MASTITIS IN LOW SOMATIC CELL COUNT DAIRY HERDS –
preliminary results from a postal questionnaire survey

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SUMMARY
A questionnaire survey of dairy farmers with low bulk tank milk somatic cell counts 
(BTMSCC) was carried out to assess the level of mastitis and to quantify risk factors for 
mastitis. Questionnaires were sent to 3009 producers with an average BTMSCC in 1997 of 
less than 100,000 cells/ml. One thousand eight hundred thirty nine replies were received, a 
61% response rate. The average reported incidence of clinical was 22.8 cases per 100 
cows/year. Simple and complex analyses were done to assess the associations between 
potential risk factors and a binary (yes/no) outcome variable of more than 25 cases of mastitis 
per 100 cows/year. The following factors, which were associated with an increased risk of 
disease, remained in the final logistic regression model: leaking milk in the parlour, leaking 
milk at other times, milking and dry cow straw yard housing (compared to cubicle housing), 
ininfrequent mucking out of the calving area (less than once a month), access to an outdoor 
yard, changing teat liners more often than every 6000 milkings and sometimes or always 
wearing rubber gloves during milking. The implications of the results for future research and 
the development of control programmes for mastitis are discussed.

INTRODUCTION
Mastitis is one of the most common diseases affecting dairy cattle. It is estimated that mastitis 
costs the UK dairy industry £200 million each year (1). However, the incidence of mastitis 
has been reduced from an estimated 120 cases per 100 cows/year in 1960 (2,3) to the current 
level of 35-45 cases per 100 cows/year (4,5). This is mainly attributed to the control of 
contagious pathogens, namely Staphylococcus aureus, Streptococcus agalactiae and 
Streptococcus dysgalactiae, through the introduction of improved control measures, notably 
the 5 point plan (6,7). The main source of infection for contagious pathogens is the infected 
quarter, and transmission usually takes place in the parlour. Reduction in the prevalence of 
contagious mastitis pathogens has been associated with a decline in the average bulk tank 
milk somatic cell count (BTMSCC) in the UK from 573,000 cells/millilitre (ml) in 1971 to 
the most recent estimate of 180,000 cells/ml in 1996 (8). Financial incentives to reduce 
BTMSCC accelerated this decline in the early 1990s.

Environmental pathogens survive in the cow’s environment, i.e in the soil or bedding, which 
is the main source of infection. The main environmental organisms are Escherichia coli and 
Streptococcus uberis. Recent reports from the Veterinary Laboratories Agency (VLA) of the 
Ministry of Agriculture, Fisheries and Food (MAFF) have highlighted the increased 
importance of environmental compared with contagious pathogens (quoted in 8). There is 
evidence from the United States (9,10,11) and the Netherlands (12,13) that low BTMSCC 
herds suffer a higher level of environmental mastitis, compared with herds with higher 
BTMSCC. It is also well recognised that current control measures for mastitis are 
considerably less effective in controlling environmental pathogens compared with contagious
pathogens. There has been no large scale study of mastitis in low somatic cell count (SCC) herds in the UK previous to this study. The aim of this work was to identify management and other factors associated with farmer reporting of mastitis in low SCC herds.

Questionnaires are applied commonly in epidemiological investigations to collect information on disease occurrence, associated factors and opinions. They have been used successfully in studies of mastitis (14). A postal survey was chosen as the most appropriate method to collect information from a large number of producers from all parts of Great Britain.

MATERIAL AND METHODS

Selection of farms
There are currently more than 100 processing dairies purchasing milk from producers in Great Britain. Nine dairies were asked to co-operate in this study and each collected milk from at least 400 producers. One declined to participate and a further two were unable to provide the data required. The six dairies which participated finally were supplied by 22,700 producers, approximately 80% of all producers in Great Britain (15). The dairies identified low cell count producers. In this study, low cell count herds were defined as having an average three monthly rolling geometric mean BTMSCC of fewer than 100,000 cells/ml during the period December 1996 to November 1997.

Questionnaire
A pre-tested questionnaire, an explanatory letter and a business reply envelope were posted to all of the 3009 producers who fell into the low cell count category (13% of all milk producers). The dairies either provided a list of their producers or mailed them directly. A post card reminder was posted to non-respondents 3 weeks later, with the exception of farmers supplying one dairy, as the dairy declined to allow their producers to be re-mailed. One month later a second copy of the questionnaire, another explanatory letter and a business reply envelope was posted to non-respondents.

The questionnaire contained 11 pages with 65 questions. It was designed to assess the incidence of clinical mastitis and management practices in 1997 and included questions on milking routine, milking machine maintenance, housing, bedding, dry cow therapy and management of calving cows. The majority of the questions were closed, with space available to note alternatives to the options given. The questionnaire was pre-tested on ten farmers from a local veterinary practice.

