.1 Farms

The fieldwork has been completed in Denmark but continues in the Netherlands and the UK with all farms having been enrolled (Table 1). In each country one farm withdrew after many months of initial study without installing automatic milking. In the UK one farm removed automatic milking and returned to parlour milking after 9 months. In the Netherlands one farm withdrew from the study because of personal reasons.

In the UK the last farms are only now having AMS installed. This is a partial consequence of the FMD situation earlier. It is also clear that farmer's decisions to change to AMS are highly seasonal with commitments occurring for a period in the spring and then autumn only. This raises supply and commissioning problems with the manufacturing companies. The farmers also tend to rush the process when they finally decide to purchase. In some cases this suggested that the project would struggle to obtain 6-months data pre-installation in the UK. Some problems occurred like this in the Netherlands such that it was difficult to complete as many pre-installation visits as would be preferred. In the UK major problems on some farms have arisen from lack of planning and poor co-ordination of the processes of planning, building, installation and commissioning of AMS. Typically installation companies miss target dates by weeks or months. Even then AM often starts when the ancillary facilities are incomplete, also training of staff may be partial and occasionally missing. Thus, in most cases, the pre-installation data for this project may be complete but the farmers were not always fully prepared to use AM.

Table 1 Stage of study on farms.

Country	*Recruited*	*On-going*	*Complete*	*Withdrawn*
Denmark	15	0	14	1
Netherlands	17	11	4	2
UK	16	9	5	2

4.2 Data

It is important that the data are collected, the quality checked and then stored in a secure and uniform manner for further work. This has required significant work on the project database (Dale et al., 2002). Discussions and agreement between the research partners were undertaken to resolve national differences in the format of animal identification and production recording. Previously the teams had standardised the body condition, locomotion and health scoring systems between the versions used in the three partner countries. Much of the work has been the preparation of data into report forms, usually Excel spreadsheets, that allow automatic input to the database. Such processing allows primary screening for system errors in the data. The input systems to the database are complete for all staff collected data. Training has been obtained in the UK to use the AM database systems on farms from two industrial partners so that much of the post installation data can be gathered and stored automatically.

The UK partner receives all data to add to a central database. This comes from separate databases in the Netherlands and in Denmark. Output from their databases is in the form of input tables for the main database. Overall, the data for this project are being input to a database specifically designed to contain all of the observations and measurements and to provide search facilities and selected output for more detailed analysis (Dale et al., 2002). This database is largely complete for input but not retrieval and reporting. Data for this preliminary report have been retrieved from the Excel spreadsheets that comprise the input forms to the database and from other farm electronic and paper records. Summary data tables are being compiled to give an overview of performance, to highlight missing data and to direct more detailed examinations (Table 2).

Table 2 Example of summary table of comparative data for herd UK05

Month relative to installation	**-12**	**-6**	**-3**	**-1**	**+1**	**+3**	**+6**	**+12**
Body condition score[#]	-	-	2.83	3.20	3.36	2.84	2.96	2.74
Locomotion score[*]	-	-	1.61	1.61	1.58	1.59	1.55	1.72
Fertility – services to conception	-	1.73	1.72	1.60	1.67	1.61	1.72	
Fertility - % conception	-	60	61	66	62	67	61	
Fertility – days to conception	-	131	141	142	152	158	152	
Fertility – calving index (days)	-	392	403	409	416	417	423	
12-month rolling average bulk milk cell count (‘000 cells/ml)	85	108	108	110	114	127	195	
% cows with cell count >200,000 cells/ml	14	17	11	43	-	25	36	

[#]Body condition is scored from 1= thin to 5=fat
[*]Locomotion is scored from 1=OK to 4=lame

5 Preliminary results

5.1 Body condition

Initial examinations of complete and authenticated data have allowed comparison of any changes that occurred in the body condition and lameness scoring of cows from before until after the installation of AM. This is a within farm comparison using simple average scores for all cows seen at visits and all visits either before and after for a small number of farms in all three countries. Comparisons may also be made between farms and countries (Table 3).

The body condition scores with conventional milking appear similar for the three countries with significant overlap of the ranges found. The Dutch body conditions appear slightly, but not significantly, lower. The post AM installation scores are not different although there is a very small upward trend in average and range for Denmark and the UK and in range for the Netherlands. It appears that the farm conditions associated with AM do not lead to a change in body condition or that the farm managers act appropriately in managing the different circumstances of AM. This will be tested fully with the complete data sets for the whole project.

