DairyNZ

Mastitis Technotes

A technical guide for mastitis management on New Zealand dairy farms

DairyNZ

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Who should use this resource

These Mastitis Technotes are intended for veterinarians, milk quality advisers, and other animal health professionals involved in mastitis management in New Zealand dairy systems. Developed with input from the National Milk-Quality Advisory Committee (NMAC) and wider industry expertise, they provide technical guidance to support evidence-based decision making. They are best applied alongside professional veterinary advice that considers herd-specific circumstances.

About this resource

This work builds on the principles of the SmartSAMM programme, which operated from 2009 until 2025 and was adapted from Dairy Australia's Countdown Downunder resources to reflect New Zealand dairy systems. Information in these Mastitis Technotes is a compilation of Dairy Australia's Countdown Downunder Technotes for Mastitis Control, updated with established research and practical knowledge for New Zealand dairy farming.

Disclaimer

This resource is provided for informational purposes only and does not replace professional veterinary advice, diagnosis, or treatment. Decisions regarding mastitis management, including treatment selection and antimicrobial use, should be made in consultation with a qualified veterinarian, with consideration of individual herd circumstances, relevant regulations, and antimicrobial stewardship principles.

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Overview of the Mastitis Technotes

Mastitis remains one of the most costly and preventable diseases in New Zealand dairy herds, with risk and control measures shifting across the seasons, from calving through lactation to drying off. Each chapter provides the technical knowledge needed to manage mastitis and milk quality at each stage.

Calving

The two weeks before and after calving are the highest-risk window for new intramammary infections, driven by immune suppression at calving and greater exposure of teats to mud and manure. This chapter sets out how to reduce that exposure, including calving-pad and grazing management, additional precautions warranted for first-calving heifers, residue and milk-quality rules that apply to colostrum and early-lactation milk, and detection and treatment of clinical cases as they arise. A herd consistently exceeding five clinical cases per 100 calvings within this window warrants a more structured review of calving environment and management.

Lactation

Once cows are in full lactation, mastitis control shifts from managing infections at and after calving, to preventing new infections, and promptly detecting and treating those that do occur. This chapter covers the key elements of mastitis control during lactation, including milking routine, hygiene and machine function, post-milking teat disinfection, managing teat-end damage, detecting clinical cases through fore-stripping and filter checks, and using bulk milk and individual cow somatic cell counts to monitor herd trends. Post-milking teat disinfection is the single most effective measure for preventing new mastitis infections during lactation. A herd with more than one clinical case per 100 cows per month, or a bulk milk somatic cell count (SCC) approaching 400,000 cells/mL, warrants a structured investigation.

Drying off

Cows are most vulnerable to new intramammary infections in the first two to four weeks after the last milking, before the teat canal has fully closed. This chapter covers deciding a herd's dry cow strategy, selecting which cows need antibiotic treatment at dry off, the effective use of internal teat sealants, culling cows that are unlikely to respond to treatment, managing milk yields before dry off, hygienic administration of products at dry off, and regular udder checks after dry off to catch problems early. Aim for a dry period of at least six, and preferably eight, weeks.

Review and plan

This chapter covers the biosecurity risks of buying and selling cows, including screening replacements for SCC and clinical history before purchase. Cows should not be purchased with an individual SCC above 250,000 cells/mL, and any indicator exceeding warning levels should prompt veterinary input. Mastitis control is an ongoing programme, and the chapter closes with the annual review process: assessing the past year against targets, servicing equipment, and setting goals for the season ahead.

Calving

Technotes 1–4

Technote 1

Reducing exposure to environmental mastitis bacteria

In this technote:

Mastitis is typically classified into two categories:

1. **Cow-associated mastitis.** This is caused by bacteria that inhabit the udder tissue or the skin of the teat and are commonly spread cow-to-cow at milking.
2. **Environmental mastitis.** This originates from bacteria that survive in the cow's surroundings - such as manure, mud or dirty water. While milking can aid their entry through the teat canal, the environment is the main source of infection. Common environmental pathogens include *Streptococcus uberis* and various coliform bacteria.

① Causes and characteristics of environmental mastitis

Environmental mastitis is caused by opportunistic pathogens from the cow's surroundings - such as soil, manure, bedding, calving areas, water sources, or non-mammary body sites. Infections occur when environmental contamination is high, or udder immunity is compromised.

Most environmental mastitis cases occur in the first few weeks postpartum, when cows are immunocompromised and teats are heavily exposed to mud and manure at calving. However, exposure to environmental pathogens can occur at any stage: pre-calving, during calving, at milking, or while grazing.

In lactation, key risk factors include teat end exposure to manure on feedpads or yards, milking wet or dirty udders and administering intramammary treatments without adequate teat-end hygiene. In the early and late dry periods, risk increases if the keratin plug fails to form, allowing easier bacterial entry.

Streptococcus uberis is the predominant environmental mastitis pathogen in New Zealand dairy herds (McDougall *et al* 2007). It generally responds well to antibiotic treatment, with cure rates around 80% (McDougall *et al* 2007).

➜ **Technote 14.4 and 14.5** discuss *Strep. uberis* and different approaches to the use of Dry Cow Treatments (**DCT**) and Internal Teat Sealants (**ITS**).

Coliform bacteria are an increasingly recognised cause of mastitis in New Zealand (Lacy-Hulbert 2012; Watts 2024; Anon 2025). These gram-negative, lactose-fermenting rods from the *Enterobacteriaceae* family, such as ***Escherichia coli***, *Klebsiella* spp. and *Serratia* spp., originate from soil, water, and faeces. They cause both sub-clinical and clinical disease, with *E. coli* and *Klebsiella* capable of causing acute severe mastitis due to the endotoxins released when the bacteria die.

Less common environmental pathogens include ***Candida*** spp. (yeast) and ***Prototheca*** spp. (algae), and their key characteristics are summarised in the following Tables.

Streptococcus dysgalactiae displays features of both environmental and cow-associated mastitis (**see Technote 5**). It can be isolated from the environment as well as cow body sites (mouth, udder and vagina). Teat end damage is a major risk factor for infection (Ericsson-Unnerstad *et al* 2009).

