2022

BRITISH MASTITIS CONFERENCE

Organised by

The Dairy Group

Topics:

- Are there optimal techniques for identifying mastitis?
- Alternatives approaches to mastitis treatment
- Research updates
- Recent developments in milking technology
- Questioning evidence to aid decision making
- AHDB Mastitis Control Plan Case Study

Wednesday 9th November 2022
Pitchview Suite, Sixways Stadium, Warriors Way, Worcester, Worcestershire, WR3 8ZE

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CHAIRMAN'S INTRODUCTION

Welcome to the 2022 British Mastitis Conference at Sixways Stadium, Worcester.

Over the past 12 months, the Organising Committee has brought together a group of speakers that it believes will provide interesting, thought provoking and stimulating presentations. We have endeavoured to strike a balance between up-to-date research findings and practical presentations with clear take home messages. We have also taken on board strong feedback from last year´s conference that we should move to an electronic version of the Proceedings.

The first paper asks the question Is there an optimal technique for identifying mastitis and will be followed by a paper on alternative approaches to mastitis therapy. We will then have a short break for tea and coffee with time for delegates to look at the posters and ask questions of the presenters.

Building on the previous success, again endorsed by delegates, we have selected four posters from the Research Update section for oral presentation. The four papers are followed by an opportunity for delegates to debate with each of the presenters.

After lunch I will be looking at Recent developments in milking technology to improve udder health and milking efficiency. This is followed by a paper on questioning the evidence to help in decision making for mastitis treatment strategies. The final paper at BMC 2022 will be an AHDB Mastitis Control Plan case study.

This year sees another varied selection of high-quality poster submissions – all targeting improvement in udder health and overall milk quality. I urge you all to make time to review the posters and speak with the authors. Many of you know that the presenters put a great deal of effort into providing the abstracts and preparing and presenting their posters. So please do read their work and vote.

We endeavour to find you the best speakers with the most relevant (and latest) information. This is only achievable thanks to the generous support of all our sponsors. This year our sponsors are: Hipra (Gold), ADF Milking Limited (Gold), MSD Animal Health (Gold), Boehringer Ingelheim (Silver), Peacock Technology (Silver), Vetoquinol (Silver), Norbrook (Silver) and Ambic (Bronze).

As always, the event could not happen without able administration, provided by Karen Hobbs and Anne Sealey at *The* Dairy Group.

Finally, thank you for attending and supporting the conference. I trust you will have an enjoyable and worthwhile day and we hope to see you at our 35th BMC in 2023.

Ian Ohnstad, British Mastitis Conference Chairperson
The Dairy Group

TIMETABLE of EVENTS

08:45	**ARRIVE / REGISTRATION / COFFEE & TEA AND POSTER DISPLAY**	
09:45	**CHAIRMAN'S INTRODUCTION**	**Ian Ohnstad** *The* Dairy Group, UK
	Session One	
09:55	Is there an optimal technique for identifying mastitis?	**Michael Farre** SEGES, Denmark
10:30	Alternative approaches to mastitis therapy	**Jude Roberts** Map of Ag, UK
11:05	**COFFEE and POSTERS**	
	Research updates (also presented as posters)	**Elizabeth Berry** BCVA, UK
11:40	Effect of less regular milk recording on mastitis pattern analysis	**Al Manning** QMMS, UK
12.00	Impact of milk price on the cost of mastitis and herd performance	**Kathryn Rowland** Kingshay, UK
12:20	Association between dry cow treatment, management practices and somatic cell counts in herds conducting selective dry cow therapy	**Clare Clabby** Teagasc, Ireland
12:40	New milking installations - review of compliance with BS ISO 5707:2007	**John Baines** MEA, UK
13:00	**LUNCH and POSTERS**	
14:10	**WELCOME BACK AND VOTING ON POSTERS**	
	Session Three	**Brian Pocknee** DHC, Spain
14.15	Recent developments in milking technology to improve udder health and milking efficiency	**Ian Ohnstad** *The* Dairy Group, UK
14.50	Mind the gap: Questioning evidence to help you decide	**Simon Archer** Epidemiologist, Veterinary Consultant, UK
15.25	AHDB Mastitis Control Plan case study	**Katie Fitzgerald** Bishopton Veterinary Group, UK
16:00	**POSTER AWARD**	
16:05	**CLOSE**	

Titles of Papers and Presenters

Scientific programme

Titles of Posters and Authors

Poster abstracts – presented at the Technology Transfer Session
(presenting author underlined):

Poster abstracts – also as an oral presentation in the Research Updates session

(presenting author underlined)

FURTHER INFORMATION

Organised by *The* Dairy Group, BCVA, QMMS and University of Nottingham

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AMBIC

National Mastitis Council is a professional organization that promotes research and provides information to the dairy industry to help reduce mastitis and enhance milk quality. For more than 50 years, NMC has distinguished itself internationally as a leader in meeting those objectives.

A global organization for mastitis control and milk quality

What does NMC do?

- Provides a forum for the global exchange of information on mastitis and milk quality
- Publishes educational materials, including books and brochures
- Establishes guidelines for mastitis control and milking management practices
- Monitors technological and regulatory developments relating to udder health, milk quality and milk safety
- Conducts meetings and workshops, providing educational opportunities for all segments of the dairy industry
- Funds the NMC Scholars program

Who are the members of NMC?

NMC membership is comprised of people from more than 40 countries, representing a wide range of dairy professionals who share an interest in milk quality and mastitis control. These people include veterinarians, milk quality consultants, dairy producers, university researchers and extension specialists, milk procurement field staff, equipment and supply representatives, regulatory officials and students.

What can NMC do for you?

The continued pressure to ensure milk safety and improve milk quality, as well as the need to increase production efficiency, requires greater team effort among producers, veterinarians and other dairy professionals. Each team member plays a key role in developing successful mastitis control programs. NMC can serve as your resource for information related to udder health, milking management, milk quality and milk safety.

Why join NMC?

- To receive the latest technical and applied information on udder health, milking management and milk quality
- To provide leadership on milk quality issues within the industry
- To participate and learn about mastitis and milk quality developments at NMC meetings
- To establish valuable industry contacts
- To support education and research efforts that help raise awareness and understanding of milk quality issues

NMC membership benefits

- NMC annual meeting and regional meeting proceedings, which contain all of the papers and posters presented at the meetings
- The NMC electronic newsletter addresses the latest information on udder health, milking management and milk quality
- Access to the "members-only" section of the NMC website, which includes the NMC Proceedings Library, NMC newsletter archives and NMC membership directory
- Opportunities to network with other dairy professionals concerned with milk quality, udder health and mastitis prevention, control and treatment

Working together

Since 1961, NMC has coordinated research and educational efforts to help control the losses associated with mastitis. By bringing together all segments of the industry, a strong and successful organization has been created to enhance the quality of milk and dairy products. NMC welcomes your active participation and support. Please visit the NMC website for additional information and resources.

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IS THERE AN OPTIMUM TEST PROCEDURE FOR IDENTIFYING MASTITIS?

Michael Farre
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SUMMARY

Mastitis identification and selecting which animals and quarters should get antimicrobial treatment has always been a challenge to dairy farmers and dairy veterinarians. Short-term, the dairy farmer needs to know if this clinical case needs treatment, should be left without, or which action will be cost-efficient. In the longer perspective, we value monitoring the dynamic of pathogens in a dairy farm to target and continuously adjust the preventive measure.

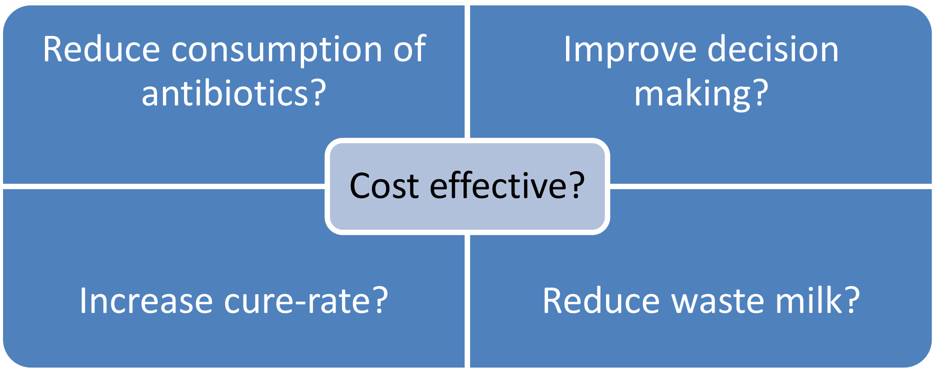
As herd veterinarians working with udder health and doing on-farm consulting, we often struggle to understand the decision system because, on many dairy farms, the decision for treatment / no treatment is blurred and not always rational. Many dairy farms are searching for further decision support for themselves and their staff members if they make the decision regarding mastitis treatment.

Thus, during the last decade, many options have become available for identifying clinical mastitis and, to some degree, the pathogen involved in the clinical mastitis at dairy farms. Here we will focus on the possibilities of implementing on-farm selection as a decision support tool to target mastitis treatment and the use of antimicrobials.

INTRODUCTION

The on-farm selection gets used for procedures supporting deciding on treatment/ no treatment for clinical mastitis. The approach can have several aims depending on the farm's goals, as illustrated in figure 1.

Figure 1. Some of the potential aims of on-farm selection



To uncover if the concept will add value to a dairy farm, as illustrated in figure 1, the aim has to be precise, and both dairy farmer and herd veterinarian need to discuss the criteria for success and the distribution of responsibility. Also, a practical consideration is the availability of diagnostic laboratories and the logistic options to send samples and receive feedback within a reasonable timeframe as part of continuous monitoring. This point is vital because it's risky solely to depend on diagnostic from a farm-based system without any second opinion to monitor performance and efficiency

The easy-to-handle systems are typically either a classical agar plate with different selective media or small test tubes with solutions where milk is added. Then by reading growth or sometimes change of colour, an indication of growth, no growth, gram-positive, gram-negative is the outcome within 12-24 hours. Combined with clinically grading mastitis (Pinzón-Sánchez and Ruegg, 2011), this information can be a decision support tool in an on-farm selection system for mild and moderate mastitis.

The scientific literature has focused on several aspects of on-fam culture; initially, reducing the number of treatments was in focus. In that case, the study from(Lago et al., 2011) find reductions in consumption of antimicrobials at about 50 % and one day less milk withdrawal time. In New Zealand, a similar study from (Mcdougall et al., 2018) indicated a 25 % reduction in the consumption of antimicrobials, and the number of cows with relapse within 60 days did not increase compared to the control group.

As mentioned previously, implementing on-farm culture can be an asset, but it always has several aspects to consider. No matter the implemented procedure, it has to be cost-effective depending on the farm's conditions. According to a simulation study(Down et al., 2017), reduced bacterial cure rate and the proportion of gram + bacteria at the herd level could compromise the cost-effectiveness of an on-farm culture system. Thus, the pathogen profile must be regularly identified and monitored to evaluate the cost-benefit.

Another aspect of the delayed treatment is public concern for animal welfare, where even mild clinical mastitis can cause discomfort(Gibbons et al., 2012) for dairy cows. This issue needs attention, but to be fair, many dairy farmers already delay treatment of intermittent mild mastitis and keep the milk out of the bulk tank for a couple of days, similar to the procedure often implemented in on-farm culture.

Personal experience from larger farms is that giving critical members of the staff special training and responsibility motivates and creates awareness as a side effect that adds value to work satisfaction and motivation.

Deciding to implement the concept raises the question of which system to use in terms of complexity and level of information the test can provide. But training in the chosen system implemented is vital for success(Sipka et al., 2021). Focusing on a culture system with incubation, the sensitivity and specificity of the media can vary considerably(Ferreira JC et al, 2018), and there search for evidence and literature before deciding on the brand.

DISCUSSION

The concept of on-farm selection has pros and cons that the herd veterinarian and dairy farmers need to address in the planning process. First, they need to be clear about the aim of doing it; reduction in consumption of antimicrobials, less waste milk, increased cure rate, creating more awareness among the staff, e.g., or another aim for implementing the system.
Usually, dairy farmers want the entire package, but this is not always possible. Also, the fact that the dairy farmer, to a more considerable degree, accepts that clinically sick animals await treatment is worth debating to agree on the definition of animal welfare.

Thus, if the aim is precise and the dairy farms have the resources in terms of facilities and engaged staff, the concept of on-farm selection can be an asset. The on-farm test systems available are at different levels, and the more complicated, the more detailed the answer is provided. Therefore the complexity need to balance the aim for the particular farm.

CONCLUSIONS

Implementing on-farm selection can benefit the dairy farm in different aspects, as long the aim is precise, and a support system is in place to monitor and supervise it regularly. It can reduce the rate of treatment in most herds, but regular monitoring of pathogen distribution is still necessary to target preventive measures.

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NOTES

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ADVANCES IN MASTITIS THERAPY

Jude Roberts
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INTRODUCTION

There have been many significant improvements in various aspects of udder health in recent years:

- Mastitis prevention through the 5 point plan, the 10 point plan and subsequently the Mastitis Control Plan (1,2)
- Monitoring of mastitis pattern through pattern analysis and the QuarterPro tool (3)
- Reduction in the severity of some mastitis cases through the use of vaccination (4)
- Improvements in diagnostics allowing more rapid, accurate or even cow side testing to target therapy more appropriately (5)
- Reduction in new infections acquired during the dry period through use of internal teat sealants on all animals (6)
- Selective dry cow therapy to minimise antibiotic use whilst treating animals that are infected (7,8)
- Understanding the likelihood of treatment success to decide which animals to treat and when cure rates are likely to be very poor (9)

However, there will always be clinical mastitis cases that do require treatment. This paper aims to review the options for mastitis treatment by presenting the evidence available and discussing potential future therapies.

MASTITIS THERAPY OPTIONS

Current intramammary antibiotic licensed treatment options

The mainstay of treating clinical mastitis cases is with the use of lactating cow intramammary antibiotics. In the UK there are several products that possess a marketing authorisation for use as lactating cow intramammary therapy, with a wide range of active ingredients and dosing regimes. In line with the 2020 European Medicine Agency scientific advice about the use of antibiotics in animals (10), only products in the prudent use category D and cautious use category C will be presented here.

Table 1 Current marketed lactating cow intramammary tubes (source: VMD https://www.vmd.defra.gov.uk/ **alongside NOAH and pharmaceutical company data) in EMA Categories D and C**

Lactating cow tube	Active ingredient(s)	Tubing interval	Number of tubes in course	Treatment duration
Category D antibiotics				
Orbenin LA (Zoetis)	Cloxacillin 200mg	48 hours	3	144 hours
Procapen (Forte)	Procaine benzylpenicillin 3g	24 hours	3	72 hours
Ubropen (Boehringer Ingelheim)	Benzylpenicillin 600mg	24 hours	3 - 5	120 hours
Category C antibiotics				
Albiotic (Huvepharma)	Lincomycin 330mg Neomycin 100mg	12 hours	3	36 hours
Combiclav LC (Norbrook)	Amoxicillin 200mg Clavulanic acid 50mg Prednisolone 10mg	12 hours	No maximum	N/A
Mastiplan LC (MSD)	Cefapirin 300mg Prednisolone 20mg	12 hours	4	48 hours
Synulox LC (Zoetis)	Amoxicillin 200mg Clavulanic acid 50mg Prednisolone 10mg	12 hours	No maximum	N/A
Ubrolexin (Boehringer Ingelheim)	Cefalexin 200mg Kanamycin 100,000IU	24 hours	2	48 hours

These licensed treatment regimens should form the basis of the standard treatment protocols on all our farms. The decision around the choice of active ingredient as well as the formulation should be done on a farm by farm basis using information such as mastitis infection rate and pattern, bacteriology and through close monitoring of recurrence and cure rates.