Analysis of results
The records were stored and manipulated in “Access” (Microsoft Inc.) and analysed using Epi-Info version 6 (Center for Disease Control, Atlanta, USA) and STATA (Stata Corporation, College Station, USA).

The mastitis incidence was calculated as the reported number of cases of clinical mastitis per 100 cows/year. A binary (yes/no) mastitis variable was created to divide the herds into high (>25 cases per 100 cows/year) and low mastitis incidence categories (≤25 cases or fewer per 100 cows/year). The associations between disease and all potential explanatory variables were screened using bivariable chi² or t-tests as appropriate. Variables with significance probability (p≤0.2) were used in further analysis. They were grouped into 5 categories: milking preparation, milking routine, housing, bedding and management. A second stage of selection was performed within each group of risk factors. The variables were tested in a backward
stepwise elimination logistic regression model, with mastitis as the dependent variable. The statistical significance of each variable was tested using the likelihood ratio. Variables with \( p \leq 0.1 \) were used in further analysis. In the final stage risk factors were combined in a backward stepwise elimination logistic regression model, using \( p \leq 0.05 \) as the lower inclusion level. Biologically plausible interactions between the main effects were tested. The goodness of fit of the model was tested.

RESULTS

Response rate
Of the 3009 questionnaires mailed 1838 were returned, a response rate of 61%. One thousand seven hundred and seventy one questionnaires were usable.

Herd characteristics
The average herd size was 78 (s.d. 42). Ninety six percent of herds had Friesian Holstein cows. Cubicles and straw yards were the two main housing systems.

Mastitis data
The average number of cases of mastitis reported was 22.8 per 100 cows/year, ranging from 0.6 to 147.1 (Fig. 1). The binary mastitis variable split the herds into two groups, 68% herds having 25 cases or fewer per 100 cows/year, and 32% having more than 25 cases. The median mastitis incidence in each group was 13.1 and 36.7 cases per 100 cows/year, for the low and high incidence groups, respectively. Ninety percent of farmers reported that 10% or fewer cows with mastitis were clinically sick, and 5% of farmers reported 30% or more cows as clinically sick. The incidence of mastitis was greater in herds where more than 10% of cases were reported as clinically sick (28.8 compared to 21.4 cases per 100 cows/year, \( p < 0.001 \)).
Seventy seven percent of farmers reported keeping mastitis records (15% of the records kept were computerised); and they reported a significantly higher level of mastitis compared with those not keeping records, 24.0 compared with 18.8 cases per 100 cows/year (p<.001). Sixty three percent of farmers reported culling cows for mastitis in 1997, whilst 43% reported culling for high SCC. The average percentage of the herd culled for mastitis and high SCC in 1997 was 2.3% and 1.6%, respectively. Approximately 7% of farmers reported mortality due to mastitis in 1997 (an overall mortality risk of 0.11%).

Table 1. Variables associated with mastitis in the second stage screening (p≤0.1)

<table>
<thead>
<tr>
<th>Association with mastitis</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Milking preparation variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>always / sometimes wearing rubber gloves</td>
<td>dry wiping with a cloth</td>
<td></td>
</tr>
<tr>
<td>post milking teat disinfection by spray</td>
<td>Washing udders and drying with a cloth</td>
<td></td>
</tr>
<tr>
<td><strong>Other milking variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increasing frequency of liner change</td>
<td>Gathering cows together before milking</td>
<td></td>
</tr>
<tr>
<td>leaking milk on entering the parlour</td>
<td>rotary parlour</td>
<td></td>
</tr>
<tr>
<td><strong>Bedding variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>straw in milking cow accommodation</td>
<td>increasing frequency of mucking out dry cow accommodation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sawdust/wood shavings in calving area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sawdust/wood shavings in dry cow accommodation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>increasing frequency of mucking out calving area</td>
<td></td>
</tr>
<tr>
<td><strong>Housing variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milking cows in straw yards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dry cows in straw yards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>access of milking cows to outdoor yard</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Management variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>disinfecting teat end before using dry cow therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>leaking milk (other than in the parlour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high milk yield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31-40% replacement rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>leaking milk before calving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>milking cows once a day for more than 13 day before drying off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>increasing length of dry period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not offering fresh feed after both milkings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Regression analysis**

A total of 52 variables were found to be significantly associated with mastitis from the bivariable analysis. Twenty five variables were significantly associated with mastitis from the second screening stage and were tested in the final regression model (Table 1). Nine variables remained in the final model (Table 2). None of the interactions tested were found to be
statistically significant. A good fit was demonstrated between the observed and expected values.