Characteristics of common environmental mastitis pathogens

Characteristic	*Streptococcus uberis*	*Escherichia coli**	*Enterococcus* species
Reservoir of infection	These bacteria can be isolated from the environment, faeces and many sites on cows. Some cows (5-10% of the herd) pass large numbers in their faeces The udders of chronically infected cows are a potential reservoir, and their milk may contaminate milking equipment.	These bacteria are part of the cow's normal gut flora and are excreted in faeces, so they are widespread in the environment. In rare cases, udders of chronically infected cows are a reservoir of infection, and their milk may contaminate milking equipment.	These bacteria can be isolated from the intestinal tract, faeces, infected udders and the environment.
Spread	Contamination of teat surfaces occurs in the environment. Passage into the udder can occur at any time, including during milking.	Contamination of teat surfaces occurs in the environment. Passage into the udder can occur at any time, including during milking. Some strains have virulence factors that increase their ability to colonize and persist in the environment or host tissues and cause mastitis.	Contamination of teat surfaces occurs in the environment.
Risk of infection	*Strep. uberis* is the most commonly bacteria isolated from clinical mastitis cases throughout lactation (Anon 2025). Infection is common in the dry period or during calving, especially if there is teat end damage or udder oedema. At these times, changes in udder secretions and lack of flushing by milking make cows more susceptible. Infections with *Corynebacterium bovis* may also make quarters more susceptible to *Strep. uberis* mastitis in the dry period (Woolford *et al* 2001).	In NZ, *E. coli* is becoming an increasingly common isolate from clinical cases, after *Strep. uberis* (McDougall *et al* 2018; Anon 2025) Risk of infection increases for cows managed in environments that increase faecal contamination of teats i.e. feeding or calving pads, indoor housing, zero-grazing or fed diets with a high starch content (Lacy-Hulbert *et al* 2002).	Infection occurs most frequently in the first two weeks of the dry period and during the calving period particularly when teat end hygiene is poor. Infection can occur throughout lactation especially when cows are maintained in dirty environments.
Clinical signs	Severity of clinical signs may vary from slightly abnormal milk to severe swelling of the udder and an elevated temperature. Severity can increase when treatment is delayed.	Coliforms do not usually invade udder tissue so most cases due to *E. coli* self-cure, with minimal long-term effect on the cow. Occasionally they can cause a sudden and severe toxaemia where cows may develop a high temperature, or later, a low temperature, and may become recumbent and die. Quarters usually return to part production in the same lactation (Gröhn *et al* 2004).	It is difficult to differentiate clinical signs from those of *Strep. uberis* infection. Less research has been done as they are less prevalent (McDougall *et al* 2007). Between 5-15% of suspected cases of *Strep. uberis* mastitis may turn out to be *Enterococcus* spp. when fully speciated (Salmon *et al* 1998).

Characteristic	*Streptococcus uberis*	*Escherichia coli**	*Enterococcus* species
Duration of infection	The majority of infections are short-lived but a proportion (up to 10%) can become chronic (McDougall *et al* 2004). The median duration of subclinical infections was found to be 16 days but different strain types could cause infections within the same cow over a lactation, so many infections appear to last longer than 1 month.	*E. coli* can grow exponentially in the udder, leading to quick onset of clinical signs. The bacteria are shed in the first 6-12 hours of clinical signs, reducing thereafter, with endotoxins remaining that cause ongoing inflammation. Most infections are of short duration, with more than 50% lasting less than 10 days but some (1-2%) can last for more than 100 days. Cases may be culture negative because the cow has already eliminated the bacteria.	Most infections are short-lived but a small percentage may become chronic.
Cow Somatic Cell Counts (SCC)	Most infected cows have elevated SCC. Some can be extreme (>10,000,000 cells/mL) and may result in increases in the bulk milk SCC (**BMSCC**).	Cow SCC rapidly increases following infection and persists for about two weeks. In chronic cases SCC tend to be high (about 500,000 cells/mL) although they can fluctuate.	The SCC will be elevated in infected cows.
Milk quality	*Strep. uberis* infections, if undiagnosed, can impact the BMSCC. In extreme cases, they may impact the bulk milk total plate count or Bactoscan.	Clinical and chronic coliform cases may not contribute significantly to BMSCC but can cause coliform grades in the bulk milk (Malcolm 2023).	Bacteria are not usually isolated from bulk milk.
Management during outbreaks	Adjust springer mob feeding levels to reduce 'bagging up' and milk leakage pre-calving. Manage calving cows to minimise exposure to contamination. Back fence if practical and move freshly calved cows onto clean pasture. If possible, use sand rather than organic materials for calving pads. For cows with very tight udders or leaking milk prior to calving, consider milking and disinfecting teats. Improve pre-milking hygiene by cleaning and drying teats before attaching teat cups. Use ITS at the next dry period to prevent new infections.	Manage cows to minimise exposure to contamination. The source of udder contamination should be sought and corrected e.g. feed-pads and stand-off pads, laneways and access to waterways, calving paddocks. Recent changes in feeding management should be reviewed. Improve pre-milking hygiene. Overseas, vaccination with J-5 vaccines in the dry and early lactation periods reduces the severity of many *E. coli* infections but remains of doubtful value for NZ herds.	Control measures are similar to *Strep. uberis* and include good hygiene of teats and udders before calving, milking clean, dry teats, good post milking teat disinfection and use of ITS at dry off.

* *Escherichia coli* infection is often called 'coliform mastitis', but such infections can also be due to *Klebsiella* spp. or *Serratia* spp.

Characteristics of increasingly common environmental mastitis pathogens

Characteristic	*Klebsiella* species	*Serratia* species	*Prototheca*	Yeasts and Moulds
Reservoir of infection	Sawdust or organic bedding material used on loafing pads, calving pads or indoor housing can harbour high numbers of these bacteria. Cows grazed with access to muddy, wet, marshy areas and pools of standing water are also at risk. Many healthy adult cows shed *Klebsiella* in their faeces so any bedding contaminated with manure can contain *Klebsiella* (Zadoks *et al* 2011).	Source of infection can be from soil and plants (environmental). It can survive if present in water used to mix chlorhexidine-based teatspray. Muddy, wet, marshy areas and pools of standing water pose another risk to grazed cows. Spread during milking has been reported (Isaksson & Holmberg 1984). Damaged teat ends increase risk of infection.	*Prototheca* is an alga so can be found in soil, plants, streams and stagnant ponds, faeces, sheds and yards. Infection may be introduced into the udder through direct contact with contaminated water/soil or with intramammary treatment if teat ends are not dried or prepared aseptically.	Fungi (yeasts and moulds) can be isolated from many sites in the environment, including feedstuffs (Williamson & di Menna, 2007). Contaminated intramammary tubes or materials can be a source if teat ends are not dried or prepared aseptically.
Spread	Primary sources include faecal material and the environment	Infections can be spread via contaminated teat disinfectant or sourced from the environment. They can also be spread cow to cow via the milking machine.	*Prototheca* can also be spread cow-to-cow (Gonzalez 1996; Moroni *et al* 2015).	Yeast does not spread contagiously.
Risk of infection	Cows are most susceptible in early lactation. Most of the risk is for housed cattle (Zadoks & Munoz 2007).	Infection rates are highest over the dry period and usually develop into a chronic infection.	Cows are susceptible at any time during lactation or at dry off.	Unhygienic infusion of mastitis treatments in lactation or at dry off, or use of a feed pad are risk factors for new infections by yeasts and moulds.
Clinical signs	The bacteria can cause a sudden and severe toxaemia where cows may develop a high temperature and may become recumbent and die. Similar to *E. coli*, these bacteria do not usually invade udder tissue – toxins cause the damage. Quarters usually return to part production in the same lactation (Gröhn *et al* 2004).	Many *Serratia* infections are subclinical and characterised by high somatic cell counts in infected quarters, but clinical mastitis may occur. Clinical signs are most often mild. Cows are rarely systemically ill. Infections tend to be chronic and clinical signs may be intermittent.	*Prototheca* can cause clinical mastitis as well as chronic, subclinical infections.	Yeasts can cause clinical mastitis as well as chronic, subclinical infections.