Use of non-steroidal anti-inflammatory drugs (NSAIDs)

NSAIDs are anti-inflammatory, anti-pyretic, counter endotoxin-induced cellular damage and provide analgesia. These effects are all interlinked with both Gram positive and Gram-negative pathogens producing pro-inflammatory mediators that initiate an immune response. This response may begin locally but can rapidly develop into a systemic response with consequences to lactational performance. A very recent publication reviewed the literature and concluded that it is the release of systemic mediators of inflammation, rather than an influx of somatic cells, that drives the reduction in milk production in clinically health glands that neighbour inflamed glands (11). This further enhances the benefits of providing direct anti-inflammatory action and mitigating the endotoxin-induced damage through the use of NSAIDs.

The UK currently has four NSAID active ingredients licensed for use in cattle: carprofen, flunixin, ketoprofen and meloxicam.

There is a significant amount of evidence to justify the use of NSAID's in all cases of clinical mastitis – mild, moderate and severe. The advice from several sources is to treat with the NSAID as soon as possible, in particular it should be given whilst awaiting the outcome of any pathogen identification that may be being performed.

The improvements described following the use of a systemic NSAID include better clinical outcomes (recovery), improved bacteriological recovery, lower SCC, reduced size of udder, reduced pain signs, improved physiological parameters (rectal temperature, rumen contractions and respiratory rate) and improved milk appearance (12, 13, 14, 15, 16).

A recent paper has investigated the effects of NSAID administration on the integrity of the blood milk barrier following administration (17). The main findings were that NSAID does not prevent disruption of the mammary epithelial barrier but does aid its recovery (in contrast to corticosteroids, covered in the next section). However, overdose of NSAID would cause tissue irritation and delayed restoration of the membrane. The NSAID effect varies with active ingredient (in particular whether selective or non-selective) and the dosage applied. It should be noted that this study was *in vitro* using LPS challenge but the results will likely mean that the potential for use of NSAIDs in an intramammary formulation may be limited and require thorough investigation and evaluation.

Use of corticosteroids

Corticosteroids suppress almost all components of the inflammatory process. Their pharmacological and physiological effects are very broad, and therefore the potential for adverse effects is considerable. These effects are minimised and localised through use of topical, or intramammary in the case of mastitis, therapy. Glucocorticoids are known to protect the blood–milk barrier during mastitis, however, this reduced disruption alongside immunosuppressive effects could influence the severity and cure rates of mastitis with both positive and negative effects (18,19).

- Systemic use as an adjunct for mastitis

There is limited evidence to justify the systemic use of corticosteroids as an adjunct to antibiotics for mastitis therapy. There are two studies that demonstrated a benefit on milk production (20) and reduced local inflammation, reduced rectal temperature and improved milk production (21). However, both studies described changes in blood leukocytes and neutrophils consistent with adverse effects on the immune system and immune defence. This is consistent with a more recent paper that also found the systemic use of dexamethasone suppressed neutrophil function and had a deleterious effect on immune function (22). In experimental work investigating the effects of dexamethasone, the product is given prior to or at the time of the experimental challenge (e.g. LPS infusion) and therefore these potential positive benefits are near impossible to replicate in a clinical setting.

- Local use within intramammary preparations

There are three licensed intramammary products that contain steroid within the ingredients (Combiclav LC – 10mg prednisolone, Norbrook; Mastiplan LC – 20mg prednisolone, MSD and Synulox LC – 10mg prednisolone, Zoetis).

Prednisolone is an anti-inflammatory with effects in both the early and late phases of inflammation and a half-life of 18 to 36 hours. It is six times less potent than dexamethasone. When applied topically into the udder it reduces swelling and size of the infected quarter and promotes the return to a normal temperature. Published work demonstrated that the addition of prednisolone to cefapirin gave a synergistic effect to result in a lower density of leukocytes in tissue and milk and hastening resolution of clinical signs and inflammatory markers. Bacterial growth was inhibited in quarters treated after 36 hours with cefapirin alone and 18 hours in cefapirin with prednisolone (23).

Use of extended antibiotic therapy

At what point does "standard" therapy become "extended" therapy?

There are three licensed products that can be used for extended therapy in accordance with the marketing authorisation: Combiclav LC, Norbrook and Synulox LC, Zoetis - these products are licensed for the treatment of *Staph. aureus* for extended duration with no maximum number of tubes declared.

Ubropen, Boehringer Ingelheim – is licensed for between 3 and 5 days treatment and is a narrow spectrum category D product.

There are a number of papers that compare standard with extended therapy in a variety of situations and with a variety of a variety of active ingredients. These have different experimental designs, bacterial evaluation and assessment of clinical and bacteriological cure rates and can not straightforwardly be applied to a clinical setting.

A summary of the most relevant and practical results provides the following information:

- In undifferentiated clinical cases of mastitis there are no benefits of extended therapy compared with conventional therapy, cure rates remain comparable between groups for mild, moderate as well as severe cases (24,25,26)
- Extended therapy may show an increased bacteriological cure if *Strep. uberis has* been demonstrated (27,28,29)
- Narrow spectrum therapy should be chosen when an identified casual agent likely to respond to therapy is present (30)
- In persistently high SCC cows there is no advantage when no information on bacteriological cause is present. Extended therapy could be indicated if *Strep. uberis* is present (31)

Use of systemic (injectable/parenteral) antibiotic therapy

The EMA scientific advice on antibiotic use lists the routes of administration in order of effect on the selection of AMR. Local individual therapy eg intramammary use is top of the list, and therefore least likely to select for AMR with the guidance stating that antimicrobial selection pressure should be "as local and as short as possible". Careful consideration should therefore be given before embarking on systemic therapy.

The evidence is considered in a few key areas:

- Likelihood of bacteraemia

A recent study assessing whether severe mastitis cases are associated with bacteraemia found that only 1.4% of cases had culturable pathogens detected in blood (32). Severe mastitis cases are almost as frequently caused by Gram positive as by Gram negative microorganisms. In the study, 70 cases of severe mastitis were investigated with 75.7% of milk samples yielding bacterial growth, the most common pathogens being *Strep. uberis* (22/70), *E. coli* (12/70) and *Staph. aureus* (4/70). PCR was positive in blood on 8 out of 38 samples analysed. The authors concluded that regardless of the pathogen, it is recommended to prevent the increased expression of the factors involved in the inflammation to treat the animals.

In summary, the evidence suggests that the vast majority of cows that have severe clinical mastitis are NOT bacteraemic.

- Likely improvement of cure rate

The addition of a parenteral antibiotic to mild and moderate cases of clinical mastitis does not improve cure rates (33,34,35,36).

Severe clinical mastitis is more likely to be associated with a bacteraemia or septicaemia and there is varied evidence about treated with systemic antimicrobial treatment. One study compared the addition of injectable ceftiofur to intramammary pirlimycin and found no effect on the outcome of severe clinical mastitis when all etiologic agents are included in the analysis (37). When analysing only severe cases caused by coliform bacteria the percentage outcome that were culled or died reduced from 37% to 14% with the addition of parenteral ceftiofur. By comparison, enrofloxacin treatment compared to placebo did not result in a higher probability of survival (38).

- Choice of antibiotic?

It is likely that most of the products that were given systemically were not able to achieve and sustain a therapeutic concentration in the mammary gland. For example, at normal doses, systemically administered sulfonamides, penicillin, aminoglycosides, and cephalosporins do not readily distribute into the mammary gland (40).

- Licensed systemic antibiotic treatments

There are four licensed products that can be used alongside an injectable antibiotic in accordance with their marketing authorisation: Category D - Procapen, Forte; Ubropen, Boehringer Ingelheim; Category C - Combiclav LC, Norbrook and Synulox LC, Zoetis.

Treatment without an antibiotic

There is a wide range of evidence supporting treatment of clinical coliform mastitis without the use of antibiotics due to the high self-cure rates and absence of bacteraemia. This will not be covered in more detail here.

Alternative and potential therapies

- Lactic acid bacteria: probiotic bacteria appear to reduce internalisation of some pathogens by colonising the udder and preventing mastitis by forming a protective biofilm. *In vivo* this biofilm inhibits the growth of mastitis causing pathogens (41), however *in vitro* this did not significantly affect pathogen invasion (42). When used in food supplements they may reduce rumen derived LPS production which has been demonstrated to increase the blood milk barrier permeability and increase inflammation, nutritional use of probiotics is not discussed in more detail in this paper. Intramammary infusion of probiotics has been shown to alter teat microbiota to help prevent the colonisation of mastitis causing pathogens (also in 42). There is much active research in healthy and infected teat canal microbiomes and we will likely increase our knowledge and understanding in this area and then potentially be able to target probiotic use more effectively.

- Bacteriophages: viruses that target bacteria have been studies as potential targets for mastitis therapy for around a decade (43,44,45). At present there is no published data regarding *in vivo* applications, however *in vitro* experiments have been evaluated for most of the major mastitis causing pathogens. The main drawback to phage therapy at present is their lack of environmental stability, thereby requiring specific storage and handling of the product. They also induce phage-specific humoral response and memory, which can hamper therapeutic success (46).
- Endolysins: bacteriophage endolysins are effective against Gram positive pathogens and reduce colonisation of *Staph aureus* on teat skin (47)
- Antimicrobial peptides (AMP): new generation antibiotics that have a major role in the innate immune system. They can have broad spectrum activity and act synergistically with conventional antibiotics however they are unstable and have cytotoxic effects on bovine cells. Natural peptides include cathelicidins produced by neutrophils when mastitis is present, they directly control infection and regulate host defences. At present they are investigated more as a mastitis indicator but there may be scope to include them in treatment strategies (48). There are two bacteriocins, Nisin and Bovicin HC5, that are considered as an alternative to antibiotics and are being evaluated for both prevention and treatment of mastitis. They are antimicrobial peptides synthesised by ribosomes and secreted by many Gram positive and Gram negative bacteria. They demonstrate a targeted, effective and safe approach and are reported to have well established therapeutic effect against mastitis causing microorganisms *in vitro* (49, 50). Resistance against AMP limits their potential as antimicrobial agents but the mechanisms of resistance are being investigated and examined to determine whether these can be reduced or eliminated for future applications.
- Immunomodulators: another area of active research with a few published methods for treatment of mastitis. Antibodies to the specific pathogen on intramammary microbeads can enhance phagocytosis and has demonstrated effects comparable to antibiotic treatment with NSAIDs (51). Interleukin-2 (IL-2) systemic injection in the skin region drained by the supramammary lymph nodes 3-5 days after calving increases epithelial and white cell function and acute phase protein response to defend against pathogens (52). Immunoglobin production against mastitis pathogens through immunising hens with a killed vaccine and then isolating IgY from yolk which demonstrates enhanced phagocytic activity provides potential for further investigating (53).

Similarly, other antibody immunomodulators have been shown to provide some pathogen protection by reducing adherence and entry to the mammary gland. The main drawback appears to be that systemic uptake of immunomodulators increases the chances of other indirect effects which can be positive (e.g. increased protection against other infection) or negative (e.g. abortion).

- Nanoparticle based therapy: another new and active area of research aimed at prevention rather than therapy for mastitis but could also be utilised as a delivery mode alongside antibiotics to enhance function or to overcome problems related to multi-drug resistant bacteria. Therapeutic techniques with nanoparticles allow drug (or other therapy) delivery in nano formulations to enhance uptake and improve delivery, particularly against bacteria which evade conventional therapies e.g. *Staph. aureus*. Complementary or herbal active ingredients can also be delivered in a targeted manner in this way e.g. honey, curcumin (from turmeric) or plant derived quercetin. There is little *in vitro* evidence for this therapy at present, however mouse models demonstrate positive responses. A good review is contained within the article by Sharun et al (54).
- Stem cell therapy: whilst this therapy was initially aimed more at regenerating or repairing damaged tissues, it can also be extrapolated to increase expression of epithelial cells and potentially target the acute phase protein or other response. Since mammary stem cells are responsible for multiple functions, they could be utilised for tissue repair or increasing milk yield. Therefore, there needs to be specific work on the characterisation of mammary stem cells and their areas of development to ensure advancement in this area is carefully targeted to therapy rather than production enhancement.
- Natural protein factors: lactoferrin is a natural whey protein that possesses limited anti-bacterial and anti-inflammatory effects which can enhance antibiotic therapy and improve pathogen clearance *in vivo* (occasionally also referenced as an immunomodulator). However, a similar protein, phospholipase A2, can be evaded by biofilm production and therefore this area of investigation is not proving as positive as originally hoped (55).
- Acoustic pulse therapy: shock wave therapy can penetrate deeper tissues and break scar tissue, it is therefore being investigated as an adjunct to supportive therapy to minimise tissue damage and aid healing and recovery.
- Herbal or botanical therapy: in South America and India for example, the use of herbal therapy to replace antibiotic and anti-pyretic agents has been evaluated in various routes of administration with highly variable results published. Homeopathic, non-antimicrobial and other alternatives to conventional treatments are not advised in the treatment of clinical mastitis, however their use as an adjunct to therapy is practiced widely despite little evidence available about active compound quantity, shelf life, absorption, bioavailability as well as effect. That said, an old quotation by Dr Carl Sagan presented that "the absence of evidence does not mean evidence of absence" and we can all play our

part in monitoring cure rates when these therapies are tried, whilst also ensuring we do no harm.

With any therapy used, it should be noted that legal and statutory requirements should be followed for both milk quality and inhibitory substances.

CONCLUSIONS

Whilst we may not have exciting new therapy options immediately around the corner, there are many different active avenues of research that hold great potential to increase our success with mastitis treatment whilst reducing our reliance on antibiotics. It is clear that all clinical cases of mastitis will benefit from NSAID therapy and that many clinical mastitis cases will benefit from prompt, effective antibiotic treatment. We should be using narrow spectrum products where possible, intramammary formulations in most circumstances and ensuring we provide supportive therapy for severe cases.

The prevention of mastitis is paramount to reduce the number of cases that we will need to treat, we can use the mastitis control plan alongside other measures such as genomics.

When we are treating clinical cases, whatever we use, we should be closely monitor cure rates – what proportion of cases are only affected once? What proportion of cases result in 3 cell counts <200,000 or 2 < 100,000cells/ml as well as absence of further clinical signs? We can monitor the treatment of cases to determine the optimum treatment protocols for our farms and ensure we justify the most appropriate use of antibiotics when we do need them.

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EFFECT OF LESS REGULAR MILK RECORDING ON MASTITIS PATTERN ANALYSIS

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The AHDB Dairy Mastitis Control Plan focusses on three areas of mastitis control: data analysis to diagnose the predominant mastitis pattern, targeted interventions on farm and monitoring of outcomes. Diagnosis of the predominant mastitis pattern is made based on somatic cell count and clinical mastitis data. Herds are classified by their predominant patterns of infection – where new infections are coming from (contagious or environmental) and when they are occurring (dry period or lactation).

In 2018, the process of making this diagnosis was automated through the launch of the Mastitis Pattern Analysis Tool. This has since been refined and was re-launched in 2022. Infection patterns are classified as Environmental Dry Period (EDP), Environmental Lactation (EL), Contagious or Mixed (a combination of any of these patterns).