**Table 2. Final regression model for the outcome variable of mastitis (p≤0.05, n=1371)**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Odds ratio</th>
<th>Standard Error</th>
<th>95% C.I.</th>
<th>LRS $\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>leaking milk (other than in parlour)</td>
<td>1.90</td>
<td>0.24</td>
<td>1.49</td>
<td>2.43</td>
<td>5.12</td>
</tr>
<tr>
<td>leaking milk on entering the parlour</td>
<td>1.84</td>
<td>0.41</td>
<td>1.20</td>
<td>2.85</td>
<td>2.79</td>
</tr>
<tr>
<td>straw yard housing for milking cows</td>
<td>1.44</td>
<td>0.24</td>
<td>1.04</td>
<td>1.98</td>
<td>2.21</td>
</tr>
<tr>
<td>byre/stalls for milking cows</td>
<td>0.55</td>
<td>0.24</td>
<td>0.23</td>
<td>1.31</td>
<td>-1.34</td>
</tr>
<tr>
<td>kennels for milking cows</td>
<td>1.09</td>
<td>0.28</td>
<td>0.66</td>
<td>1.82</td>
<td>0.34</td>
</tr>
<tr>
<td>other milking cow housing</td>
<td>1.70</td>
<td>1.32</td>
<td>0.37</td>
<td>7.79</td>
<td>0.68</td>
</tr>
<tr>
<td>straw yards housing for dry cows</td>
<td>1.34</td>
<td>0.19</td>
<td>1.01</td>
<td>1.77</td>
<td>2.05</td>
</tr>
<tr>
<td>byre/stalls for dry cows</td>
<td>2.04</td>
<td>0.79</td>
<td>0.96</td>
<td>4.36</td>
<td>1.85</td>
</tr>
<tr>
<td>kennels for dry cows</td>
<td>0.80</td>
<td>0.26</td>
<td>0.42</td>
<td>1.51</td>
<td>-0.68</td>
</tr>
<tr>
<td>other dry cow housing</td>
<td>0.48</td>
<td>0.25</td>
<td>0.17</td>
<td>1.33</td>
<td>-1.41</td>
</tr>
<tr>
<td>mucking out calving areas less frequently than once a month</td>
<td>1.38</td>
<td>0.18</td>
<td>1.06</td>
<td>1.80</td>
<td>2.40</td>
</tr>
<tr>
<td>changing liners more often than every 6000 milkings</td>
<td>1.36</td>
<td>0.20</td>
<td>1.02</td>
<td>1.81</td>
<td>2.11</td>
</tr>
<tr>
<td>access to outdoor yard</td>
<td>1.34</td>
<td>0.17</td>
<td>1.04</td>
<td>1.73</td>
<td>2.30</td>
</tr>
<tr>
<td>not offering fresh feed after both milkings</td>
<td>1.30</td>
<td>0.16</td>
<td>1.02</td>
<td>1.64</td>
<td>2.17</td>
</tr>
<tr>
<td>wearing rubber gloves always/ sometimes when milking</td>
<td>1.28</td>
<td>0.16</td>
<td>1.01</td>
<td>1.63</td>
<td>2.03</td>
</tr>
</tbody>
</table>

**DISCUSSION**

There is no widely accepted definition of a low somatic cell count dairy herd. Published studies have used BTMSCC of fewer than 150,000 (14,16,17) and 70,000 cells/ml (18) to define low cell count herds. A cut-off value of 100,000 cells/ml in this study resulted in the selection of 13% of herds.
This survey achieved a 61% response rate, which compares favourably with other published questionnaire studies (19,20). It is important to obtain a high response rate because the respondents choose to reply and thus may have different opinions, management styles and disease problems compared to those who do not respond (21). No significant difference in mastitis incidence was found between respondents to the first, second and third mailings. So there was no indication that speed of response was associated with mastitis incidence.

The average herd size was 78 cows and the average annual lactational yield per cow was 6456 litres, compared to the national averages of 75 cows and 5790 litres per cow per year (15). This would indicate that whilst low SCC herds are no different in size to the national herd milk production is more than 10% greater.

The incidence of mastitis reported (22.8 cases/100 cows/year) was considerably lower than other recent reports. DAISY (the Dairy Management System) data from 144 herds for the period 1994-6 revealed an annual incidence of more than 43 quarter cases per 100 cows/year (4). However, this represented 25.9% of cows with 1.6 quarter cases per cow per year. It is possible that farmers in the present survey recalled the number of cows affected rather than the number of cases. Since farmers who kept records reported more cases than those who kept no records, it is possible to hypothesise that recall alone results in an underestimation of mastitis incidence. An alternative explanation is that these low cell count herds experienced lower levels of mastitis. However, this is not supported by other recent work which found a positive association between BTMSCC and mastitis incidence only in herds with a BTMSCC of over 300,000 cells/ml (22), and no overall association between mastitis incidence and BTMSCC (23).