Characteristic	*Klebsiella* species	*Serratia* species	*Prototheca*	Yeasts and Moulds
Duration of infection	Cows that survive clinical *Klebsiella* mastitis often develop chronic mastitis, more so than for *E. coli*. Milk may appear normal, but SCC are high, and repeated clinical cases may occur. Cows with chronic *Klebsiella* mastitis are often culled for high cell count, recurrent mastitis or production loss.	Shedding in milk has been documented from 55 days to over 5 months in duration (Todhunter *et al* 1991)	*Prototheca* can be shed in milk and passed from cow to cow. *Prototheca* does not respond to antibiotic treatment.	Yeasts and moulds are not sensitive to antibiotics, and such infections can be exacerbated by antibiotic use. Infections by these organisms can become chronic.
Cow Somatic Cell Counts (SCC)	Cell counts are generally high, consistent with chronic mastitis.	Many *Serratia* infections are subclinical and may be characterised by elevated SCC in the infected quarter. Clinical mastitis may occur in infected animals.	*Prototheca* can cause high cow SCC due to their poor response to antibiotic therapy.	Yeasts can cause high cow SCC due to their poor response to antibiotic therapy.
Milk quality	Cases are often clinical and their milk is excluded from the bulk milk.	*Serratia* may be intermittently shed by infected cows and therefore may not be detected through culture or in bulk milk consistently.	*Prototheca*, being an alga, will not be detected by a standard plate count but may be detected by Bactoscan.	Yeasts do not usually affect milk quality but may be detected in bulk milk cultures.
Management during outbreaks	Remove cows from sources of mud, manure, dirt, soiled organic bedding (Moroni *et al* 2015). Reduce stocking density if cows are housed and improve pre-milking teat hygiene. Consider segregating and/or culling infected cows because response to therapy is poor (Zadoks & Munoz, 2007).	Remove risks due to poor hygiene and environmental contamination of teat ends. Improve pre-milking teat hygiene. Check for contamination of the teat spray and change to an iodine-based product if using chlorhexidine. Some success with treatment with non-beta-lactam antibiotics has been reported (Munn *et al* 2024). Culling remains the more appropriate option in the long run.	Culling or drying off infected quarters of infected cows is the only way to manage these infections. Once infected, cows should be identified and milked last to reduce risk of spread. Minimise access to muddy and wet areas and review intramammary treatment technique.	Culling or drying off infected quarters of infected cows is the only way to manage these infections. Once infected, cows should be identified and milked last to reduce risk of spread. Review sources of contamination of teat ends, and review intramammary treatment technique.

Characteristics of less common environmental mastitis pathogens

Characteristic	*Pseudomonas aeruginosa*	*Trueperella pyogenes*	*Bacillus cereus*	*Nocardia* species
Reservoir of infection	These bacteria are common in the environment – in places such as water sources and ponds. It can colonise water hoses and hot water systems and is resistant to some sanitisers.	These bacteria are common in the environment.	These bacteria are common in the environment and form heat- and chemical-resistant spores	These bacteria are common in soil. They can also survive in chlorhexidine-based teat disinfectants.
Spread	Spread is from contaminated water, either in the environment or water used to wash teats. Infection may be introduced into the udder with intramammary treatment if intramammary tubes are immersed in contaminated water or teat ends are not prepared aseptically.	Occasional individual cases may be associated with teat or udder injury. These bacteria are one of a mix of bacteria causing 'summer mastitis' described in Europe and spread by flies.	Infection may be introduced into the udder with intramammary treatment if teat ends are not prepared aseptically. Mastitis has been associated with feeding heated brewer's grain containing spores.	Infection may be introduced into the udder with intramammary treatments if teat ends are not prepared aseptically. Spread can be by contaminated water used to wash teats or in contaminated teat disinfectant. Spread from cow to cow at milking is possible.
Risk of infection	Cows are susceptible during milking and whenever intramammary infusion takes place.	Dry cows are more at risk of infection.	Risk of infection increases during udder infusion.	Infection occurs sporadically.
Clinical signs	Cases range from a mild to a severe acute form with septicaemia and death. Affected cows do not respond to treatment. If infection occurs after administering antibiotic DCT and/or ITS at dry off, cows may become very sick.	Infection commonly causes a severe mastitis. Typically, the quarter is hard, the teat is often very swollen, and secretions may consist of thick pus. Function may be permanently lost in affected quarters and teat obstruction following inflammation is common.	Mild to peracute forms. Haemorrhage and gangrene can occur. If infection occurs after administering DCT, clinical signs may not be seen until next calving.	Although cows are sometimes sick, infection is rarely fatal. Affected quarters are usually swollen or hard with lumps. Lumps may rupture and discharge to the surface. Infected cows do not respond to treatment. **WARNING**: Take care when handling infected cows as *Nocardia* species can cause respiratory infections in people.

Characteristic	*Pseudomonas aeruginosa*	*Trueperella pyogenes*	*Bacillus cereus*	*Nocardia* species
Duration of infection	Cases are usually chronic and unresponsive to therapy. Generally low numbers of bacteria are shed, with intermittent shedding in chronic cases.	Cases are usually chronic and unresponsive to therapy. Large numbers of bacteria are passed in the secretion.	The bacteria may be a contaminant of milk samples. Clinical cases should be identified from repeat cultures.	Bacteria in fresh milk may not survive refrigeration or freezing of the sample, so culture samples should be plated promptly.
Cow Somatic Cell Counts (SCC)	Cell counts are generally >500,000 cells/mL in chronic infections.	Secretions are usually not suitable for measuring SCC.	Cell counts are usually very high.	Cell counts are usually very high.
Milk quality	Milk supply can be contaminated by water sources. These bacteria may cause milk spoilage.	Cases are usually clinical and their milk is excluded from the bulk milk.	Cases are usually clinical and their milk is excluded from the bulk milk.	Bacteria can be recovered from the bulk milk. This represents a potential milk quality hazard because the organism may not be killed by pasteurisation.
Management during outbreaks	It is important to assess the intramammary technique being used and management of cows immediately after treatment. Affected cows do not respond to available antibiotics. Culture of water sources is often unrewarding, while changing water hose rubberware is often useful. Identification of infected quarters may require repeated culture. Positive cows should be culled.	In countries where 'summer mastitis' is common, careful management during the dry period (e.g. locating cows in low-risk paddocks) is essential. It can occur in areas with hot, humid summers. Improved fly control is recommended if there is a herd problem. Assess intramammary infusion technique, as poor technique can be a risk factor. Teat damage is also a risk factor.	It is important to assess the intramammary technique being used and management of cows immediately after treatment.	It is important to assess the intramammary technique being used and management of cows immediately after treatment. Affected cows do not respond to available antibiotics. Culture of water sources is often unrewarding. Assess the sterility of teat disinfectant. Infected cows should be culled. **WARNING**: Human infections are possible.