As part of interpreting this diagnosis, it is important to consider data quality. Conventionally, most farms have milk recorded on a monthly basis, however there are limited data on the impact of less frequent milk recording on diagnosis of mastitis patterns. This study assesses how less frequent milk recording impacts measures of intramammary infection.

Data were collated from a convenience sample of 30 QMMS milk recording herds. In the past 18 months, these farms recorded on average 10.5 times (range 4-18). Alternate milk recordings were removed from the data to simulate the effect of halving the frequency of recording (or doubling the interval between recordings). Using TotalVet, somatic cell count parameters were calculated and a mastitis pattern analysis report was generated for all 30 farms using the original and modified data.

Reducing the frequency of milk recording led to a significant increase in the lactation new infection rate: defined as those cows moving from a low cell count to a high cell count during lactation (>30 days in milk). There was also a significant reduction in apparent chronic infections – those cows with high cell counts for consecutive months. There was no significant difference in the apparent prevalence of infection or any of the markers of dry period performance (dry period new infection rate, fresh calver infection rate, dry period cure rate).

Based on the original data, 17 herds were classified as EDP, 12 as EL, and 1 as Mixed Environmental. The diagnosis for modified datasets was consistent in 25 out of 30 cases. In one case, the frequency of milk recording was too low for a diagnosis to be determined. All remaining patterns remained classified as ‘environmental’, though the diagnosis shifted between EDP and EL in four cases.

Reducing the frequency of milk recording resulted in a higher apparent lactation new infection rate, and a lower apparent rate of chronic infections. Despite these changes, pattern analysis results revealed the same epidemiological diagnosis in the majority of farms. In order to make robust assessments of a dry period pattern it is important that a representative population is SCC tested within the first 30 days of lactation, and that all clinical mastitis cases are recorded.

This study did not assess the ability of milk recording to detect a changing pattern. It is possible that less frequent milk recording may compromise pattern analysis in the face of a mastitis outbreak.

NOTES

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IMPACT OF MILK PRICES ON MASTITIS COSTS

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SUMMARY

A high loss of potential milk production due to mastitis with current milk prices as they are, adds up to a huge loss of income from the milk cheque. Every litre of milk should be treated like gold dust. Variable costs have risen significantly compared to last year according to Kingshay Costs of Production results. Many producers are looking to increase output to spread these higher costs over more litres to give the greatest return on investment. With a shift towards higher yielding, larger herds, more pressure is placed on cow health. One way to increase output is to address animal health issues such as mastitis, fertility and lameness which are major limiting factors to production. Mastitis has become a major reason for cows leaving the herd accounting for 9.1% of all culls. With milk prices over 50 ppl for some producers, the cost of mastitis per case increases and therefore needs recalculating frequently, although cull cow values are still strong and offsets some of this lost income.

INTRODUCTION

When comparing the costs of impaired herd health, mastitis is one of the main health incidences that can greatly impact on performance and profitability, alongside lameness.

METHODOLOGY

The Dairy Costings Focus Report analysed data from over 200 herds using Kingshay's Health Manager service, for the year ending March 2022. Kingshay have developed a variety of health & fertility cost calculators, updating these annually using current milk prices. In the report, a milk price of 42p/litre was used to calculate the cost of mastitis, with a typical herd size of 200 cows yielding 8,500 litres per cow.

RESULTS

Average mastitis levels dropped from 39 cases per 100 cows in 2018, and 32 last year, to 30 cases in 2022. With the focus for farmers to reduce antibiotic usage and somatic cell count, the reduction in mastitis cases is encouraging. See table 1.

Table 1 Trends in mastitis cases over the last 5 years

Cases per 100 cows	2018	2019	2020	2021	2022
Mastitis	39	39	36	32	30

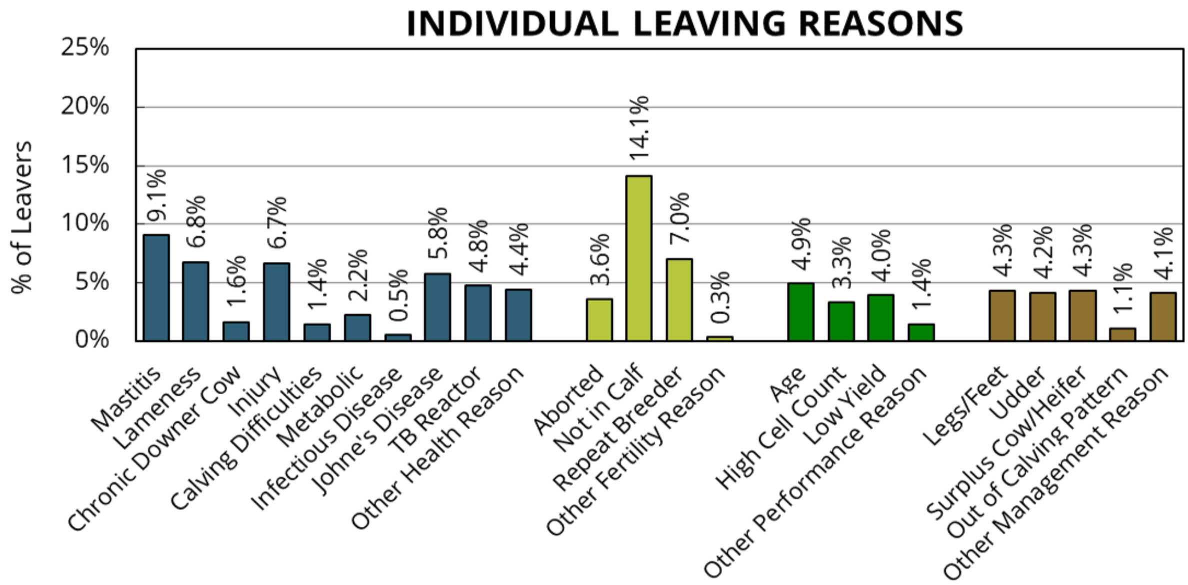
The average cost of mastitis, based on 30 cases per 100 cows totalled £10,010: 28.2% up on last year's average of £7,808 due to the higher milk prices. If herds aim to lower their mastitis cases to 16 cases (to be in top 25%), then this would be a saving of £4,676 per year. This potential saving could be offset and "invested" in infrastructure or systems to future proof herd performance.

Table 2 Comparisons in costs per case for mastitis

Cases per 100 cows	Group	Top 25%	Est. Cost per case	Group cost	Top 25% cost	Difference
Mastitis	**30**	**16**	**£334**	**£10,010**	**£5,344**	**£4,676**

As in previous years, infertility remained the top reason for cows leaving the herd, at 25% of culls. Mastitis stayed in second spot, with culls increasing from 7.9% to 9.1%, year-on-year, which may be why mastitis cases have subsequently dropped.

Figure 1 Reasons for cows leaving the herd



CONCLUSIONS

Producers continue to make gains when it comes to herd health, with all cases dropping again, year-on-year. However, the cost per case has increased, making it even more important to focus on improving health in future. It is important for producers to focus on efficiencies to maximise potential income - marginal gains add up and bolster the bottom line. Herd health and fertility play a key part in farm profitability and financial sustainability.

NOTES

ASSOCIATION BETWEEN DRY COW TREATMENT, MANAGEMENT PRACTICES AND SOMATIC CELL COUNT IN HERDS CONDUCTING SELECTIVE DRY COW THERAPY

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INTRODUCTION

Farm factors and management practices have an increasingly important role to play in the outcome of selective dry cow therapy (McCubbin et al., 2022). The objective of this study was to evaluate the association between dry cow treatment, farm management practices and SCC in the following lactation in herds conducting selective dry cow therapy (SDCT).

MATERIALS AND METHODS

Twenty-one commercial spring calving pasture-based herds that had been conducting SDCT were recruited for this study, from autumn of 2020 to spring of 2021. Milk recording data (milk yield, SCC, parity, calving date) and dry-off data (dry cow treatment and date) were provided by the herd owners. The dry cow treatment decision (antibiotic plus teat seal, AB+TS or teat seal only, TS) was specific to each herd. An online survey was developed to assess milking and dry period management practices and farm facilities in the studied herds. SCC data was transformed to the base 10 logarithm (LogSCC) for analysis. We analysed the association between 1) dry cow treatment, 2) milking management, and 3) dry period management and SCC at the first milk recording of the following lactation in three separate analyses:

1) The analysis of the association between dry cow treatment and SCC included: Treatment (AB+TS, TS), LogSCC at the last milk recording of 2020, Parity (2,3,≥4), Milk Kg at the last milk recording of 2020, Milk Kg at the first milk recording of 2021 and DIM at first milk recording 2021.

2) The analysis of the association between milking management and SCC included: Treatment (AB+TS, TS), Parity (2,3,≥4), LogSCC at the last milk recording of 2020, Milk Kg at the last milk recording of 2020, Milk Kg at the first milk recording of 2021 and DIM at the first milk recording of 2021, Mastitis records (none, subclinical only, clinical only, both subclinical and clinical), regular use of California Mastitis Test (Yes, No), Strip cows before milking (never, all cows, high SCC cows only, seasonally.

3) The analysis of the association between dry cow management and SCC included: Treatment (AB+TS, TS), Parity (2,3,4>), LogSCC at the last milk recording of 2020, Milk Kg at the first milk recording of 2021 and DIM at the first milk recording of 2021, Number of cubicles per cow (<1, 1, >1), Frequency of cleaning of cubicles (daily, twice daily).

RESULTS

Data from 2,027 cows were available for analysis. Overall, treatment (AB+TS vs TS), parity, LogSCC at the last milk recording of 2020, milk yield in the last milk recording of 2020 and first milk recording of 2021 had a significant association with LogSCC. In analysis 1, LogSCC at the last milk recording of 2020 was associated with higher SCC (0.13 log points, $P < 0.0001$) at the first milk recording in the following lactation. For analysis 2, keeping clinical and subclinical mastitis records was associated with lower LogSCC (0.08 log points, $P = 0.007$) compared having only clinical mastitis records. Farms recording clinical cases had a significant association with a higher LogSCC compared to keeping no records. Where CMT was routinely used, a significantly lower LogSCC (0.08 log points) was found compared to no use. Farms that discarded the first strips of milk always and on high SCC cows had an associated lower LogSCC compared to farms that never or occasionally stripped. For analysis 3, cows housed in farms with one or less than one cubicle per cow had a higher LogSCC (0.09 and 0.08 log points respectively, $P < 0.05$) compared to cows housed in sheds with more than one cubicle per cow. Cleaning cubicles twice per day was associated with 0.08 lower LogSCC ($P = 0.02$) compared to once a day.

CONCLUSION

The association between dry cow treatment and SCC in the following lactation varied depending on the SCC at the last milk recording of the previous lactation. Lactation and dry period management practices associated with lower SCC in the following lactation were: recording mastitis events, using CMT, consistently stripping cows before milking, having more than one cubicle per cow at housing and cleaning cubicles twice daily.

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NEW MILKING INSTALLATIONS - REVIEW OF COMPLIANCE WITH BS ISO 5707:2007

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Correct operation and setup of milking machines are recognised in international standards (1) as being important in meeting the physiological needs of lactating animals and achieving high standards of milk hygiene and quality.

It is axiomatic that new milking machine installations should be installed, set up and operate correctly. The Milking Equipment Association requested an independent review of 103 commissioning tests of new installations conducted over a 3-year period, in order to provide an indication of "direction of travel". Table 1 compares the findings with two previous studies (3,4).

Table 1 - Static Test Compliance with Relevant Standard

Element	% satisfactory 1997(3)	% satisfactory 2009(4)	% satisfactory 2022
Vacuum gauge	70	84	61
Vacuum line drainage	90	92	86
Fall on milkline	95	76	95
Provision of test points	80	42	61
Vacuum level	80	61	87
Pulsation characteristics	65	88	83
Vacuum regulation	90	91	68
Vacuum and milk system leakage	40	66	69
Blocked air bleeds	80	83	96
Damaged rubberware	40	87	91

It should be noted that the relevant standards referred to in 1997 were an earlier version (1).

CONCLUSIONS

1. Of the parameters examined in detail, those which may impact most significantly on milking efficiency and udder health have improved since 1997 and 2007.

2. The study highlights:
    a. the continued need for independent commissioning testing of new milking installations;
    b. the importance of training and education of technicians involved in installation, testing and service of milking equipment.

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RECENT DEVELOPMENTS IN MILKING TECHNOLOGY TO IMPROVE UDDER HEALTH AND MILKING EFFICIENCY

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SUMMARY

As dairy farms come under increased pressure to reduce their environmental impact by improving their efficiency, reducing mastitis and enhancing milk quality will come sharply into focus.

When this focus is combined with a squeeze on the availability of labour, there is more interest in adopting techniques that can be implemented to replace labour with technology.

This paper looks to examine a number of developing technologies that have the potential to improve both milking efficiency and milk quality and have been evaluated independently by *The* Dairy Group.

INTRODUCTION

The 2022 Kingshay Dairy Costings Focus Report highlights that between 2018 and 2022, the mastitis case rate of their monitored farms had fallen from 39 cases / 100 cows / year to 30 cases / 100 cows / year (1). This improvement however is still above the maximum advisory rate described by the AHDB Dairy Mastitis Control Plan of 25 cases / 100 cows / year (2).

During the same period, the average annual GB somatic cell count has increased very slightly from 161,000 cells/ml to 164,000 cells/ml (3).

In May 2020, the Royal Association of British Dairy Farmers (RABDF) submitted evidence to the Migration Advisory Committee (MAC) on the importance of recognizing dairy farm workers as highly skilled and proposed these staff should be included on the MAC Occupation Shortage List (4). Unfortunately, dairy farm workers were not recognized as either skilled or in short supply during the last consultation in 2021.

In 2021, the RABDF survey highlighted that only 31% of dairy staff stay in post more than 5 years and that 63% of farms struggle to recruit staff. Of the farms that participated in the survey, 42% employed overseas labour as they found it difficult to recruit staff from the UK.

It seems clear with the on-going challenge of recruiting and retaining dairy staff, alongside the need to continue to improve milk quality, reliable technologies that can assist or replace staff may become more important. This paper discusses a selection of technologies that may improve milking efficiency and udder health.

Although the evaluation of some of these technologies has not been published in peer reviewed journals, the evaluations have been undertaken in an independent, rigorous manner.

REDUCING MASTITIS CASES

The National Mastitis Council has a 10 point Recommended Mastitis Control Programme which highlights a number of critical areas (5).

These include;

- Establishment of Goals for Udder Health
- Maintenance of a Clean, Dry, Comfortable Environment
- Proper Milking Procedures
- Proper Maintenance and Use of Milking Equipment
- Good Record Keeping
- Appropriate Management of Clinical Mastitis
- Effective Dry Cow Management
- Maintenance of Biosecurity for Contagious Pathogens and Marketing of Chronic Cows
- Regular Monitoring of Udder Health Status
- Periodic Review of Mastitis Control Program

Within the section on Proper Milking Procedures, the programme stresses the importance of attaching teat cups within 90 seconds of udder preparation, ensuring the cups hang squarely and level with the udder, and application of teat disinfectant immediately following teat cup removal ensuring complete coverage of teats.

CORRECT CLUSTER PRESENTATION

IDF Bulletin 396/2005 (6) highlights the importance of correct cluster presentation. It states '*Observe whether units are adjusted to hang evenly on the udder and if hose supports are being used ensure they are used effectively. Effective support should be provided for the long milk tube and the cluster adjusted so that cluster weight is evenly distributed on the four teats. Even weight distribution of the cluster and adequate support for the long milk tube will result in fewer liner slips and unit fall-offs and more even milking between quarters'*.