Table 3 **Preliminary data on the overall average (range) of mean body condition and locomotion scores for a sample of herds studied in three countries before and after installation of an AMI**

	Body condition		**Locomotion**	
	Before	After	Before	After
Denmark N=3	2.92 (2.53-3.34)	3.05 (2.61-3.42)	-	-
Netherlands N=5	2.82 (2.06-3.41)	2.79 (2.28-3.67)	1.89 (1.58-2.17)	1.93 (1.54-2.38)
UK N=5	3.02 (2.60-3.65)	3.17 (2.83-3.91)	1.67 (1.33-2.31)	1.72 (1.55-2.22)

5.2 Lameness

The locomotion scores are from the UK and the Netherlands (Table 3). Perfect locomotion scores 1 and lame cows score 4. The average scores before and after AM installation are marginally higher, but not significantly so, in the Netherlands than in the UK. In both countries there was a very small, not significant increase, after installation of AM. The ranges for both countries are similar. This preliminary data suggest no obvious impact on cows maintained in AM farms. This will be tested further with the full data set, including the effect of total confinement. To date no obvious changes have occurred.

5.3 Fertility

Fertility data for several UK farms have been obtained from the National Milk Records service. Data will be available from 12-months prior to installation of AM and the first 12-months after installation. The preliminary analysis compares rolling 12-month averages at 6-months prior to installation and 6-months after installation (Table 4). This allows comparison for the same time of year of the effects of changing to AM.

To date there are no obvious differences in the number of services needed to achieve conception or the conception rate at first service. This suggests that fertility is not being compromised by the change to AM. There may be an increase in days to conception suggesting that a delay in return to oestrus may be occurring or that oestrus is being observed less reliably or that cows are being observed later. This will be tested when more data are available. A consequence is that the calving interval may be extended but the few data available require substantiation.

Table 4 Preliminary data on the fertility in five UK herds (averages and ranges) comparing the 12-month rolling means 6 months prior to installation with 6-months after AMI installation.

Time	No. services to conception	% conception	Days to conception	Calving interval (days)
6-months before	1.73	54 (33-63)	125	404 (386-418)
6-months after	1.70	52 (34-67)	138	416 (406-423)

5.4 Milk quality and mastitis

Milk quality is often assessed as a primary indicator of the quality of farm management and udder health. So far, problems have been identified on several farms in different countries. The initial data for the UK (Table 5) add to previously expressed concern (v.d. Vorst, 2002) that bulk milk cell count increases as a response to the introduction of AM. There is also an increase in the proportion of milking cows that produce milk with a cell count in excess of 200 000 cells/ml. The rise is an increase of up to 50% more cows with a high cell count although some farms report a much smaller or no change. This suggests a variation in response of risk that may be related to management or performance of AM. The data from the Netherlands appear similar. In the Netherlands the threshold applied is 250 000 cells/ml so the rise is smaller in proportion of cows affected. The results here correspond well with Danish observations showing an increase I the proportion of higher cell count cows (Rasmussen et al., 2001).

Initial investigations on one farm in the UK suggested that only some cows may experience problems but this was found to be an artefact of the commercial cell counting service taking incorrect proportions of milk to reflect each milking. No account was being taken of

variations in milking frequency and yield over a 24h period. There was no demonstrable change in individual cow cell count.

Table 5 Preliminary data on the milk cell count in herds approximately 6-months prior to installation and 6-months after AMI installation.

	Netherlands (n=7)		*UK* (n=5)	
	~6-months before	~6-months after	6-months before	6-months after
Bulk milk 12-month rolling average cell count ('000 cells/ml)	-	-	111	195
% cows with milk >250 000 cells/ml (NL)	19	24	18	32
% range of cows with milk >200 000 cells/ml (UK)	(10-31)	(14-34)	(7-29)	(13-46)

Reasons for the increase in cell count in bulk milk and individual cows are being investigated. First the treatment records for three of the UK herds have been examined (Table 6).

Table 6 Incidence of clinical mastitis, determined as new cases treated and recorded in the farm medicines record book for 12 months before and 12 months after installation of AM.

	Incidence of clinical mastitis (cases/100 cows/year)	
Farm	Before	after
UK01	13	28
UK03	64	115
UK05	96	66

Farm UK01 produces to organic standards. The records prior to installation of AM appear to be an incorrect representation of clinical mastitis as only cases treated with licenced medicines were recorded. During farm visits several cases were identified by project staff but were 'unrecognised' in the farm records. After installation of AM antibiotic treatment was restarted partly in response to the alerts from the milk electrical conductivity system and partly because of supposedly high individual cow cell counts that were later shown to be in error. The bulk milk cell count rise from 194 000-216 000 cells/ml suggests relatively little change in the prevalence of mastitis in the herd.