② Calve in clean, dry environments to minimise bacterial exposure

The udder is highly susceptible to new infection at calving, and many early-lactation infections originate at this time (Smith *et al* 1985; Hogan & Smith 1998; Parker *et al* 2007). Ideal calving areas are well-drained, sheltered paddocks with good grass cover, free from irrigation, dairy effluent, and mud. However, many New Zealand farms rely on calving paddocks or pads where cows can be supervised easily especially in areas of high rainfall.

If possible, heifers should be calved separately from the adult herd. Heifers are more likely to be bullied and be forced to calve in the less suitable areas of the calving paddock or calving pad.

Grazing management

Pasture contamination with environmental bacteria, especially *Strep. uberis*, is primarily driven by grazing. Key recommendations include:

- **Use back-fencing** to restrict access to recently contaminated areas.
- **Increase grazing area** in wet weather, to reduce stocking density.
- **Allocate pasture to springer mobs** to minimize pugging and udder contamination.
- **Shift calved cows (<12 hours)** and those close to calve into a clean break.

Planning is needed to maintain access to drinking water. Consider using mobile troughs and laneways. When cows are calving on grass it is also important to ensure prevention of metabolic disease.

Alternative arrangements

Where pasture calving is impractical, farmers may use loafing pads, calving pads, stand-off pads or indoor housing, all of which can increase risk of environmental mastitis (Washburn *et al* 1992; Lacy-Hulbert *et al* 2002). Drainage and bedding selection are key factors for reducing udder contamination and risk of mastitis, especially in composting barns.

- Organic bedding (straw, post peelings, shavings or sawdust) support higher bacterial loads than non-organic bedding (washed sand, ground limestone).
- Coarser materials (e.g. long straw or shavings) are preferable to more finely chopped or ground organic material (e.g. chopped straw or sawdust), by reducing the surface area for bacterial attachment and growth (Hogan & Smith 1998)
- Straw may contain high loads of environmental streptococci, such as *Strep. uberis* (Bramley 1982, Smith & Hogan 1997) whereas sawdust and other wood products may contain high levels of coliform bacteria, such as *Klebsiella* spp., even when fresh (Hogan *et al* 1989). Kiln-dried sawdust has lower counts.
- Daily replacement of contaminated sawdust with fresh sawdust is more effective than weekly replacement at maintaining lower counts (Bramley 1992). Sawdust should not be used as bedding if it cannot be kept dry (Blowey & Edmonson 1995)

All bedding materials (organic and inorganic) rapidly develop high pathogen counts once contaminated with manure (Blowey & Edmonson 1995). Regular removal and replacement and effective drainage are essential. Chemical disinfection of bedding with agricultural or hydrated lime or formalin, is not effective (Hogan & Smith 1998).

Rubber mats are easier to keep clean but can harbour bacterial films. Concrete or concrete slats are easier to keep clean but not suitable for calving. Cows maintained on concrete for 12 hours or more per day for more than three days should be given at least one full day on an alternative surface where they are free to lie down and rest (NAWAC, 2019).

The best indicator of environmental mastitis risk is checking for faecal contamination on the teats and udders of freshly calved cows. A practical rule of thumb for calving areas is:

- no more than two pats of manure per square metre and
- no water visible in hoof or foot prints.

Both criteria serve as crude but effective indicators of hygienic conditions and teat contamination risk.

Options for surface types, in preferred order (highest to lowest) are:

- The best clean, grassed paddocks with minimal surface water
- Well-drained inorganic material, such as sand
- Well-drained organic material.

➜ See the DairyNZ website for more information on off-paddock infrastructure or **MPI.govt.nz** for a copy of the Animal Welfare code.

③ Monitor number of mastitis cases in recently calved heifers

Mastitis in recently calved heifers (first calvers) is an indicator of pre-calving management. Infections may occur any time from puberty through to the few weeks immediately before calving, or during the calving process itself (Compton *et al* 2007a).

Strep. uberis mastitis was observed at calving for:

- 8% of first-calf heifers across 11 herds (Pankey *et al* 1996).
- 13-23% of heifers and 13% of cows in more recent studies (Compton *et al* 2007a; McDougall *et al* 2007).

Most cases are due to environmental streptococci (68% of cases; Pankey *et al* 1996). Heifers may be particularly susceptible because they:

- calve more slowly and spend more time on the ground,
- may leak milk prior to calving (Waage *et al* 2001), and
- may suffer from udder oedema, which can reduce teat and udder defences to resist bacterial challenge (Slettbakk *et al* 1995; Compton *et al* 2007b).

Studies (Slettbakk *et al* 1995, Waage *et al* 1998, Compton *et al* 2007a, b, Parker *et al* 2008, McDougall *et al* 2009) report key risk factors for *Strep. uberis* infections as:

- breed (Friesians are more at risk than other breeds),
- difficult calving and/or retained placenta,
- milk leakage prepartum,
- short teat end to ground distances,
- dirty udder,
- high milk flow rate,
- large herd size and higher levels of herd production,
- high stocking density,
- peripartum nutritional management.

➜ **Technote 2** describes strategies for reducing mastitis in first calving heifers.

The **"trigger for action"**, using the median performance of New Zealand herds, defines a calving period trigger (two weeks pre- to two weeks post- calving) as 5 clinical cases per 100 calvings.

If clinical case rates exceed this threshold, review the calving environment and management, ideally with support from an independent adviser, to provide a 'fresh pair of eyes'. Note that a high rate of mastitis at calving may reflect infections acquired earlier but only became clinical at calving.

➜ The DairyNZ **Mastitis Focus Report** can calculate these indicators if clinical case treatment records and cow SCC records are available in herd improvement systems.