Practical experience highlights that poor cluster presentation can lead to un-even milking, incomplete milking, light quarters and increased frequency of liner slippage. This may pre-dispose the cow to mastitis.

There are a number of commercially available solutions to improve cluster position. It is important to stress that, irrespective of the cluster positioning device employed, it is important to ensure the long milk and pulsation tubes are a suitable length, the routing of the pipes is appropriate and the cluster is not twisted during attachment.

The impact of a cluster support device developed by JH & PM Solutions Ltd (Lactalign) was examined in 2021. The device was evaluated over a period of eight weeks, with an initial evaluation undertaken prior to installation and two subsequent evaluations four and eight weeks after installation on a 72pt Boumatic rotary parlour.

The assessed criteria included;

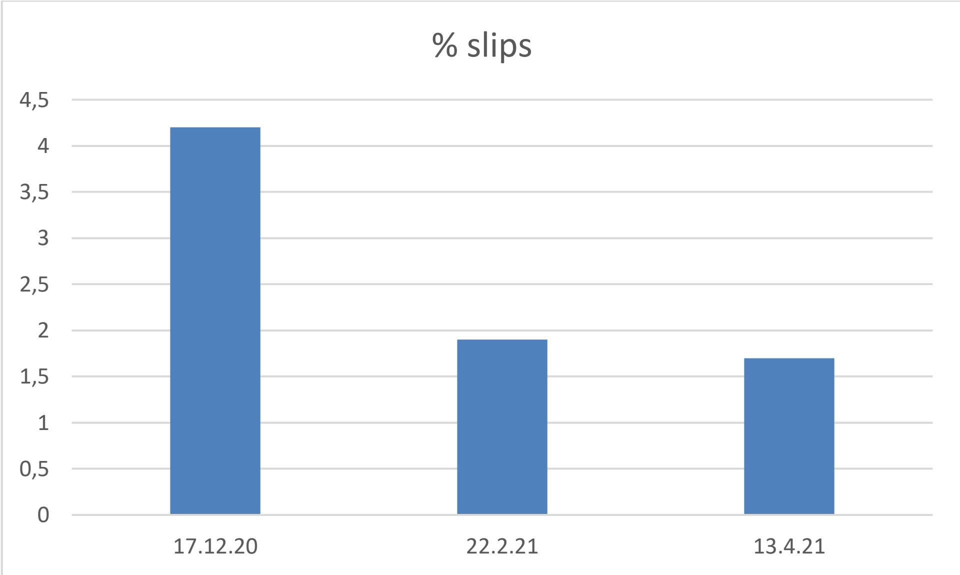
1. Milk yield (measure of completeness of milking)
2. Milking speed (litres /min and attachment time)
3. Duration of milking session
4. Number of slips
5. Number of kick offs
6. Number of re-attachments
7. Cow behaviour (score cow response from no movement, mild lifting of feet through to removal of cluster)
8. Mastitis incidence by quarter

Detailed examination of milk yield and milking speed data showed no measurable difference after the Lactalign devices were installed.

Milk flow rates and milking duration remained relatively un-changed.

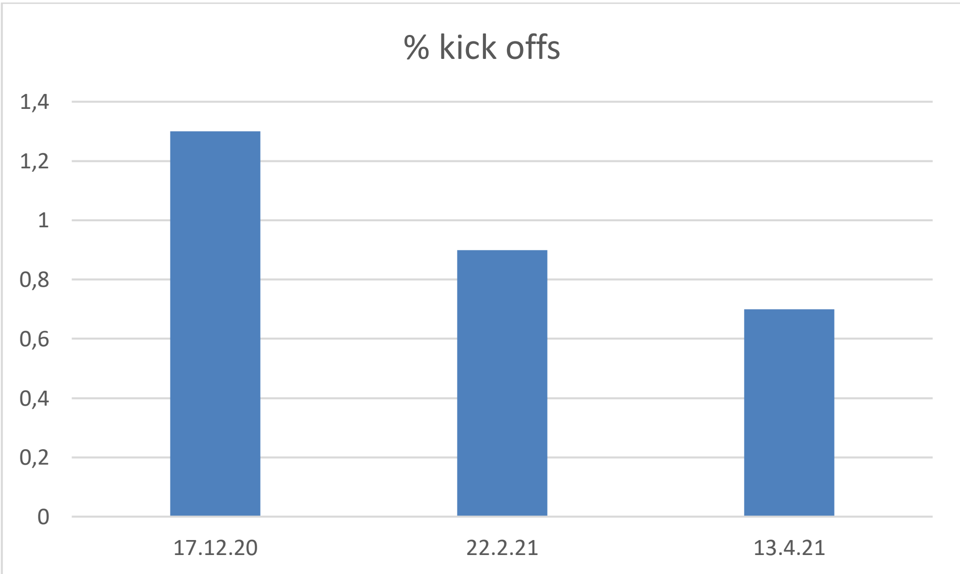
There was a however, a measurable reduction of 59.6% in the number of liner slips noted at each milking, once the Lactalign technology was installed (Figure 1).

Figure 1 – Liner slips as a % of total milkings



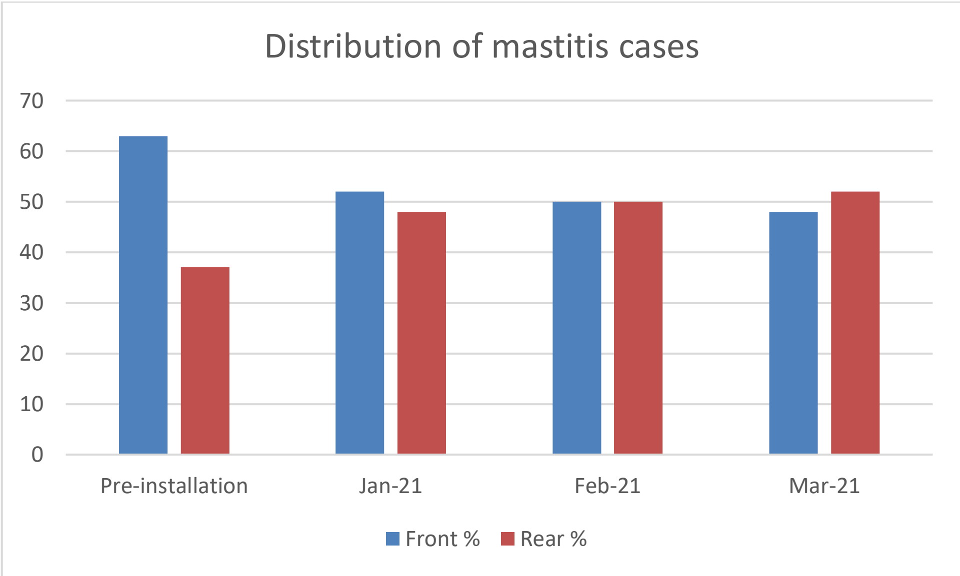
There was also a measurable reduction of 47.0% in the number of kick-offs (Figure 2).

Figure 2 – Unit kick-offs as a % total milkings



Although there was an overall reduction in total mastitis cases during the evaluation, the reduction may be due to the impact of other management changes made during this period. However, there is a marked re-distribution of mastitis cases between front and rear quarters during the period of the evaluation (Figure 3).

Figure 3 – Distribution of mastitis cases between front and rear quarters.



APPLICATION OF TEAT DISINFECTANT POST MILKING

The importance of post milking teat disinfection as part of a mastitis control strategy is well documented (7, 8). Accurate administration of an effective post milking product, as soon as practical after milking, aids in the control of contagious mastitis pathogens as well as helping condition the teat skin.

Whether teats are dipped or sprayed, the objective must be to cover all teat ends and the majority of the teat barrel. This requires more time and effort when spraying. Studies have demonstrated that on average only 50.0% of a teat barrel receives disinfectant when sprayed compared with 95.0% when dipped (9).

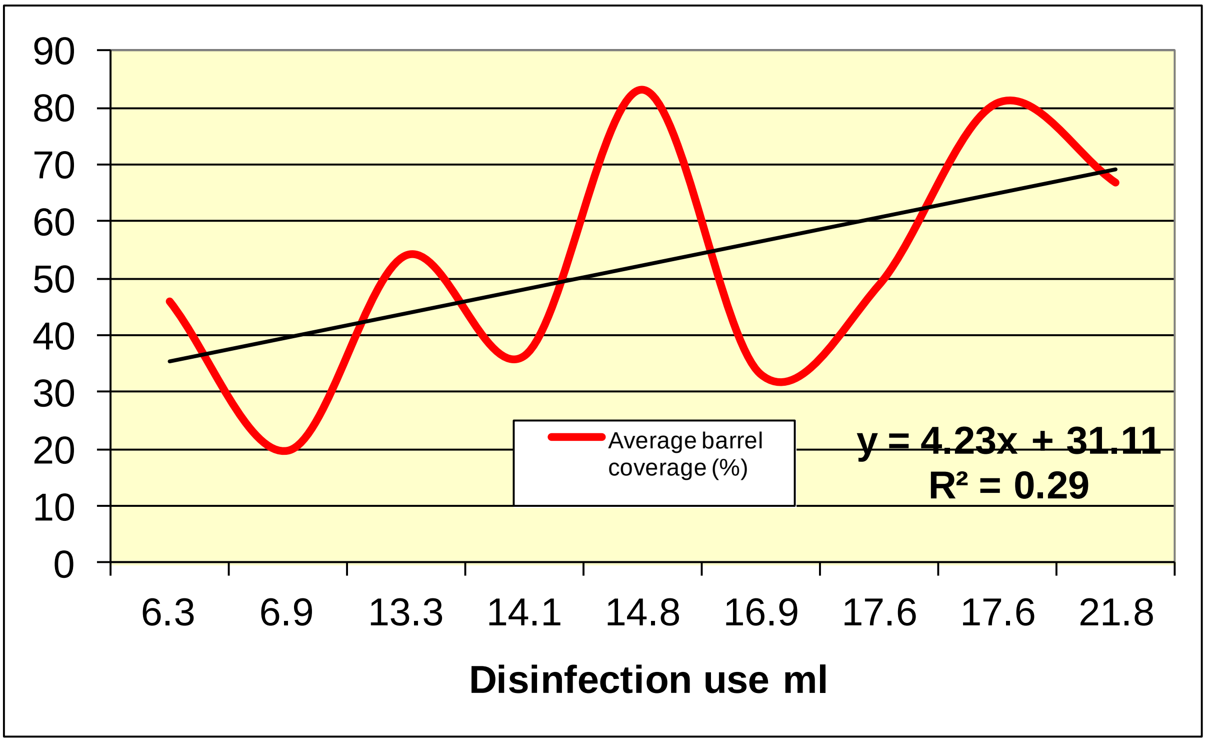
There is also a measurable difference in product consumption between dipping and spraying. Dipping typically consumes 8.0 – 10.0ml /cow / application while spraying consumes nearer 12 – 15ml /cow/ application.

Platform mounted teat spray system

A platform mounted teat spray unit (Ambic Locate´n´Spray) which applies teat disinfectant once the milking cluster has been removed was evaluated. The percent teat coverage (barrel and teat end) was examined with a number of spray regimes as well as consumption of teat disinfectant product.

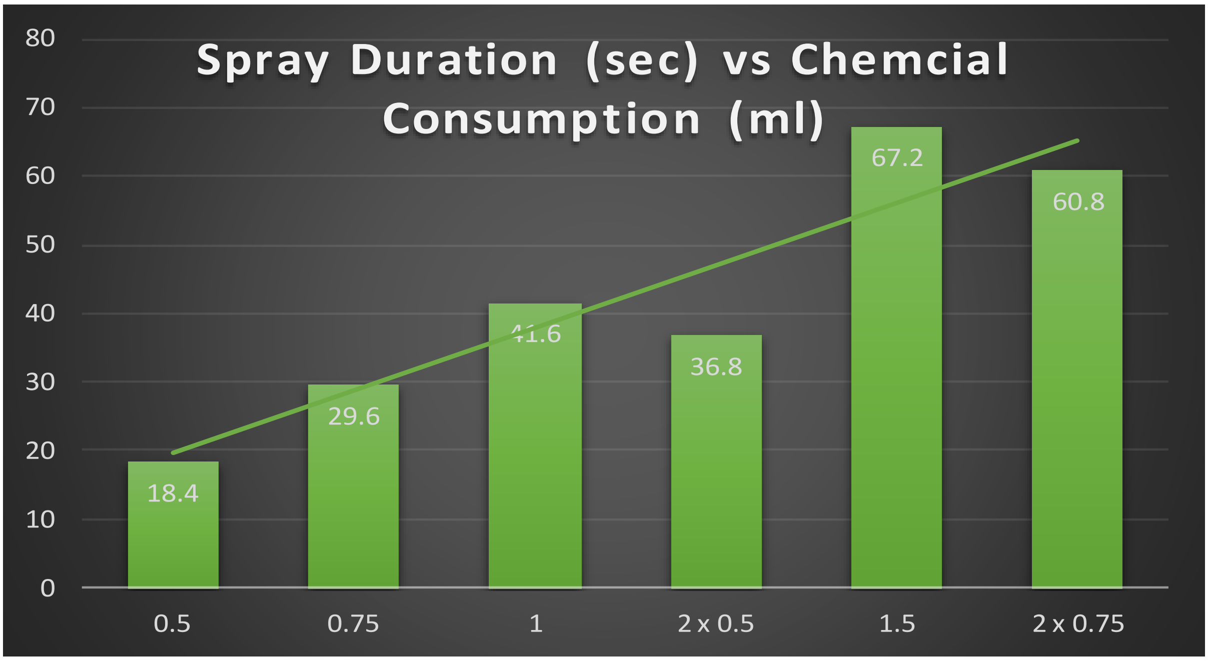
The relationship between teat coverage and chemical consumption is demonstrated in Figure 4.

Figure 4 – Relationship between % teat coverage and product consumption.



As the spray duration increases, or the system applies a double spray there is a significant increase in the consumption of teat disinfectant. Generally, the longer the spray duration, the greater the consumption of teat disinfectant. This can be seen in Figure 5.

Figure 5 – Relationship between spray duration and chemical consumption.



While the consumption of product is a significant factor in the success of the system, the percentage teat coverage is also highly significant.

When the system is installed and commissioned on a rotary parlour, the balance needs to be struck between teat coverage and chemical consumption. This relationship can be seen in Figure 6.

Figure 6 – Spray duration and frequency vs teat coverage

Spray duration (secs)	% teat end covered	% teat barrel covered
0.5	96	62
0.75	97	71
1.0	97	87
1.5	98	91
2 x 0.5	100	89
2 x 0.75	99	89

Even on the short single 0.5 second spray application, the teat barrel coverage was better that the average achieved with the manual teat spray evaluation.

Robotic Teat Spray system

A robotic teat spray robot developed by Peacock Technology Ltd was evaluated to examine its effectiveness at applying teat disinfectant and to consider how teat coverage could be influenced by chemical consumption.

The robot was examined using a spray consumption of 30ml/cow and 60 ml/cow and the results for the whole herd can be seen in Figure 7.

Figure 7 – Chemical consumption and teat coverage

Consumption (ml/cow)	% Teat end covered	% Teat barrel covered
30	89	73
60	96	86

The robotic teat spray unit relies on a camera to see the teats and fix their location. When tails are not adequately trimmed, the tail can interfere with the camera which reduces the accuracy of teat disinfection.