A significant rise in the incidence of clinical mastitis from before to after installation was apparent on farm UK03 and contributed to this farm removing AM after approximately 9-months of use. The prevalence of mastitis probably increased as bulk milk cell count increased from 118 000 cells/ml to 183 000 cells/ml. The actual number of cases treated was 40% higher because there were up to 10 cases each month of a repeat clinical mastitis in quarters treated within the previous 4-weeks and this sub clinical mastitis may have been the main cause of the rise in bulk milk cell count. This has not been separated previously from records. It suggests that consideration must be given to methods of treating, especially using intra mammary antibiotic, when cows are milked at irregular intervals. The causes of mastitis have not been determined and so other changes in risk factors have not been fully considered.

Contrary to the previous two farms there was a significant reduction in the reported incidence of clinical mastitis on farm UK05. However, this farm saw a considerable increase in bulk milk cell count over the first few months of use of AM, from a 12-months rolling mean of 110 000 cells/ml to 240 000 cells/ml. The cell count has since slowly declined to 223 000 cells/ml.

5.5 Teat condition

Teat condition after milking varies with milking conditions and the design of milking liner in use. It is to be expected that there is wide variation between farms. This is shown here in Table 7 for three of the main teat conditions observed to be affected by milking. All three farms used the same AM systems and the same liner. They are consistent in the proportion of teats found to be discoloured or ringed at the base after milking. This is indicative of acceptable milking, vacuum, pulsation and prevention of over milking. Farms UK01 and UK05 appear similar in the tendency for the teat duct orifice to be open after milking. However, farm UK03 appears to have an increased proportion of cows with an open orifice. Until other conditions are compared this must be assumed to be a cow effect. It indicates a potential risk to invasion of bacteria in to the mammary gland and hence infection. This farm did report more clinical mastitis. Such data allow identification of potential risk factors to good animal health and may direct management to avoid them or minimise their impact.

Table 7 **Preliminary data from three UK herds on the changes in three key areas of teat condition influenced by milking, for the period 6-months before to 12-months after installation of AM.**

Farm	% teats red or blue after milking		% teats with ring of tissue at the base after milking		% teats open after milking	
	Before	After	Before	After	Before	After
UK01	43	13	20	6	34	28
UK03	11	16	0	0	32	62
UK05	12	15	0	0	37	18

Detailed studies on farms in the Netherlands on changes in teat orifice condition from before cows are milked by AM, in the transition period and the effects over the length of the lactation are being made. Early indications are that the degree of hyperkeratosis found at the orifice does not change significantly, the trend is for less hyperkeratosis with AM (Figure 1).

The scoring system is described by Neijenhuis et al. (2000) and broadly is a deterioration of teat orifice conditions from left to right on the figure. This suggests that, to date and in this aspect, a properly managed AM system may not pose an obvious risk to teat health.

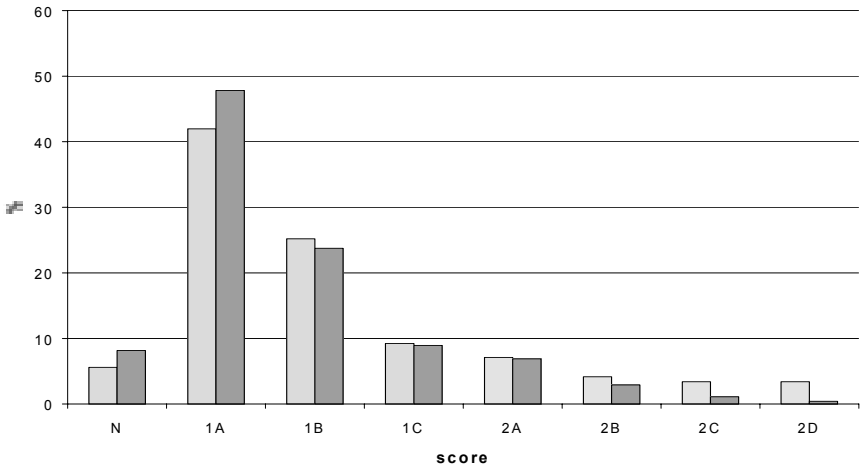

Figure 1 Teat orifice hyperkeratosis before (left column) and after installation of AM.

6 Discussion

This preliminary report is based on only small amounts of data from the study of 45 farms in the three partner countries. Only such a synopsis of the study is possible because the study is incomplete on most of the farms and on others the data collation and validation are still underway.