④ Bring newly calved cows in for milking as soon as possible after calving

Pankey *et al* (1996) reported that many 'over-conditioned' heifers leaked milk prior to calving and had a higher prevalence of mastitis. They proposed that improved heifer management around calving period could reduce new intramammary infections, recommending:

- minimising exposure to muddy conditions;
- milking heifers as soon as possible after calving; and
- applying an effective teat disinfectant after every milking.

Subsequent research has tested these strategies. Milking newly calved heifers earlier, on average 9 hours after calving compared with 19 hours, reduced the risk of clinical mastitis by 45% Compton & McDougall 2008). This was achieved by ensuring newly calved heifers were brought to the dairy twice daily, rather than once.

Pre-calving teat disinfection has also been investigated. Applying teat spray to heifers three times weekly before calving reduced *Strep. uberis* recovery from teat swabs and tended to reduce incidence of *Strep. uberis*-associated clinical mastitis but did not reduce total clinical mastitis incidence (Lopez-Benavides *et al* 2009).

Although these studies focused on heifers, early calf removal and pre-calving teat disinfection are likely to confer similar benefits for older animals.

➜ **Technote 4** describes how to check udders and milk from quarters of freshly calved cows.

⑤ Maintain udder hygiene to prevent mastitis risk

Keeping teats and udders clean helps reduce the number of bacteria around the teat end, which is an important step in preventing mastitis (Schreiner & Ruegg, 2003). Keeping udders clean is easier if the tail switch is kept well-trimmed, if the udder is kept clean and if the legs are kept free of dirt and manure.

Tails should be trimmed before dry-off and again at the first milking after calving. Dirty teats should be washed with a low-pressure hose and hand scrubbed before milking, ideally with drying, when in the colostrum herd. Some farmers report that use of teat spray before milking is helpful for improving teat condition, but only whilst cows are in the colostrum mob, and the milk is being discarded.

➜ **Technote 5** describes good milking technique, including pre-milking teat preparation, and the importance of consistent routines.

⑥ Fix areas that make udders dirty

The risk of environmental mastitis is greatly increased when cows are held for long periods in wet, muddy areas. Congregation of cattle in paddocks, on farm tracks and races, on feed pads and other structures can increase exposure to environmental bacteria as well as reduce the health of teat skin.

If keeping cows in dirty areas is (likely to be) unavoidable, make sure that:

- Teats of lactating cows are washed and dried before attaching cups
- Dry cows are protected by internal teat sealant at dry off.

Strep uberis

Humid conditions, especially after rain, promotes environmental mastitis by increasing udder contamination with mud and faeces, creating ideal conditions for bacterial growth (Blowey & Edmondson 1995; Lopez-Benavides *et al* 2007).

On New Zealand dairy farms, *Strep. uberis* levels in the environment are highest in winter and early spring, coinciding with peak infection rates. Contamination is greatest on cow tracks, races, and areas where cows congregate (e.g., under trees, near gateways) (Hillerton & Berry 2003).

Mud-prone areas like feed pads, gateways, and dairy entrances pose significant risk. Prolonged standing on yards or races exacerbates exposure. Improved cow flow and strategic use of concrete can help mitigate these risks.

***E. coli* and other coliform bacteria, yeasts and algae**

The risk of mastitis with these environmental pathogens increases when teats are exposed to direct faecal contamination or contaminated water. Farms using feed pads to feed more than 40% of the diet have experienced more infections caused by *E. coli* and other environmental bacteria (Lacy-Hulbert *et al* 2012). Feed pads, stand-off pads and indoor systems require good management and maintenance of the surface materials to ensure that the benefits of such systems are not outweighed by the increased costs of mastitis, and also lameness (Laven & Holmes, 2008).

Short-term management solutions for gateways and races

Proactive management can reduce the mastitis risk in the short term:

- Temporarily fence off muddy areas under trees or in wet areas.
- Reduce mud around paddock gateways by alternating between two or more gateways into the same paddock or stabilisation of these areas with gravel or lime if the soil type is suitable.
- Remove mud and slurry on farm races regularly using a scraper blade.
- Plan grazing management so that paddocks spread with farm dairy effluent are not grazed again for at least for 3-4 weeks. Studies have found that *Strep. uberis* remains on the soil for up to 4 weeks after spreading of effluent in winter, but only 1-2 weeks in summer (Lopez-Benavides *et al* 2007).
- Wash and dry dirty teats before applying teat cups to minimise environmental mastitis when it is unavoidable that teats become dirty.
- Protect dry cows with ITS at drying off if grazing in muddy areas e.g. on crops, is highly likely in the dry period.

Long-term considerations for feed pads and housing

Feed pads must be carefully designed to reduce mud, particularly when the pad is covered for shade or protection from rain, and the drying and sanitising effect of sunlight is lessened.

For covered feed pads and barns, effluent management, choice of bedding materials, and size and configuration of lying areas or cubicle systems all contribute to lying behaviours, which in turn affects cleanliness of the udder and legs. Resources are available to support design of these systems.

➜ The **DairyNZ Dairy cow housing guide** provides useful tips and reminders for planning and building dairy cow housing.

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Technote 2

Taking care with heifers

In this technote:

1 Strategies to reduce heifers mastitis

The following strategies have **proven effective** in reducing mastitis at and around calving in first-calving heifers.

1. Internal teat sealants before calving

Infusing an internal teat sealant (**ITS**) into heifer glands ~1 month pre-calving significantly reduced mastitis risk (Parker *et al* 2007; 2008). In a study of 255 heifers across 5 herds, ITS lowered post-calving *Streptococcus uberis* intramammary infection (**IMI**) by 84% and clinical mastitis by 68% (Parker *et al* 2007). A larger trial with 1000 heifers across 30 herds showed a 65% reduction in post-calving IMI, 70% reduction in *Strep. uberis* infections in previously infected quarters, and 70% lower clinical mastitis incidence (Parker *et al* 2008).

Use of ITS at 35 or 75 days pre-calving showed similar mastitis risk reduction in barn-managed US heifers (Larsen *et al* 2021). A retrospective New Zealand study also linked ITS use to lower SCC and increased milk yield (Robertson *et al* 2017).

The teat sealant provides a form of physical or chemical barrier in the teat canal that prevents bacterial invasion or colonisation (Notcovich *et al* 2020). It may also reduce the incidence of milk leakage pre-calving, which is itself a risk factor for mastitis in heifers (Waage *et al* 1998). Milking staff need to be aware that flecks of teat sealant may persist in milk for some weeks after calving (Berry & Hillerton 2002) and may be incorrectly diagnosed as cases of clinical mastitis.

Good hygiene at the time of application is imperative and some veterinary practices provide technicians to perform the task. For herds with an above average rate of heifer mastitis (**5% or more heifers clinical at calving**), this approach becomes cost effective.

2. Applying teat spray before calving

Applying teat spray at any time prior to calving, such as when heifers are trained for milking in the farm dairy, is likely to have a beneficial effect at reducing bacterial numbers on teats and improving teat skin condition.