When the data was re-examined, excluding all cows where tails were not trimmed, the teat end and barrel coverage improved significantly. This can be seen in Figure 8.

Figure 8 – Chemical consumption and teat coverage (Only trimmed tails)

Consumption (ml/cow)	% Teat end covered	% Teat barrel covered
30	95	81
60	100	94

This data confirms the importance of a regular tail trimming regime.

It is clear that both these technologies can consistently apply teat disinfectant to the teat barrel and teat end and are capable of performance significantly above that achieved by a manual operator.

PROPER MAINTENANCE AND USE OF MILKING EQUIPMENT

Machine milking can be considered successful if cows are milked quickly, gently and completely. While milking gently and quickly can sometimes be considered to be conflicting, an understanding of the relationship between milking machine settings and application of a milking routine can go someway to mitigating this conflict.

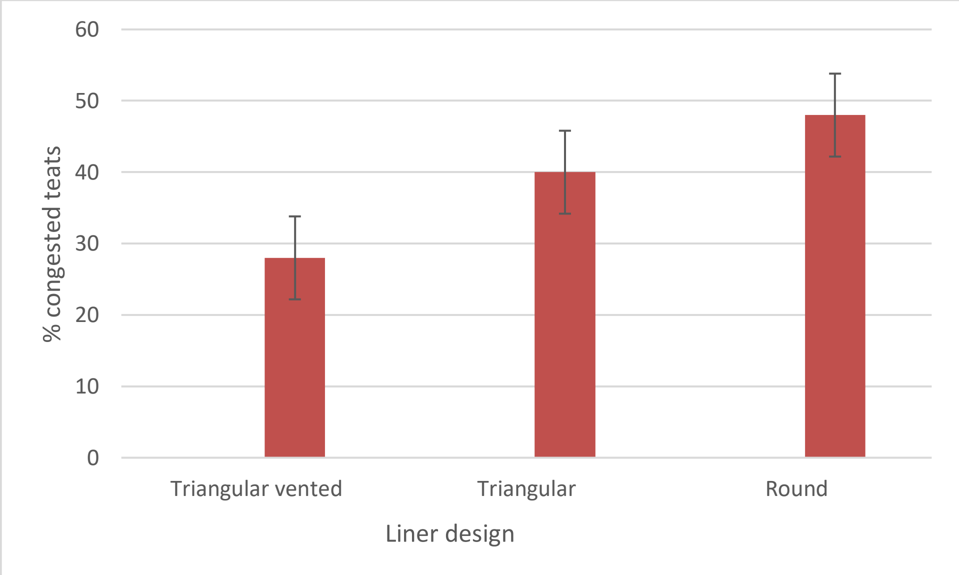
If milking quickly is achieved by increasing the vacuum level, this can often be associated with an increase in teat congestion. There is considerable evidence that any milking machine induced circulatory impairment can increase new mastitis infection rates (10, 11).

If the dimensions of the milking liner are not well suited to the dimensions of the teat, particularly when the bore of the liner is larger than the diameter of the stimulated teat, congestion can occur. This is most often seen with heifers (12).

Circulatory impairment and congestion are most visible at the base of the teat where the teat attaches to the udder. The congestion can be seen as a palpable ring of teat tissue which takes the form of the liner mouthpiece. This is generally caused by high mouthpiece chamber vacuum (> 20.0 kPa) as a result of a poor seal between the teat and the liner.

There are a number of solutions to minimising the prevalence of mouthpiece rings. These include matching the teat and liner dimensions or installing liners with a constant air admission (vent) in the mouthpiece. These solutions can be very successful in reducing measurable teat congestion (13), as can be seen in Figure 9.

Figure 9 – Levels of teat congestion with different liner designs (MilkRite InterPuls)



A variation on the theme of controlling the mouthpiece chamber vacuum using air admission has been developed by ADF Milking Ltd. Their InVent system employs a valve which opens when vacuum in the liner mouthpiece increases above 20.0 kPa. This system was examined to assess the impact on post milking teat condition.

Teats on three commercial dairy farms were assessed and the results are shown in Figure 10.

Teats were scored post milking for teat base ringing, congestion and colour. Teats scoring 1 showed no evidence of change, teats scoring 2 showed slight change while teats scoring 3 showed significant change in the teat tissues.

Figure 10 – Post milking teat condition with 'InVent' system

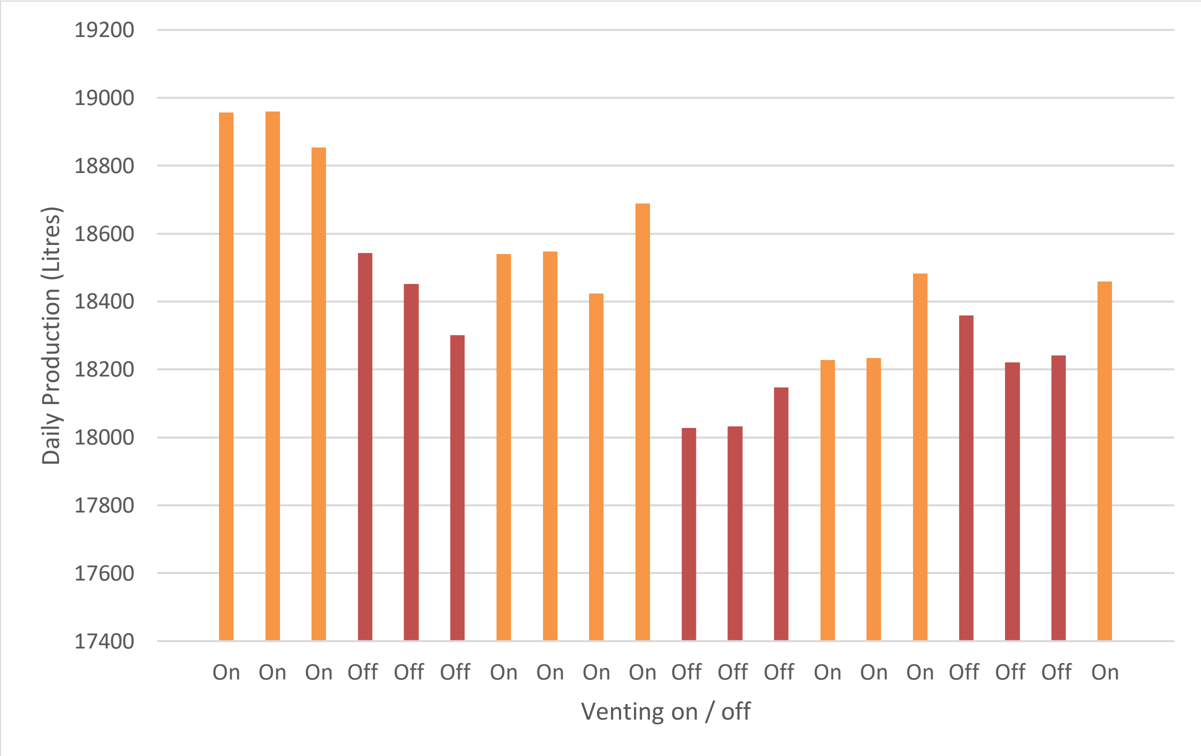
			Score %			p value*
			1	2	3	
Overall	Ring	Not Vented	19.6	53.2	27.2	<0.001
		Vented	23.7	64.7	11.6	
	Congestion	Not Vented	57.7	26.0	24.8	<0.001
		Vented	71.5	24.0	4.4	
	Colour	Not Vented	66.7	24.8	8.5	<0.001
		Vented	85.1	13.3	1.5	

When teats become congested, the peak milk flow rate decreases and there is an increase in milking duration. It is also likely that teat congestion can lead to a reduction in the completeness of milking (14).

Recent milking studies of the ADF equipment have examined the relationship between teat congestion, milking speed and completeness of milking.

The variable venting was systematically disabled and enabled over a period of 21 days. On the days that the venting was enabled, the milk production increased. This is demonstrated in Table 11.

Figure 11 – Daily Milk Production with venting enabled & disabled



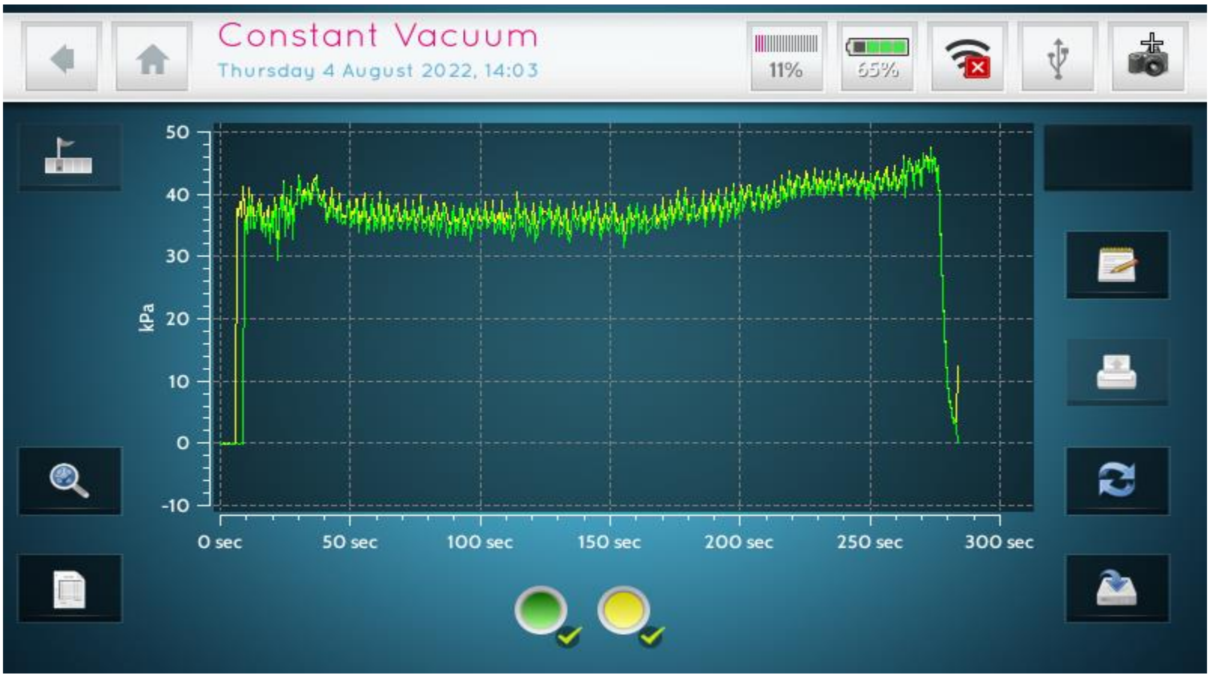
While milking speed can be improved by increasing the working vacuum level, which in turn increases the liner vacuum at peak milk flow, this can often be to the detriment of the teat tissues.

BS ISO 5707:2007 states that '*Both research and field experience indicate that a mean liner vacuum within the range 32.0 to 42.0 kPa during the peak flow period of milking for cows ensures that most cows will be milked quickly, gently and completely*'.

DeLaval Ltd have recently developed a milking technique which adjusts the liner vacuum level depending on the milk flow rate. This technique is termed flow responsive milking. As the flow rate increases, the liner vacuum increases which has the effect of increasing the milk flow rate. As the flow rate starts to decline, the liner vacuum is reduced.

A typical liner vacuum trace, with conventional equipment, can be seen in Figure 12.

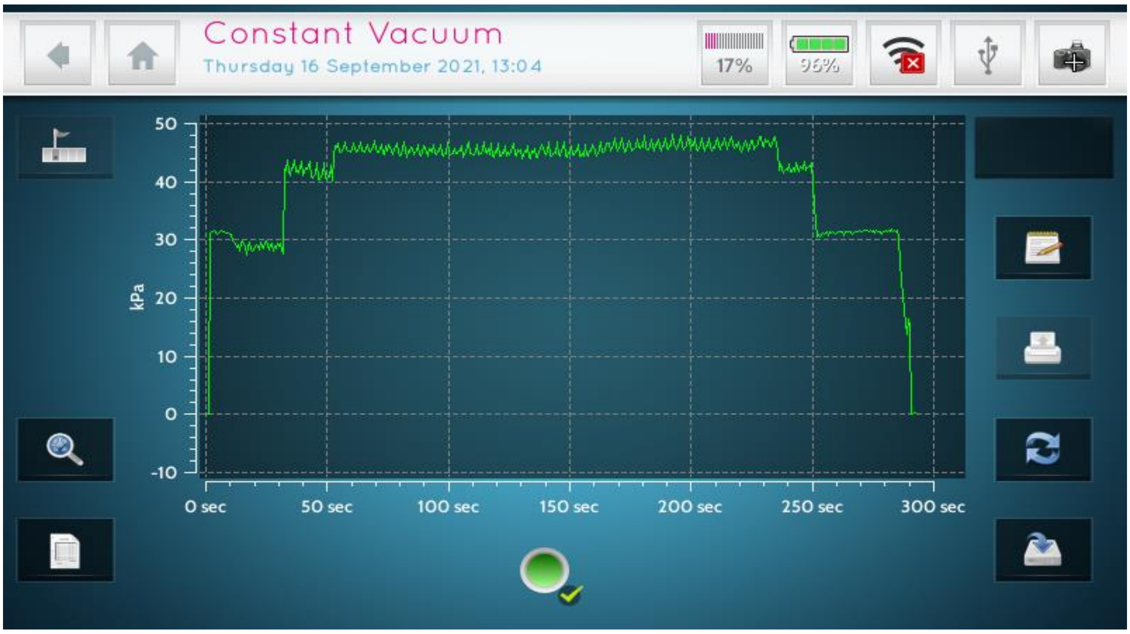
Figure 12 – Typical liner vacuum trace for conventional milking.



This example shows an initial period of bi-modal milking with peak flow commencing after 50 seconds. The peak flow period ends around 200 seconds after attachment and the liner vacuum increases to reflect the reduction in milk flow. At peak milk flow, average liner vacuum is around 36.0 kPa.

When Flow Responsive milking is operating, liner vacuum increases in steps as the system vacuum is increased. During peak milk flow, the liner vacuum is above the guidelines indicated by BS ISO 5707:2007. This can be seen in Figure 13.

Figure 13- Liner vacuum with Flow Responsive milking



An evaluation was carried out on a 72 point DeLaval rotary installation in England. Data was extracted from DeLaval DelPro before and after the installation of Flow Responsive milking. Teat condition scoring was also undertaken. A summary of the assessment can be seen in Figure 14.

Figure 14 – Results of Flow Controlled milking evaluation

Parameter	Result
Average Milk flow	+ 8.1%
Peak Milk flow	+ 13.0%
Reduction in milking time	41.0 seconds
% Forced unit removal	- 0.4%
Congestion	No change
Hyperkeratosis	No change

All of these examined technologies offer the potential to improve milking performance without compromising cow comfort and teat condition. If teat congestion can be managed at a higher operating vacuum level, then milkimg speed will increase.

CONCLUSIONS

It is likely that labour availability will remain a challenge for dairy farmers around the world. Milk quality will remain a critical part of efficiency gains as farms adapt to a low carbon future.

This paper has set out to describe a number of currently available technologies that have the potential to both save labour and improve milking efficiency. The technologies described in this paper are not meant to be exhaustive but rather reflect emerging systems which have been subjected to independent field evaluation.