Selected topics of infectious and production disease have been included to indicate the major areas of concern for the impact of AM on the dairy cow and the milking herd. Simple analyses have been undertaken to indicate areas that may be of little concern and to show where there may be areas of significant concern. These suppositions may change as the data available grow. Where potential problems appear some initial background on the basis of the concern is given. Substantial amounts of background information have been collected from extensive questionnaires applied to each farm prior to, during and at the end of the study to ascertain changes in farm management approach and user attitude to AM.

The body conditions of cows is usually highly variable with breed, stage of lactation, feeding and is a consequence of management and activity of the cows. Wide ranges in condition within and between herds are to be expected and these appear to have been determined. However, within the ranges there is no evidence that any problems occur in cows becoming too thin or too fat. It may be that individual problems can occur but generally the quality of feeding management is such that this area appears of no potential problem.

A similar preliminary conclusion appears valid for locomotion and lameness in the cows. Both of these factors may vary with season and if cows are grazed part-time. The full data set will allow more refined determination of individual risk. So far no problems have been shown.

The fertility of herds examined when milked with AM does not appear to have changed but only a limited time has been examined. The only change seen is a slightly longer time to conception. Any effects on calving interval are not yet obvious and will require data from more farms completing their first year using AM.

Concerns on milk quality, especially bulk milk cell count, have been raised previously (v.d. Vorst et al., 2002) and these seem to be supported in this study. The bulk milk cell count increases on average and there is an increase in the proportion of high cell count cows contributing to the bulk tank count. In addition, there is limited evidence of an increase in the incidence of clinical mastitis. However, the results are inconsistent between farms. Some show no change in cell count or a reduction in reported clinical mastitis. Early detailed examination of the data suggests that distinctions have to be considered between bulk tank cell count and the cell count of individual cows. The latter has been found in one farm to be confused by the sampling service not coping with more frequent milkings and variable milking intervals such that milk samples were improperly aliquoted. A limited study by the project team found no elevation in individual cow cell count.

The study of mastitis treatment records shows the increased number of clinical mastitis cases treated. More detailed, but early and preliminary data show a possible large increase in the repeated rate of clinical mastitis, up to 60% of cases. The same cows and quarters show repeated clinical cases. This suggests that much of the prevalence of mastitis may result from an inadequacy of the treatment applied. Similar effects have been known from three times daily milking in conventional systems (J. E. Hillerton, personal observations). The treatment

regimens of intra mammary antibiotic are not optimised for variable milking intervals and for more than twice daily milking.

Underlying much of the rise in cell count, possible only to particular cows in the herd as up to 50% appear to remain with a cell count less than 100,000 cells/ml after the introduction of AM, is the response to more frequent and irregular milking. Changing milking frequency from twice daily, to anything from three to six-times daily, results in a rise in cell count that takes 2-7 days to reduce and stabilise (v. d. Iest & Hillerton, 1989; Hillerton & Winter, 1992). If milking frequency becomes variable then it may be that cell count never reduces but stabilises, and this may explain why only certain cows are affected with the irregular milking frequency. The whole data set will be examined to determine the relative role of milking frequency and infection in the rise in cell count where it occurs.

The whole aspect of mastitis and milk cell count after installation of AM will remain controversial. Detailed study of the whole data set including the variability between farms, farmer approaches and risk factors should contribute to a much better estimation of the potential problems that can occur and their avoidance.

Teat condition seems to improve in the limited number of studies undertaken. The farms reported here all use the same AM and same liner. Whilst the proportion of discoloured and ringed teats was variable between farms before installation of AM it is lower and more consistent with the liner in use. The proportion of teats open after milking remains inconsistent between farms. It is important to recognise that this may occur on some farms. The whole data set will be used to examine for milking and management factors related to this observation. It is important that all farms examine cows to know if this occurs. In conventional milking farmers would be advised to ensure cows remain standing for up to 60 minutes after milking to allow the orifice to close. This is not possible with AM. The coincidence between a high number of open orifices and an increase in clinical mastitis on farm UK03 suggests that this is major risk factor to be managed.

To-date there is no indication that longer-term teat changes such as hyperkeratosis of the orifice increase. This has previously been considered a potential risk from longer machine attachment times per day and possibly lower milk flow rates. The full study will be required to confirm if there is truly no risk.

Overall cows, farms and farmers adjust well and do not encounter major, common problems in converting to AM. Individual problems are being observed, more than reported here, and these will receive more detailed study. These are mostly on farms where major adjustments to several parameters were made simultaneously e.g. AM, housing, bedding etc. The most obvious problem encountered, but not on all farms, is a rise in bulk milk and individual cow milk cell count. A number of hypotheses on the causes remain to be tested using the full data set. It is by no means certain that this is entirely an increase in intra mammary infection.

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