When tested for reducing mastitis in heifers at calving, application of an iodine teat spray three times weekly for at least 3-weeks prior to calving reduced the prevalence of subclinical mastitis by

Strep. uberis at the first milking after calving (Lopez-Benavides *et al* 2009). When tested across 6 New Zealand farms and 397 heifers, they observed 50% less cases of clinical mastitis by *Strep. uberis* for sprayed heifers, although the incidence of clinical mastitis by all pathogens was not significantly reduced.

3. Removing calves within 12 hours of calving

Picking up calves twice a day instead of once a day has practical benefits for mastitis in heifers. Reducing the interval between calving and first milking from 19.5 to 9.8 hours significantly lowered the prevalence of clinical and subclinical mastitis in heifers (Compton & McDougall 2008a). Across 4 herds and 480 heifers, twice-daily removal and immediate milking of freshly calved heifers led to 45% fewer cases of clinical mastitis compared to once-daily removal and delayed milking. Heifers milked earlier also showed less udder oedema. Farmers noted practical benefits, including less mis-mothering and easier management of smaller calving groups.

Other strategies that are likely to be helpful (McDougall *et al* 2009) include:

- Minimising the risk of dirty udders by managing pasture allocation following rain.
- Minimising the risk of dystocia or retained foetal membranes.
- Maintaining physically separate heifer and cow mobs pre- and post-calving.
- Pre-calving milking, although this may increase the risk of a negative energy balance through the pre-partum period.

The following strategies have been tested and proven ineffective, or inappropriate, for New Zealand conditions:

1. Antibiotic treatments before calving

Nickerson (2009) reviewed US studies on intramammary antibiotic infusions in heifers. A single treatment of dry cow antibiotic therapy into infected glands during gestation achieved *Staphylococcus aureus* cure rates of 67-100%, but benefits were mainly seen in herds with high prevalence. Pre-calving infusions with lactating cow antibiotics 1-2 weeks before calving showed moderate success (59-76% cure vs. 26-31%), although improvements in SCC and milk yield were not consistent. These approaches offered limited protection against environmental pathogens.

2. Parenteral treatment at calving

Treatment by injection with 15 million IU micronised procaine penicillin at the first milking after calving was compared with no treatment, across three herds and 597 heifers. Treatment reduced the odds of clinical mastitis within the first 7 days by more than 50% and mastitis within the first 100 days by nearly 50% (Bryan & Taylor 2009).

In another study, across 967 heifers and 17 commercial herds, treatment with 15 million IU micronized procaine penicillin within 7 days prior to calving resulted in a 30% reduction in risk of clinical mastitis within the first 21 days after calving. The greatest benefit was observed when the treatment was administered on the day of calving (Williamson & Lacy-Hulbert 2010).

In New Zealand, use of antibiotics prior to calving in heifers represents an off-label approach. These practices are not recommended, due to the high cost of treatments and risks of inhibitory substance residues in the colostrum or milk after calving.

3. External teat sealants before calving

External teat sealants are non-irritant latex, acrylic or polymer-based films that are applied like a teat dip to produce a layer over the teat end and were designed to prevent entry of bacteria into the teat canal. However, they only remain present for around 7 to 10 days and require weekly reapplication.

Overseas studies observed that when applied around 10 days pre-calving, external sealants reduced IMI prevalence by 19%, major pathogen IMI by 40%, and environmental streptococci by 50%, with no significant effect on coagulase negative staphylococci or Gram-negative IMI (Timms 2001).

In New Zealand studies, twice-weekly application pre-calving of external teat sealants reduced overall IMI by 27% and major pathogen IMI by 36%, but did not significantly affect clinical mastitis rates (McDougall *et al* 2008).

4. Nutritional Strategies

While there is evidence that nutrition pre-calving influences the risk of mastitis (Waage *et al* 1998), increasing hay intake pre-calving did not reduce the incidence of clinical mastitis under New Zealand management systems (Compton & McDougall 2008b).

Supplementation with selenium also showed no benefit in otherwise Se-replete heifers (Compton & McDougall 2008a).

Use of ionophores (e.g. lasalocid sodium and sodium monensin) to change the bacterial microflora of the rumen led to reductions in risk of ketosis and less udder oedema but these changes did not translate into significant reductions in mastitis in heifers at calving (McDougall *et al* 2008).

For reducing the risk of mastitis in first-calving heifers:

1. Use of an ITS prior to calving (minimum 3 weeks) before planned start of calving has shown the most dramatic results in the field.
2. Farmers who are able to implement twice daily collection of calves are finding benefits for both cow and calf health.
3. Application of teat spray pre-calving is always of benefit, if it is practical for an individual farm situation.

② Select the pre-calving heifer strategies that are most suitable for the herd

Teat sealants have proven to be the most effective and practical solution, especially in herds where case rates are above 5%. Considerations include access to trained technicians to administer treatments, and availability of infrastructure to operate safely.

The main alternative approach focuses on twice-day pickup of calves and prompt milking of heifers, and/or with application of teat spray prior to calving. Early removal of calves can also provide significant welfare benefits for the calf if this is coupled with feeding or tubing with 'gold' colostrum to prevent failure of passive transfer of immunoglobulins and antibodies (Denholm *et al* 2017; Mason *et al* 2022).

Choice of strategy for an individual herd will vary, depending on a combination of factors, which include:

- Gap in performance between usual incidence of clinical mastitis for first-calving heifers and industry targets.
- Costs, potential risks and likely benefits of each approach.
- Availability of infrastructure for safe administration of ITS to heifers, 4 weeks before planned start of calving.
- Labour availability to pick up newly-born calves twice per day and bring newly-calved heifers in to be milked.
- Opportunities to allow heifers' teats to be teat sprayed regularly (2-3 x per week) in the last 3 weeks before planned start of calving.

⚠ The "trigger for action" is that herds experiencing more than **5 cases of clinical mastitis within 2 weeks of calving, per 100 heifer calvings** should consider ways to reduce heifer mastitis more proactively.

➜ The DairyNZ **Mastitis Focus Report** can calculate the incidence of clinical mastitis among heifers in the calving period (14 days before and 14 days after calving) if clinical case treatment records and cow SCC records are available in herd improvement systems.

③ Familiarise heifers with the farm dairy pre-calving

It takes about two weeks for most heifers to establish a quiet, reliable response to milking. To maximise production and minimise risk of injury to milkers and animals, milking staff must be patient and as gentle as possible during this period.

Extra labour may be required for the calving period in seasonal herds. Training heifers by moving them through the milking area pre-calving was found to reduce difficult behaviour post-calving (Eicher *et al* 2007) although wide variation is observed between individual animals (Bremner 1997).