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MIND THE GAP: QUESTIONING EVIDENCE TO HELP YOU DECIDE

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SUMMARY

The starting point for effective decision making in mastitis management is questioning evidence. This can build an understanding of costs, potential benefits, and the likelihood of achieving results as good as expected or better. This requires evidence to support intervention efficacy. All evidence is generated by human beings, and this can introduce bias in its communication and interpretation. If appropriately applied, scientific principles provide tools to extract meaningful signals from random variation in data.

Assessing the strength and usefulness of evidence requires an appreciation of how it has been derived. This applies to all sources of evidence, scientific or otherwise. Notwithstanding the study design used, the validity of evidence from research is influenced by *how* the research was conducted.

A hypothesis is a statement about how something is thought to work, based on the evidence available. The scientific method is dependent on testing hypotheses. This is an iterative process of generating ideas, and refuting them to refine knowledge. Importantly, not all hypotheses are equally likely to be true, and hypothesis testing decisions accept errors within certain bounds. As such, hypothesis testing can be abused which can lead to questions about scientific credibility. A system of accreditation would be useful as a marker of quality to assist readers identify studies of the highest quality. This is based on peer-review and the process is evolving in line with modern evidence sources and decision-maker needs.

Scientific studies are done to tell us something about how the world is believed to work. To assess how useful a scientific study is to inform a particular management decision, it is necessary to compare what was done in the study, to real-world circumstances, and assess research quality and trustworthiness. All research is necessarily based on sampling, i.e. it does not cover all potential scenarios. Therefore, interpretation of research findings is dependent on assumptions. The key for avoiding gaps, is awareness of what is known and what is assumed.

The only certainty is that evidence is uncertain. Some uncertainty can be reduced by further research, but uncertainty about the future is ubiquitous. In the face of unavoidable uncertainty in the practical application of evidence, having a surveillance system in place can help flag deviations in expected

outcomes. However, when considering real-word data, it remains important to distinguish random variation from any true effect.

Expert opinion comes into play in the absence of accessible evidence, and should be assessed for credibility and applied as evidence with caution. An approach to mitigating uncertain evidence involves monitoring the outcomes of interventions such that management can be adapted if required.

INTRODUCTION

Mastitis is an occupational hazard for dairy cows. Developing management strategies to curtail economic and welfare consequences is dependent on effective decision making in the selection and implementation of interventions. These principles can be applied to interventions to remove existing cases from a herd and/or limit the occurrence of new cases.

The starting point for effective decision making is questioning evidence, to build an understanding of what the stakes are. These relate to:

- The consequential costs of mastitis cases
- The costs of interventions
- The efficacy of interventions
- Uncertainty in achieving expected outcomes

The consequential costs of mastitis cases relating to lost milk revenue and onward transmission may not be fully recorded or otherwise do not appear in accounts. Consequential costs may be offset by intervention costs including labour, consumables, and investments. Reviewing farm-specific values for both is recommended[1].

The main difference between intervention and consequential costs is that intervention costs are known as they come with a bill. However, they do not come with a guarantee of effectiveness. Rather there is a range of evidence sources that tell us something about expected efficacy with varying degrees of bias. Effective decision making is dependent on appropriate questioning of this evidence, and any underlying assumptions. Evidence gaps can be a starting point for negotiating intervention value. This applies broadly to all products and services that may be considered. Although short-term outcomes of interventions depend on an element of luck, in the longer-term adopting an evidence-based approach alongside appropriate recording and monitoring of outcomes is likely to pay off.

Marketing of products making medicinal claims (e.g. medicines indicated for the treatment and/or control of mastitis in dairy cows) is regulated by governments. This provides important assurance of the quality, safety, and efficacy of veterinary medicinal products, but limitations remain.

The aim of this review is to provide guidance on assessing the types of evidence that could support interventions for mastitis treatment and control, and raise awareness of where evidence gaps exist.

COSTS OF MASTITIS

Costs of mastitis are a good starting point for decision making, and fall into two categories; those that are incurred given the occurrence of cases, and those incurred to avoid the occurrence of cases.

Consequential costs of mastitis

These costs are incurred when cases of mastitis occur. Direct costs include treatment, labour, discarded milk, and mortality. Indirect costs include subsequent production losses through milk yield suppression, case recurrence, transmission to other cows, and culling. Indirect costs are unseen, and have been shown to be larger than direct costs. Estimates of average total consequential costs per clinical case have been between £120 and £370[2]. Importantly, such figures are dependent on prevailing economic conditions, and assumptions made by researchers. This means it is important to use farm-specific estimates. Cost calculators are available to assist[3], although it remains important to check underlying assumptions are relevant before applying figures calculated by a 'black-box'.

Intervention costs

Interventions are taken to be any change to management, or the environment intended to influence the rate of removal of existing mastitis cases from a herd and/or the occurrence of new cases. Interventions may be applied to individual cows (e.g., teat disinfection), or the whole herd (e.g., storage of bedding material).

In contrast to consequential costs, intervention costs are known (at least once an intervention has been implemented). Notably, quotes for interventions from suppliers are usually farm specific. Discerning clients will be used to requesting assurance of certainty in estimates for such costs. Furthermore, suppliers are expected to demonstrate they are trustworthy, e.g., through transparency about what is offered, and track record. The same applies to suppliers of research in support of intervention efficacy, particularly if this influences intervention value.

Intervention value

The decision to implement a particular intervention requires decision-makers to be satisfied the intervention has adequate value, given the cost. For changes targeting outcomes related to mastitis treatment and/or control, the pay-off is through reduction in consequential costs. This requires a judgement to be made about expected intervention efficacy, and the chance of achieving results at least as good as expected. On top of this, decision makers vary in 'willingness-to-pay', which captures what outcome individual decision-makers would consider to be successful[4]. This can be likened to the required return on investment, and is influenced by the availability of competing opportunities. In addition to reduced consequential costs of mastitis, this may incorporate decision-maker characteristics that are hard to measure, such as pride in keeping a healthy herd of cows[5], or external influences such as animal welfare legislation.

INTERVENTION EFFICACY

An appreciation of the expected efficacy of an intervention is a pre-requisite for rational economic decision making. This is obtained by raising questions about what evidence is available to support decisions, and to what extent there are gaps between what is known, and what is required.

The human factor

All evidence is generated by human beings, and we are all biased. We learn from experiences all around us, but our underlying assumptions may be flawed. This may result from an innate need to recognise potentially harmful signs in our environment that we need to escape from, which is a good survival strategy if the consequences exceed the cost of escaping. As such the human brain will identify patterns in the world around us, and draw conclusions without considering context. This limits us as managers of our environment when we cannot escape. Management necessitates a cyclic process of measuring an outcome and actioning attempts to influence it. In doing so, humans struggle to distinguish natural variation in measurements from any underlying true signal. This can lead to erroneous inferences about cause and effect. If appropriately applied, scientific principles provide tools to help us extract signals from the noise. Assessing the strength and usefulness of evidence requires an appreciation of how it has been derived. This applies to all sources of evidence, scientific or otherwise.

SCIENTIFIC STUDIES

Scientific studies can be designed in several ways, depending on their purpose. This influences the strength of evidence that is provided. Studies investigating intervention efficacy can broadly be ranked from strongest to weakest based on the comparisons made, and to what extent they support inferences about causation[6]:

- Systematic review and meta-analysis
- Randomised controlled trial
- Cohort studies
- Case-control studies
- Cross sectional studies

- *In vitro* studies

This ranking serves as a rough guide, but it remains important to check what was done in individual studies.

Research quality

Notwithstanding the study design used, the validity of evidence from research is influenced by *how* the research was conducted. A version of this is presented in the Materials and Methods section of scientific papers, which requires readers to decide to what extent they can trust what is written, as this influences the validity of the results. Ideally the account should be sufficiently transparent that another researcher could repeat aspects of the research and get the same results. A system of accreditation would be useful as a marker of quality to assist readers. This is based on peer-review.

Academic careers are dependent on frequent publication of papers, which could mean quantity is be prioritised over quality. Furthermore, quality assurance through the traditional peer-review process is subject to the intrinsic human biases of (anonymous) reviewers. This has raised the possibility that 'most published research findings are false[7]'. Subsequent attempts to formally replicate experiments in published papers have been limited. However a reproducibility rate of around 40% was found for psychology studies[8], and 10% for cancer biology studies[9]. Evidence is growing that the reproducibility crisis extends to other disciplines[10]. When based on comparing the degree of statistical significance for original studies and their replicates, this does not imply that non-significant results are all false claims, since the underlying datasets may not be statistically different from each other. It is the significance of the difference in effect sizes which is relevant[11].

Hypotheses

A hypothesis is a statement about how something is thought to work, based on the evidence available. For example: 'Treatment with Intervention A reduces the risk of intramammary infection in early lactation cows by x% more compared to treatment with Intervention B.'

The scientific method is dependent on testing hypotheses. This is an iterative process of generating ideas, and refuting them to refine knowledge. Importantly, not all hypotheses are equally likely to be true, and hypothesis testing decisions accept errors within certain bounds. As a result, it is possible to continually test similar hypotheses, and eventually find false positive cases, where data are found to be inconsistent with the hypothesis by chance (so-called 'data dredging').

To mitigate this, it is useful to recognise that there are two types of research that differ in terms of the state of development of the underlying hypothesis. Confusing these types of research can be dangerous if false positive findings are misinterpreted as being true.

Confirmatory research

By convention, hypotheses are assumed to be false until there is evidence available to the contrary. Statements we are willing to accept in the absence of data to the contrary are framed in a negative sense as null hypotheses. In confirmatory research, scientific methods are based on testing hypotheses to assess if they are true or false, as such confirmatory research can provide yes/no answers. This provides evidence that may be useful to decision-makers, assuming the study is relevant to their circumstances.

Exploratory research

In the context of investigating interventions which may claim to be efficacious for mastitis control, exploratory research would be required at an early stage to define interventions and how they should be applied. Such research focuses on generating new ideas and hypotheses, rather than testing them rigorously, and importantly, most hypotheses tested are not true (e.g. for drug discovery its likely less than 10% of hypotheses tested are true).

As such, outputs from exploratory research do not provide strong evidence in support real-world questions, like 'Should I invest in Intervention A or Intervention B to control mastitis on my farm?'.

Confirmatory studies are expensive and time consuming to run. Therefore the purpose of exploratory research is to short list hypotheses for testing to facilitate efficient and timely progress in a particular field.

Confirmatory vs exploratory research

Exciting new hypotheses from exploratory research may be newsworthy, but importantly, these may not have been validated in confirmatory studies. Academics under pressure to publish papers, and publicise them, are potentially facilitated by the flexibility in methodology used in exploratory research. Despite the use of cautious language in these papers, there is a risk that falsely positive results are used to inform decisions, particularly in fields where there is a dearth of evidence. Furthermore, publication bias can favour the reporting of positive over negative findings in the scientific literature because they are deemed to be of greater interest. This is not the case if studies are well designed in terms of their intended purpose.

In the face of a reproducibility crisis in science, the credibility of research, and its value as evidence would be improved if end users could easily determine if the research was exploratory or if it was confirmatory, and if it is trustworthy. A developing marker of trustworthy confirmatory research is evidence of study pre-registration. Plans can change, and it is not uncommon for research projects to change direction as they progress, which may be due to practicalities or academic curiosity. Importantly, deviating from a plan without a defined hypothesis, can amount to doing exploratory research, where this was not the original intention. At best this reduces the strength of evidence the results provide. However it also implies that false positive findings can inadvertently be reported as true, which can happen if plans for analysing data are not well defined. The terms 'data-dredging', and 'p-hacking', describe the malpractice of multiple hypothesis testing until statistical significance is obtained. This may not be malicious since it is frequently not possible to plan analyses completely until data are known. However, in the absence of a clear analytical plan, the human brain takes control, and it likes looking for patterns (that may not exist). To avoid expensive bad decisions, it is important to recognise when this could be the case. Unfortunately, this is not always possible through the traditional peer review process, as this occurs after results are known.

The solution is to increase transparency during the planning phase through pre-registration. Commercial studies in the pharmaceutical industry can be pre-registered (confidentially) with regulatory bodies. Similarly, academic studies can be pre-registered, with timestamped study plans using tools available through the Open Science Framework (https://osf.io/). Study plans are peer-reviewed and can be published or embargoed until results are available. At this point, reviewers can compare what was done, with what was planned. At the time of writing the author is not aware of any pre-registered confirmatory studies in the public domain to support interventions in agricultural and veterinary practice. End-users should demand this assurance in value negotiations.

Gaps in scientific evidence

Scientific studies are done to tell us something about how the world is believed to work. To assess how useful a scientific study is to inform a particular management decision, it necessary to compare what was done in the study, to real-world circumstances, and assess research quality and trustworthiness.

All research is necessarily based on sampling, i.e., it does not cover all potential scenarios. Therefore, interpretation of research findings is dependent on assumptions. The key for avoiding gaps, is awareness of what is known and what is assumed.

Gap 1: External validity

The outputs of a scientific study are intended to tell us something about the target population that the study is supposed to represent. In the context of designing a study into interventions to treat or control mastitis, the target population of dairy farms, would be those farms the research results are intended to generalise to, for example the population of 'dairy farms in Great Britain (GB) today'. Mangers looking to inform a decision on a particular farm, must firstly assess to what extent their farm is represented within the target population. This requires critique of the method used to sample dairy farms within GB. The only way to ensure any sample of farms is representative of the target population of farms would be to recruit farms at random, within a framework that ensures all farms in GB are equally likely to be recruited. In some circumstances, random sampling is achievable in space, but this is not the case in time. This means even if a representative sample of farms has been obtained (or we have all the data), it is important to acknowledge that scientific studies are reporting the past, and circumstances may have since changed, as could be the case with increased cow milk yields over time. It would be also prudent to check to what extent detailed study inclusion criteria influence the meaning of results in particular circumstances. For example, was the study done in suitable species, breeds, ages, and/or sexes of animal?

For a scientific study to be feasible, researchers must gain access to the target population. To achieve this an accessible study population must be defined. This is an identifiable subset of the target population from which farms could be recruited for the study. It is important that the study population is representative of the target population. The ideal scenario would be having access to all or a random sample of potential farms that could be included. This assumes researchers can contact the managers of all farms and obtain consent for the study. However, an existing list is usually needed which introduces bias. Lists come from a range of administrative purposes, likely not relevant to the research, e.g. regulatory, voluntary recording schemes, and supermarket suppliers.

When assessing evidence from a scientific study, decision-makers should judge how far removed the study population is from the target population for the research, and if their farm belongs to the target population (external validity).

Gap 2: Internal validity

It would be a waste of resources to recruit all dairy farms in the study population. As for Gap 1, a sample of farms is sufficient, assuming they are representative of those that are excluded. This can be achieved by random sampling. The size of the subset required is dependent on what the research is intended to achieve (see Gap 4; power). However, this assumes all those on the list are contactable, and willing to participate in the study. In addition, it may be necessary to apply inclusion/exclusion criteria to farms on the list based on specific study requirements.

When assessing evidence from a scientific study, decision-makers should judge how far removed the sample of farms used in the research is from the study population they were derived form (internal validity).

Gap 3: Measurement error

Data collected from the sample of farms is intended to tell us something about those farms, or the cows on them. This requires a judgement on how data is collected for the study, and how well this represents what we are really interested in. For example, data on farm management practices may be collected from interviewing a farm manager. This could introduce response bias, which is the difference between the reality and what is recalled and/or reported about the reality. Another example could be assessing mastitis control using milk somatic cell count, which excludes milk from cows under treatment for clinical mastitis, those selectively withheld, and dry cows.