In its simplest form an odds ratio (OR) is the ratio of the chance of a disease occurring in farms exposed to a particular factor and the chance of the disease in farms not exposed. An OR of one implies no association between disease and exposure, a ratio significantly greater than one implies a positive association and a ratio less than one indicates a negative association. Simple comparisons may lead to biased estimates of OR if two, or more, exposures which are themselves associated, are both also determinants of a disease. As a result, multivariate statistical techniques are required. Conditional odds ratios, calculated from partial regression coefficients derived from logistic regression, are adjusted for all the other factors included in the regression model.

The variables which remained significant in the final model developed in this study are now discussed.

Leaking milk on entering the parlour and at other times carried the highest risks (OR 1.84 and 1.90, respectively). Mastitis caused by *E. coli* has been associated with cows leaking milk before calving (12, 24). In addition, it has been found that checking first streams of milk for mastitis was a risk factor for *S. aureus* (24) and it was concluded that the practice led to an “increased exposure” to pathogens. Leaking milk on entering the parlour may similarly increase exposure to mastitis pathogens. However, hand stripping to check the first stream of milk may result in transfer of *S. aureus* from the hands of the milker.

Housing dry and milking cows in straw yards resulted in a significant increased risk for mastitis compared with cubicle housing (OR 1.34 and 1.44, respectively). Other studies have also found that cows housed in straw yards have a higher incidence of mastitis, compared to
other housing systems (22,25). Infrequent mucking out of the calving area (less than once a month) was a significant risk for mastitis (OR 1.38). Cows are particularly susceptible to mastitis immediately before and after calving when environmental pathogens are the main cause (26). An increased incidence of *E. coli* mastitis, but not *S. aureus* mastitis, was found in herds where there was no disinfection of the calving area after parturition (12).

Access to an outside yard was found to be a risk factor for mastitis (OR 1.34). It has been demonstrated that poor sanitary conditions in the exercise yard were associated with increasing risk of the herd being positive for *S. agalactiae* (27). Whereas exercise has been shown to reduce individual cow SCC but not affect mastitis incidence (28). It is likely that the condition of the yard, and not merely access, affects mastitis incidence. Indeed, in this study a low frequency of scraping the yard was significantly associated with a greater mastitis risk in the bivariant analysis (first screening).

Not offering fresh feed after both the morning and evening milking was shown to be a risk factor for mastitis (OR 1.30). In the period immediately after milking the teat canal is patent and thus more vulnerable to penetration by mastitis pathogens. Offering fresh feed after milking may result in cows remaining standing after milking instead of returning to lie down in the sleeping area. Penetration of the teat canal by mastitis pathogens is more likely to occur in cows which lie down whilst the teat ducts are patent, compared with cows which remain standing after milking.

It is recommended that milk liners should be changed every 2500 milkings (29). Thus it may be considered surprising that changing liners more often than every 6000 milkings should be a risk factor for mastitis (OR 1.36). Similarly, it is generally recommended that rubber gloves be worn during milking (29). In this study sometimes or always wearing rubber gloves during milking, compared with never wearing gloves, was found to be a risk factor for mastitis (OR 1.28). It is likely that farmers with a mastitis problem start to wear gloves and change liners more frequently. Alternatively, dairymen may be less aware of soiled gloves compared with soiled hands. There is no evidence that frequent liner change may damage teats. Further investigation is required to clarify the importance of these factors.

**CONCLUSION**

This is the first large scale study of risk factors for mastitis in low SCC dairy herds in Great Britain. The study highlights aspects of the environment, in particular the housing system, as important risk factors for clinical mastitis. The results presented in this paper largely confirm the findings of similar work from other countries. The OR were small, which can be attributed partly to the fact that major risk factors, such as day to day management changes, stockmanship, genetics etc., were not measured. In addition data from all farms were used. A comparison of low with high incidence farms, omitting farms with a medium mastitis incidence, may have generated higher OR. The main conclusion of this study is that further control of mastitis in low SCC herds may be achieved through reducing exposure to environmental pathogens. Further analysis of the existing data by housing system should assist in developing improved control measures. However, future studies are required to investigate in more detail aspects of the environment which have been identified by this study as important risk factors for mastitis. Six hundred and ninety farmers who returned the questionnaire are currently participating in a mastitis monitoring study. It is expected that this study will generate more detailed data on the epidemiology of mastitis in low SCC herds.
ACKNOWLEDGEMENTS
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REFERENCES