➜ **Technote 5.2** describes how to ensure cows enter the farm dairy willingly.

④ Udder oedema: recognition and management around calving

Udder oedema is a swelling that occurs under the skin of the udder, and sometimes along the belly, in cows prior to calving. It mostly occurs in heifers at their first calving, but can occur at subsequent calvings, and is commonly observed during late pregnancy and early lactation. It is a significant risk factor for mastitis (Compton *et al* 2007).

Oedema largely results from compromised fluid drainage from the udder and the surrounding areas. A small amount of oedema is a normal (physiological) occurrence as the blood supply to the udder increases and changes during the period before calving.

In most cases the oedema disappears within a day or two of calving but, in severe cases, it can interfere with milking. Once milking is started, the volume of the udder is reduced, and the oedema is usually cleared. Veterinary advice should be sought if cows are very uncomfortable.

Prior to calving, the only option for treating cows and heifers with oedema remains to start milking them. Save the colostrum for their calf or make alternative arrangements. No diuretics (either oral or systemic) are available for lactating cattle in New Zealand.

Factors that may lead to high numbers of animals with udder oedema or increased severity of cases include:

- excessive feeding immediately prior to calving,
- excessive dietary sodium or potassium,
- over-fat heifers, and
- hereditary predisposition to oedema.

Advice on heifer nutrition should be sought to ensure that the diet does not contribute to severe oedema.

A review of risk factors highlighted the welfare significance of udder oedema and associations with genetic predisposition and dietary intake of anionic salts or antioxidants (Okkema & Grandin, 2021). Curiously, Melendez *et al* (2006) identified more oedema in Holstein heifers that calved in winter vs summer, gave birth to male vs female calves, or were taller than their herd counterparts, in one US herd. The relevance of these findings for New Zealand herds has yet to be determined.

5 Managing milk let-down in heifers

Ensure that all heifers have a milk let-down response at each milking after calving. The injectable form of the let-down hormone, oxytocin may be recommended for heifers that are taking time to establish a good let-down response.

Use of oxytocin can be prescribed by a veterinarian for animals described in the farm's Animal Health Treatment plan. Such animals may include:

- Cows or heifers that have not had a full let down within 24 hours after calving
- Cows or heifers that have severe udder oedema preventing proper milk let down.

Use of oxytocin as a general treatment for helping heifers to establish a milk let-down response is unproven. No advantage, in terms of less mastitis or increased milk production were observed, when the effect of oxytocin, administered at each milking for the first 5 days after calving, was compared with normal milking routine across 536 heifers on three commercial farms (Williamson & Garrett 2010).

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Technote 3

Managing withholding periods, residues and milk quality at calving

In this technote:

For milk quality reasons, and to manage residues from products used at dry-off, colostrum from all cows must be withheld from the vat for the first eight milkings after calving. First-lactation heifers may have higher levels of colostrum for longer so their milk may need extended withholding (10 milkings). Screening cows on their 4th day after calving using the Rapid Mastitis Test (**RMT**) helps identify animals that could elevate the bulk milk SCC (**BMSCC**) and increase risk of grading.

Withholding periods for milk, cull cow and calf meat need to be observed for cows that receive antibiotic Dry Cow Treatment (**DCT**). Withholding periods for milk (96 hours or eight milkings) also need to be observed for cows that receive Internal Teat Sealants (**ITS**). Each quarter treated with ITS should be foremilk stripped for 10-12 strips to remove residual teat sealant, although flecks of teat sealant may continue to be excreted for the next few days (Kabera *et al* 2018; Swinkels *et al* 2024).

① Dry cow therapy: Withholding periods and residue management

Products at dry-off

Antibiotic DCT are antibiotic preparations infused into each quarter of an udder immediately after the final milking of lactation. They are formulated to maintain concentrations above the minimum inhibitory concentration for mastitis bacteria for 30-50 days, depending on the product used.

➜ **Technote 14** describes the process for deciding the most appropriate dry cow strategy for an individual herd.

Internal Teat Sealants are non-antibiotic preparations that contain bismuth subnitrate and can be infused after the last milking, either alone, or after a tube of antibiotic DCT. Sealant formulations are designed to remain in the teat sinus for the entire dry period, acting as a physical and chemical barrier to bacterial entry through the teat canal. They remain soft and pliable within the udder and are removed naturally by the calf or by manual stripping after calving. Approximately 10-12 hand-strips are recommended to remove the product, before the first machine milking.

Withholding periods

Withholding periods refer to the *minimum* period of time that must elapse between the last treatment of an animal with a veterinary medicine and the supply of products (meat or milk) from those animals for food consumption, and are set following regulatory confirmation of the time required to comply with relevant New Zealand Maximum Residue Levels (**MRL**). The length of time that meat must be withheld is usually longer than the withholding period for milk.

When using antibiotic DCT, there are two principles relating to withholding milk that must be well understood:

1. All antibiotic DCT products are registered with a specified Minimum Dry Period after treatment, also referred to as the pre-natal treatment interval or **PNTI**. This is the withholding period that must elapse before products can be supplied for food consumption. Ideally, this would occur before the cow calves.
2. As well as the PNTI, all antibiotic DCT and ITS products have a recommended withholding period or **WHP** for milk. This is the time that must elapse after calving (rather than after treatment), before milk is supplied for processing. This is usually 8 milkings.

Milk withholding periods:

Withholding periods on the label will take the form of: PNTI + post-calving withholding period, e.g. "49 days + 8 milkings". If a cow calves before the PNTI elapses, the milk must be withheld until the entire PNTI period has elapsed plus the full 8 milkings.

Cull cow meat withholding period:

The withholding period for meat applies from the date that the cow is treated with an antibiotic DCT.

Bobby calf meat withholding period:

The likelihood of antibiotic residue in bobby calf meat depends on (1) the absorption of antibiotic from the mother's bloodstream (Rangel-Lugo *et al* 1998) and (2) the intake of antibiotic from colostrum. Limited information is available on antibiotic residues in calves born to cows given antibiotic DCT.

To minimise the risk of antibiotic residues being detected in bobby calves, a conservative approach is recommended:

- **For calves born after the PNTI has elapsed**, calves are likely to contain only traces of antibiotic, sourced from the dam's bloodstream or from suckled colostrum, so no meat withholding period is specified, although at least four days must elapse between their birth and slaughter for animal welfare regulations.
- **Calves born before the PNTI has elapsed**, and have NOT been fed milk or colostrum or suckled from the treated cow, are subject to the same meat withholding period stated on the label for the cow. The withholding period starts from the

date that the cow was treated, and the calf has to be held until this period has elapsed.

- **Calves that have consumed milk or colostrum** from a treated cow that calved within the PNTI must not be processed as bobby calves. Because calf residues in this situation would be unknown, the default meat withholding period of 91 days would apply.