When assessing evidence from a scientific study, decision-makers should judge how far-removed data are from what we want to know about the sample of farms/cows used in the research. This relates to study design, and resultant strength of evidence regarding causation.

Gap 4: Likelihood of hypotheses and prior knowledge

Gap 4 relates to understanding if research is confirmatory or exploratory, and the extent to which hypotheses have been pre-selected. This influences how clearly methodology can be planned, and hence the magnitude of potential errors.

Statistical tests are used to assess if observed data are compatible with specific hypotheses. Rather than proving hypotheses are true, the long-standing scientific method is based on falsification[12]. This is analogous to the courtroom, where the default belief (hypothesis) is that a defendant is not guilty, unless there is reasonable evidence to be doubtful. Similarly, scientific hypotheses are expressed in a negative sense for testing (null hypotheses). For example: 'The risk of intramammary infection in early lactation cows does not differ in cows treated with Product A or Product B.' In this way, disproving a hypothesis advances knowledge by proposing a new hypothesis that will similarly be considered true until evidence to the contrary is available.

Testing of scientific hypotheses can be considered as analogous to diagnostic tests. As such there are four possible test outcomes (Table 1), based on if null hypotheses are true or not, and if test results are positive or negative. Importantly 2 of these 4 outcomes represent errors. Decision makers must make a judgement on what magnitude of errors is acceptable. This specifies a cut-off risk for false positive (Type 1 error) and false negative findings (Type 2 error) below which errors are tolerable. Scientists commonly use arbitrary values for the cut offs (e.g., 0.05 and 0.2 for Type 1 and Type 2 errors respectively). Due to the potential harm of false positive findings, Type 1 errors tend to be less tolerable than Type 2 errors.

Hypotheses are not all equally likely. The less likely that hypotheses are to be true, the greater chance of false positive results. Hence, it is important to judge to what extent research is exploratory, meaning hypotheses are not well defined or at least plausible.

The power of a study (1-Type 2 error) is the likelihood of obtaining positive test results when the null hypothesis is true. If false negative results are obtained, it is important to assess if the study had enough power to detect the effect size of interest. False negative findings (Type 2 error) can occur if the sample size is too small detect an effect that exists from random variation.

Table 1 Hypothesis test outcomes and decisions: Correct decisions and errors (probabilities)

	Truth about null hypothesis (H0)	
Decision based on test result	**True (no effect)**	**False (effect exists)**
Significant/ positive: Reject H0	Type 1 error (α)	Correct decision (1- β)
Non-significant/negative: Accept H0	Correct decision (1 - α)	Type 2 error (β)

Gap 5: Transparency of research

Confirmatory research can be useful for decision making. However, assurance that a research study provides strong confirmatory evidence is dependent on transparency of the methodology. In principle, this enables readers to judge to what extent results are reproducible, and helps avoid the reporting of false positive findings. As part of a move to increase the openness of academic research practices, pre-registration of confirmatory research studies is an emerging approach to providing this assurance (see section on confirmatory vs exploratory research). Pre-registered studies have an additional peer-review of the rationale, and planned methodology before it has been implemented. Favourable review at this stage leads to acceptance in principle, regardless of results, assuming the planned methodology is followed. This provides some assurance that studies, are adequately powered, meaning the risk of false negative findings is tolerable.

There is lack of transparency if research is not reported, and pre-registration of confirmatory studies also reduces publication bias. This is where ‘negative findings’ are supressed by authors or editors if they are construed as not interesting or newsworthy. However, for real-life decision makers, negative findings (e.g., that an intervention does not work) are potentially useful. Until pre-registration of published studies is more widespread, end users of the knowledge should make a judgement about the credibility of the available studies in addition to relevance in terms of Gaps 1 to 4.

An example of where confirmatory research and study pre-registration is more established, is in the regulation of veterinary medicines. Regulations exist to ensure veterinary medicinal products on the market are of high quality, safe, and efficacious. However, transparency of the underlying research is often limited by commercial sensitivities. In these circumstance, appraisal of the evidence has been undertaken by government officials in accordance with legislation and guidelines. The regulatory system must balance its assurance function with pragmatism to promote the availability and affordability of veterinary medicines. This means there are evidence gaps, alongside the inevitable bias associated with judgements made by humans.

Minding the gaps

The only certainty is that evidence is uncertain; uncertainty comes in two types. The first type (epistemic uncertainty) relates to Gaps 1 to 4, in that *how* scientific research is conducted has an influence on the quality of evidence it provides. As such, epistemic uncertainty relates to uncertainty about the past, and can be reduced with further research. For decision-makers, the key point is understanding how to value the evidence, and hence particular interventions in their circumstance. This starts with asking questions to drive demand for evidence.

The second type of uncertainty (aleatory uncertainty) relates to uncertainty about the future, and no amount of research can remove it. In the regulation of veterinary medicines, underlying confirmatory research providing evidence about safety and efficacy, is based on limited animal studies that can never be generalisable to all potential end-users of products. This is mitigated by a national surveillance system based on passive reporting, administered by Veterinary Medicines Directorate in UK (VMD; pharmacovigilance). Any person can report a problem with a regulated product, and these are assessed in the context of likely population exposure. The system is insensitive, suffers from under-reporting, and assumes everything is OK in the absence evidence to the contrary. Passive surveillance is specific, but insensitive because adverse effects must be relatively severe and/or widespread to be detected by the system. However, the pharmacovigilance system provides a safety net to bridge the gap between what was observed in studies and what is observed in the wild. This was seen in recent years with Velactis; a medicinal product indicated for use in the herd management programmes of dairy cows as an aid to abrupt drying-off, which had its marketing authorisation suspended following reports of recumbency and death in dairy cows in 12 EU states[13].

Surveillance also occurs at a local level on dairy farms. Passive surveillance (watch and wait) can be enhanced by active surveillance through engagement with herd health and production monitoring to inform management decisions. It is useful to consider Gaps 1 to 4 in the context of this data source. As it comes from the cows that decisions are to be based on, the external validity of the data is potentially very good compared to research studies done in other settings, particularly if the data are analysed in real-time. However there are likely to be larger gaps in relation to sampling and collecting data.

Sample sizes may be necessarily small, e.g. numbers of cows calving per month, and data could have measurement errors and be influenced by a range of biases. Variation based on small samples is most likely due to chance. This means there is low power to detect effects that may exist. As for pharmacovigilance, farm health and production monitoring provide a specific but insensitive surveillance system to providing evidence. When evaluating variation in herd health and production data, it is useful to adopt a holistic approach and keep the concept of regression to the mean in mind.

The latter shows part of the reason for extreme observations (e.g. number of cows with subclinical mastitis) is chance, and as such repeated extreme observations become even less likely in the absence of an underlying reason. Therefore, continuous use to evaluate long-term trends, surveillance systems based on herd health and production management can provide insight into management choices. It is important to note this approach comes back to exploratory style research, i.e., generating hypotheses to investigate further.

EXPERT OPINION

All knowledge is obtained from experience of some form. Here 'experts' is applied as a broad term to capture the unique perspective of any person or organisation with an opinion on the required decision. Due to the inevitable biases of human brains, expert opinion is regarded as less reliable than scientific studies. Since producing and assessing scientific studies is a human endeavour, there is potential for bias to be introduced to the message that is reported, communicated, and received by end users. Those using expert opinion to inform decisions, should therefore, make a judgment on the credibility of the expert. This may include a consideration of sources of evidence the expert uses to support their views. Indicators of expert credibility could include accreditation with a professional body, and/or relevant experience.

CONCLUSIONS

Effective decision making depends on luck (short-term) and good judgement (long-term). Considerations to make the best of both are summarised in the take home messages below:

- Consider asking questions about evidence to support management interventions you are considering.
- Assess to what extent evidence is expert opinion vs scientific
- Assess the extent of evidence gaps.
- Assess to what extent evidence is trustworthy and credible.
- Assess costs and benefits and decide what effect size would make the intervention worthwhile.

- Decide if the desired outcome is likely to be achievable and if it is compatible with your attitude to risk.
- Mitigate negative consequences by maintaining a system of monitoring and review of outcome measures.

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NOTES

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CHALLENGES AND SUCCESSES IN UTILISING THE AHDB MASTITIS CONTROL PLAN IN PRACTICE: A CASE STUDY

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SUMMARY

A dairy herd Northern England, producing milk for an ARLA 360 contract raised clinical mastitis rate as a priority area for the herd. The motivation for improving mastitis was to improve welfare of the cows, reduce time spent treating cases, reduce cost of mastitis treatments and to avoid penalties from the milk buyer. The AHDB mastitis control plan was utilised to provide a framework for tackling this issue. The rolling 12 month incidence of clinical mastitis in July 2021 was 39 cases per hundred cows per year.

Assessment of clinical mastitis data demonstrated a lactation environmental pattern. Environmental assessment and management questionnaire elicited a list of areas for improvement which were prioritised with the management team with a focus on improving hygiene in the lactating cow environment and cleanliness in and around the parlour. The team responsible for milking and bedding the cows included 23 people with varying amounts of experience, hence a large focus was placed on strategies to motivate the whole team to invest in the changes.

At the 12-month review in September 2022, clinical mastitis incidence had fallen to 30 cases per hundred cows per year, with the new cases still being driven by an environmental lactational pattern. Ongoing work focusing on hygiene in the lactating cow environment, ensuring buy in from the team and retaining focus on the key areas for improvement continues.

INTRODUCTION

A dairy herd in Northern England milking approximately 750 Holstein cows with a 305 day milk yield of 11,500L identified clinical mastitis as their main focus for improvement. In July 2021, clinical mastitis incidence was at 39 cases per hundred cows per year, placing them in the top quartile for mastitis incidence in the ARLA 360 producers group. It also resulted in significant cost associated with mastitis treatment, waste milk and increased time at milking administering treatments. Cow welfare was also cited as a motivator to aim to reduce incidence of mastitis. Somatic cell count in this herd is well controlled with an average somatic cell count of 130,000 cells / ml, and chronic high cell count rate of 7%.

The AHDB mastitis control plan was selected to provide a framework to tackling the mastitis issue in this herd. The mastitis control plan provides an evidence-based approach to mastitis intervention and has demonstrated a reduction in clinical case incidence in herds which implement changes (1).

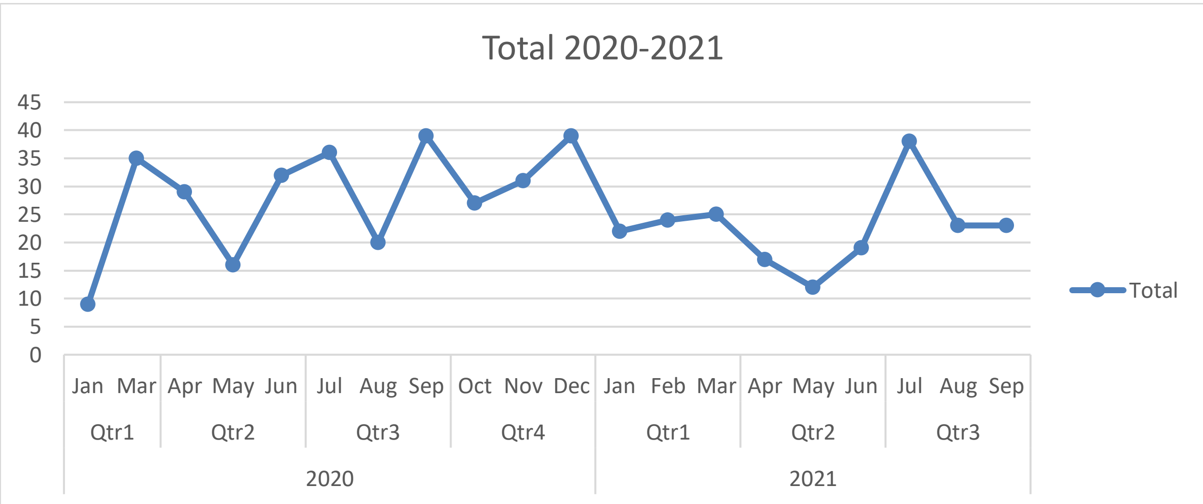
PLAN IMPLEMENTATION

The mastitis control plan was carried out as described by Green et al. (1). Data was recorded in BoviSync and was analysed using Excel. An environmental assessment of lactating and dry cow accommodation, youngstock, assessment of milking routine, assessment of cow parameters including cleanliness, teat condition, and body condition score, nutrition and mastitis treatments were carried out in accordance with the mastitis control plan questionnaire.

Mastitis Data

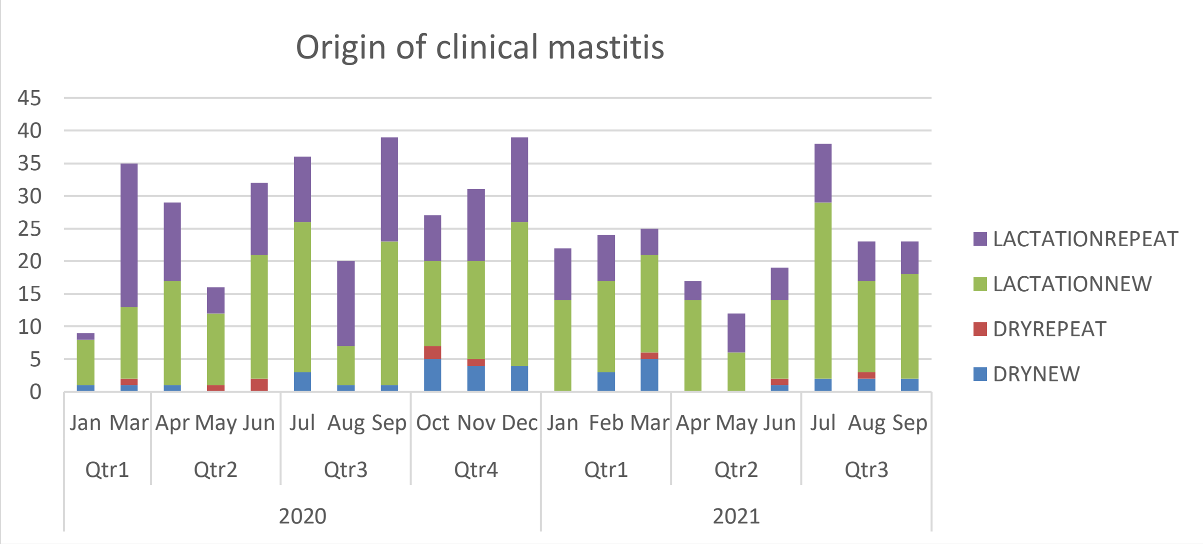
Monthly incidence of clinical mastitis showed no significant seasonal trend but had showed a tendency for a reduction in cases in 2021 in comparison to 2020 (see figure 1), with the exception of a peak of cases in July which was attributed to a problem with the slurry channel in this month.

Figure 1 Clinical mastitis case incidence by month



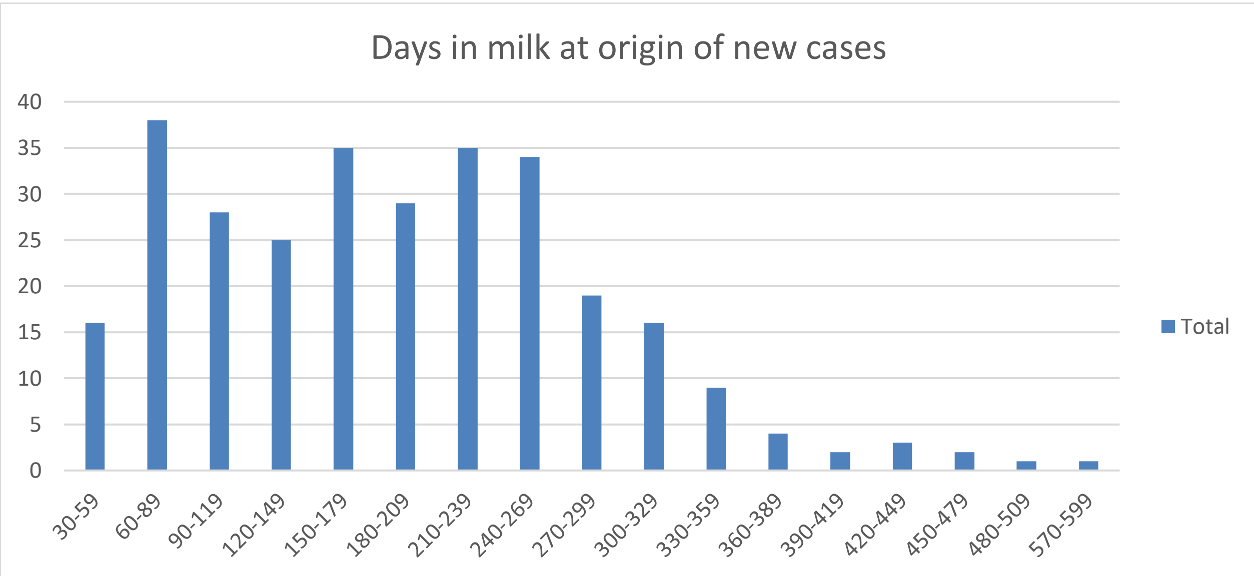
Assessment of the data demonstrated a strong lactation environmental pattern (See figure 2).

Figure 2 Mastitis origin by month



It was also observed that a large proportion of new cases originated in mid to later lactation (See figure 3).

Figure 3 Days in milk of case



Farm Management

Lactating cows were housed in 5 groups with differences in their management as described in Table 1. Cows typically moved from the fresh group at approximately 30 days in milk, and from high yielders group to the lows at approximately 150 days in milk. Cubicles were scraped of muck at each milking and sawdust raked to cover the backs. Cows were milked three times daily with manual scraping in the sand cubicles and automatic scrapers in the mat and sawdust group. Complete bedding (sweeping of backs, application of lime and application of sawdust) was completed as deemed necessary which was typically 5 times per week. Sand beds are raked at each milking and fresh sand applied as necessary. Cross passages were manually scraped at each milking however compliance in this was described to be variable.

Table 1 Differences in environment of different groups of cows

Group	Cubicles	Cubicles stocking rate (Cubicles / cows)	Feed space (m/cow)	Space availability (m^2 / cow)
1 – Fresh Heifers	Deep sand	1.7	1	11
2 – Fresh cows	Deep sand	1.05	0.6	10
3 – High yielding cows	Deep sand	0.9	0.6	10
4 – Heifers	Mattresses and sawdust	1	0.8	9
5 – Low yielding cows	Mattresses and sawdust	0.8	0.5	8

Observations and questionnaire answers were input into the control plan software and the following list of areas for improvement were generated. The results were discussed in a management team meeting.

The following items related to cow environment:

- Fresh sawdust should be applied daily
- Slurry sometimes overflows the sides of the scrapers
- The scrapers must work sufficiently often to keep alleyways clean
- Accommodation must be maintained to minimise risk of injury
- Ventilation of the milking cow accommodation should be assessed
- Cow accommodation must be maintained
- There must be 1 cubicle per cow

The following items related to hygiene at the time of milking:

- Collecting yards should have sufficient drainage to prevent excess pooling of liquid
- Pooling of liquid sometimes occurs in the post milking area
- There must be a clean yard on exit, which is scraped during the milking process

There were also areas of concern relating to hygiene in the milking parlour that were highlighted.

- There are more than 3 milkers in total
- If mains water is not used, drinking water should be tested at least annually to ensure freedom from pathogenic bacteria
- A new pair of gloves should be worn every milking
- Hands and gloves should be washed and dried during milking if they become dirty
- Irrespective of its use, only potable water must be used in the parlour
- The milking routine should take 60-90 seconds

The collection of milk samples to improve our understanding of the aetiology of mastitis on the farm was also considered important.

- An aseptic milk sample should be taken from every case of clinical mastitis

Whilst the clear predominant pattern of mastitis was lactational environmental, the farm had recently moved the cows into new dry accommodation. Some areas for improvement were noted in the plan and it was discussed that the processes for management of the new transition building must be established to prevent this area becoming a problem in the future.

- Fresh straw should be added to dry cow yards daily
- Pens should be cleaned out between each calving cow
- Feed face must be scraped daily

Implementing the Plan

A key challenge in achieving a reduction in clinical mastitis on this farm was related to the large team involved. The management structure is well defined, with the family run management team of four having specified areas of responsibility across the farm. The long list of possible improvements was discussed with the management team in relation to the mastitis data. Improving cow cleanliness through making changes to the lactating cow environment was decided as the focus. Given the significant contribution of new cases in mid to late lactation, the low yielder environment was highlighted as an area to target.

Whilst the management team were highly motivated to reduce mastitis, implementation of many of the aspects discussed would need to be taken up by the team. In total, 23 people milk the cows hence it was concluded that training and motivation of the staff were critical if the improvements necessary were to be successfully implemented.

A team meeting was held with all milking staff to provide training on environmental mastitis and to raise awareness of the role of the team in mastitis prevention. The team were then asked to input into solutions to improve the cleanliness of the cows and improve the hygiene around the milking parlour. The aim of this was to increase buy in to the changes by offering a participatory approach (2).

The outputs from the meeting were:

- Produce an agreed standard protocol for bedding up and bed up sawdust cubicles daily
- All staff to be trained on the new protocol and confirm their adherence to it. All new starters will be trained as part of their induction
- Scraper frequency to be increased and timed to ensure cows return to clean beds
- New hand scraping equipment and brushes to be sited in easy to access locations and a focus on ensuring a thorough job was to be championed
- Existing damage to cubicles and water troughs to be repaired
- A reporting process to be established for any accidental damage and a no blame culture to be assumed.
- A 'midway break' during milking to be established to scrape collecting yards and return passages
- Gloves to be worn in the parlour by all staff with no exceptions
- Training protocol to be established for use of the udder brush to ensure the correct cleaning and drying process is followed by all staff
- New starters to be trained by a member of the management team and supervised by a lead milker until they are signed off.

The management team also resolved to ensure the water source to the parlour was part of the UV filtration system and a simpler hand washing facility would be installed in the parlour. An ongoing project would be to seek advice on improving ventilation in the cow accommodation with an engineer. The management team were also highly interested in installing vented liners in the parlour, however their impact on clinical mastitis and it was discussed that their role in reducing mastitis was likely to be negligible. Stocking rate, particularly in the low yielders was discussed and options to reduce this would be reviewed.

Monitoring Progress

Quarterly meetings were held with selected management and lead milkers to review the actions. At the 12 month review, rolling 12 month clinical mastitis incidence had reduced to 30 cases / 100 cows per year. Control of somatic cell count remains excellent, with 3 month rolling cell count of 130,000 cells / ml and 3 month rolling chronic rate reduced to less than 5%.

CONCLUSIONS

The AHDB mastitis control plan provided an evidence based frame work upon which to build the actions areas for change. However, this case study has demonstrated that implementation of these changes, in a large dairy, needs to be effected through appropriate training, management and motivation of the people involved on a day to day basis. The management team were highly motivated to reduce mastitis and prepared to invest in time, training and capital improvements in order to make this a success. As a plan deliverer, an important role has been to facilitate the team to identify solutions and monitor their successes and failures.

Whilst we have seen a moderate reduction in clinical mastitis cases over the 12 month period we have implemented the plan, there is still further to go to meet the ambition of the farm and to ensure the standards of the milk contract are continually met. There is still progress to be made in achieving a consistent standard in cubicles management and hygiene in the parlour and strategies to achieve this will be the focus of the next phases of mastitis control on this farm.

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UK TRENDS IN TEAT SEALANT USAGE OVER THE LAST 4 YEARS

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SUMMARY

Data from Kingshay's antimicrobial monitoring service which enables antimicrobial purchase data to be collected on an annual basis were analysed against the 6 RUMA (Responsible Use of Medicines in Agriculture Alliance) Targets. The use and benefits of selective dry cow therapy has been encouraged for many years. Our research shows that since records began in 2018 there has not been further improvements and the use of teat sealants is lower than the 2020 RUMA target at 1.54 tubes per cow. The overall trend has seen a drop in the number of tubes used per cow for teat sealants over the last 4 years from 2.45 tubes per cow in 2018 (when selective dry cow therapy was already widely promoted) to 1.44 tubes per cow in 2020. From our data, we demonstrate the opportunity for increased uptake of these products as part of dry cow therapy, and suggest veterinary surgeons need to work with their clients to implement protocols to enable the effective use of teat sealants if the RUMA targets are to be met.

INTRODUCTION

The Kingshay antimicrobial monitoring service was established in 2017 in response to demands from farmers, vets, and milk processors to enable antimicrobial purchase data to be collected on an annual basis. This data has then been used as part of the health planning process enabling farms to reduce and refine their use of antimicrobials.

METHODOLOGY

The service obtains client sales data from the vet practice for each herd, with livestock numbers and other herd details being gathered from the farmer. The number of herds using the service has grown year on year with 940 herds being recorded in 2021. The report is then validated by both the vet and farmer to ensure its accuracy. Other enterprises (such as beef/sheep units) where antimicrobial sales were on the same account are removed and adjustments are made for products bought in bulk and not used in the specified time period. Along with dry cow therapy and a detailed list of products used and the quantity, the report includes comparisons with other herds, and to last year's results.

RESULTS

The use and benefits of selective dry cow therapy has been encouraged for many years. Since collecting records in 2018 there has not been further improvements and the use of teat sealants is lower than the 2020 RUMA target at 1.54 tubes per cow. As shown in table 1.

Table 1 Dry cow therapy (antibiotics vs teat sealants)

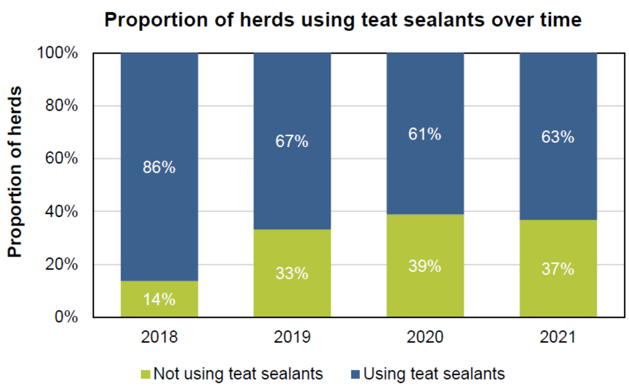
Dry Cow Therapy (tubes per cow)	2018	2019	2020	2021
Antibiotics	1.94	1.91	1.77	1.75
Teat Sealants	2.45	1.66	1.44	1.54

The overall trend has seen a drop in the number of tubes used per cow for teat sealants over the last 4 years from 2.45 tubes per cow in 2018 (when selective dry cow therapy was already widely promoted) to 1.44 tubes per cow in 2020.

The drop in number of tubes used may be due to the addition of herds supplying cheese contracts as these herds are often reluctant to use teat sealants due to concerns over black spots in cheese.

Figure 1 shows the proportion of herds using teat sealants and demonstrates the opportunity for increased uptake of these products as part of dry cow therapy.

Figure 1 Proportion of herds using teat sealants over time



CONCLUSIONS

Overall, the herds using the service have significantly reduced their antimicrobial usage over the last 4 years, however there is a significant variation in usage between herds highlighting that there are further steps many farms can implement to reduce their usage further, principally with selective dry cow therapy.

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UDDER HEALTH AND MILKING FREQUENCY IN 95 UK DAIRY HERDS IN 2021

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The AHDB Sentinel Herds Project provides an annual overview of udder health parameters in a cohort of well recorded herds, with reliable clinical mastitis records and regular individual cow somatic cell counts (SCCs). In 2017, 125 herds were recruited on the basis of quality of 2016 records. A group of 95 surviving herds supplied data for 2021, which is summarised and compared with 2016 data in Table 1. The daily milking frequency for each herd in 2021 was obtained from milk recording information or by telephone.

The difference between mastitis parameters recorded in 2021 and in the recruitment year of 2016 was tested using the Wilcoxon signed rank test. The influences of yield and milking frequency on these parameters were investigated using linear models.

Table 1 Key farm indices and udder health indicators 2021 and comparison with 2016. Significance of difference between 2016 and 2021: * $p <0.05$, ** $p <0.01$, *** $p<0.001$ (Wilcoxon signed-rank test)

Variable	N	Mean 2021	Median 2021	1st Q 2021	3rd Q 2021	Median 2016
Herd size	95	365	286	195	366	262
Mean annual rolling 305 day yield (l)	94	9073	9004	7803	10628	8831
Calculated bulk milk SCC (,000/ml)	91	160	160	118	190	161
Clinical mastitis (CM) rate (cows affected /100 cows/ year)	90	24.9	20	14	32	33.5***
Dry period origin CM rate (cows in 12)	90	0.53	0.48	0.3	0.65	0.74***
Lactation origin CM rate (cows in 12)	90	1.6	1.49	0.94	2.22	2.01***
Lactation new infection rate (%)	93	6.39	6	4.2	8.2	7.05 **
Dry period new infection rate (%)	91	15.2	14.3	10.8	18.9	14.55
Dry period cure rate (%)	91	79.1	80	73.4	87.5	80
Fresh calver infection rate (%)	92	15.9	15	12	19.2	16.2

Variable	N	Mean 2021	Median 2021	1st Q 2021	3rd Q 2021	Median 2016
% chronically infected	93	8.24	7.5	5.4	10.3	9.4*
% > 200,000 cells/ml	93	15	14.4	11.4	18.2	16.25 *

All parameters showed a significant improvement since 2016, with the exception of SCC dynamics over the dry period. As expected, yield had a significant negative effect on calculated BMSCC, and lactation new infection rate, but no effect on clinical mastitis rates. Nine herds used Automatic Milking Systems, 20 milked 3 times daily and 68 twice a day. There was no effect of milking frequency on any of the parameters analysed once the effect of yield was accounted for (Table 2).

Table 2. Models of the influence of yield and milking frequency on selected mastitis parameters

Calculated bulk milk SCC (,000 cells/ml)			Clinical cases/ 100 cows/yr		Lactation new infection rate (%)	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	248	32	27.2	9.52	11	1.5
Yield (,000l/ cow/year)	-9.8 *	3.8	-0.0002	0.001	-0.54	0.18**
X 2 milking	Reference					
X 3 milking	12.7	17.7	-2.45	5.26	0.71	0.84
AMS	13.6	24.3	-1.44	7.23	0.20	1.1
AMS – automated milking system; * P< 0.05, **P< 0.01						

More herds were below the maximum advisory rates for clinical mastitis and SCC parameters in 2021 than in 2016 (Table 3).

Table 3. Percentage of herds below maximum advisory rates (MAR) for clinical mastitis (CM) and subclinical mastitis parameters

	Lactation origin CM rate	Dry period (DP) origin CM rate	Lactation new infection rate	DP new infection rate
MAR	2 cows in 12	1 cow in 12	5%	10%
2016	50.0%	73.3%	14.4%	20.5%
2021	71.1%	92.2%	35.6%	23.0%

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