➜ See the DairyNZ website for more information on feeding **colostrum** to calves.

Remember:

- If cows calve early or a decision to cull them during the dry period is made, the date of treatment and the withholding period of the particular product must be known.
- Recommended withholding periods for milk and calf meat are longer if cows calve before expiry of the PNTI.
- Ensure that the 'dry cow' paddock is well away from the milking herd so that cows given DCT or ITS cannot accidently re-join the milking herd.
- If there is any possibility that milk may contain antibiotic residue, it should be withheld from the vat.
- Ensure all treatments given at dry-off or to dry cows have been recorded.

When antibiotic DCT products are used according to directions on the label and the appropriate PNTI and withholding periods are observed, antibiotic residues will not exceed the New Zealand MRLs, set by the Ministry for Primary Industries (MPI). Each product has its own specified withholding period.

➜ Recommended withholding periods for dry cow products are updated regularly and released annually to vets via the Index of Veterinary Specialities (IVS) and are available **on the MPI website**.

Management of Inhibitory Substance grades

Every dairy processor has to manage the risk of antibiotic residues occurring in bulk milk, resulting in an inhibitory substance or "IS" grade. Increased stringency of testing (e.g. testing each tanker load of milk before it is added to the factory silo and testing of each consignment at herd level through high-risk periods of the year) has reduced some of these risks. However, good on-farm risk management procedures remain the most critical control point for minimising the risk of antibiotics in milk.

Note that early lactation is a key risk time for inhibitory substance grades due to the high incidence of clinical mastitis. To minimise the risk of antibiotics reaching the vat:

- Mark the cow, record her details, and physically separate her from those in supply before treating her with antibiotics (i.e. follow 'MRS T').
- Milk antibiotic-treated cows last and ensure thorough hot washing of the plant following milking.
- Ensure that the withholding period is met before returning the cow to supply.
- Be aware of changes in milking frequency (e.g. once a day milking) or completeness of milking out (e.g. partial milk out of cows with milk fever), which can potentially alter antibiotic removal. Avoid partial milking out unless clinically necessary.
- Avoid use of antibiotics 'off label' (e.g. a frequency, duration, or dose which is not on the label) unless there is no other alternative. Veterinarians and herd owners who choose to go 'off label' are taking responsibility for management of residues upon themselves and require appropriate documentation to support this.

Advisers should check the MPI website for up-to-date information on the maximum residue limit (MRL) for dry cow products.

Where IS grades occur, the processor will require an audit of the on-farm practices. Usually this is undertaken by a contract service provider

(e.g. QCONZ for Fonterra) and the herd veterinarian is encouraged to attend. The herd owner can become distressed as the cause is not immediately apparent. A thorough investigation by an external party will usually help pinpoint the cause of the system breakdown. See Beal (2002) or McDougall *et al* (2004) for more on factors to investigate.

Common scenarios that lead to cows within the withholding period being milked into supply include:

- Failure to physically separate treated cows from the milking mob, so that they are milked separately.
- Failure to disconnect the main milking line from the vat before milking treated cows.
- Cows that have been treated with DCT jumping from the dry mob into the milking mob.
- Cows aborting or calving within the withholding period of the DCT.
- Changes in milking frequency during treatment (i.e. once a day milking).
- Administering DCT when cows have been non-lactating for some days.

Risk factors that have been associated with IS grading (Heuer *et al* 2003) include:

- Milking later into the calendar year
- Short (i.e. <60 day) dry periods for the herd
- Use of Whole Herd DCT rather than Part Herd DCT,
- More than 2 people administering dry cow products at dry-off
- Reduced culling of cows for mastitis
- More antibiotic tubes used in the dry period for treating clinical cases,
- Sale of colostrum
- Not marking colostrum cows
- Reported lower incidence of clinical mastitis during lactation.

➜ **Technote 4** describes detection and management of clinical mastitis in early lactation. **Technote 4.9** describes tests for antibiotic residues.

② Preventing colostrum and SCC grades in early lactation milk supply

Gold colostrum, from the first milking after calving, is a thick, yellow, and sticky substance that contains very high levels of blood proteins (predominantly immunoglobulin G1, **IgG_1**) to help protect newborn calves against disease.

Gold colostrum can have an IgG_1 concentration more than 100 times greater than normal milk, but the levels rapidly deplete with each milking (Lacy-Hulbert *et al* 1996), since the active transport of IgG_1 into the mammary gland ceases at calving (Baumrucker *et al* 2021). But this washout process takes a number of milkings to complete.

Colostrum also contains large numbers of white blood cells (somatic cells) that reflect the normal shift in mammary secretory function at this time, rather than mastitis. However, these cells can release high levels of enzymes that degrade milk fat and casein molecules, and therefore affect milk processability. If mastitis is present, much higher numbers of white blood cells will be secreted in the colostrum, and the IgG_1 concentration may not reduce (Maunsell *et al* 1998).

Elevated presence of somatic cells and IgG_1 in colostrum has a significant effect on processing efficiency of all dairy products (Tsioulpas *et al* 2007; McGrath *et al* 2016). Changes in product quality include:

- Butter – a darker colour, 'off' flavours and downgrading.
- Casein – decreases in yield due to changes in curd characteristics and poor setting.
-

- Cheese – increases in setting times, poor set, decreases in yield due to lower casein levels, "off" flavours, shorter shelf life due to high moisture retention by globular proteins, and body defects.
- Condensed milk – graininess.
- Cottage cheese – agglutination of starter bacteria.
- Milk powders – increases in drying times due to high moisture retention in globular proteins, and difficulties in achieving a standard product.
- Pasteurised milk – cream plugs.
- UHT milk – shorter shelf life and deposits.
- Whey – poor crystallisation due to altered composition.

Significant cleaning problems are also associated with processing colostral milk in the factory. It requires more frequent and comprehensive cleaning of heat transfer surfaces, more down-time for dryers and evaporators, and greater use of cleaning chemicals. Reducing colostrum levels in milk has made significant improvements in processing milk to manufactured products.

Managing the risk of grading due to colostrum or SCC

Milk supplied to the factory in early lactation is tested on a per consignment basis for the presence of colostrum and SCC. Regulations set out in NZCP1 (MPI, 2024) require that milk is withheld for 8 milkings after calving.

You cannot assess milk quality by visual appraisal. It is more appropriate to withhold milk for the recommended number of milkings and to ensure that udders are being completely milked out.

Heifers

Immunoglobulin levels and SCC can take slightly longer (~24 h) to decline after calving for heifers compared to cows (Lacy-Hulbert *et al* 1996). For herds with a high proportion of heifers calving in the first few days of the calving period, it may be prudent to extend the withholding period for heifers by an extra 24 hours.

Infected cows

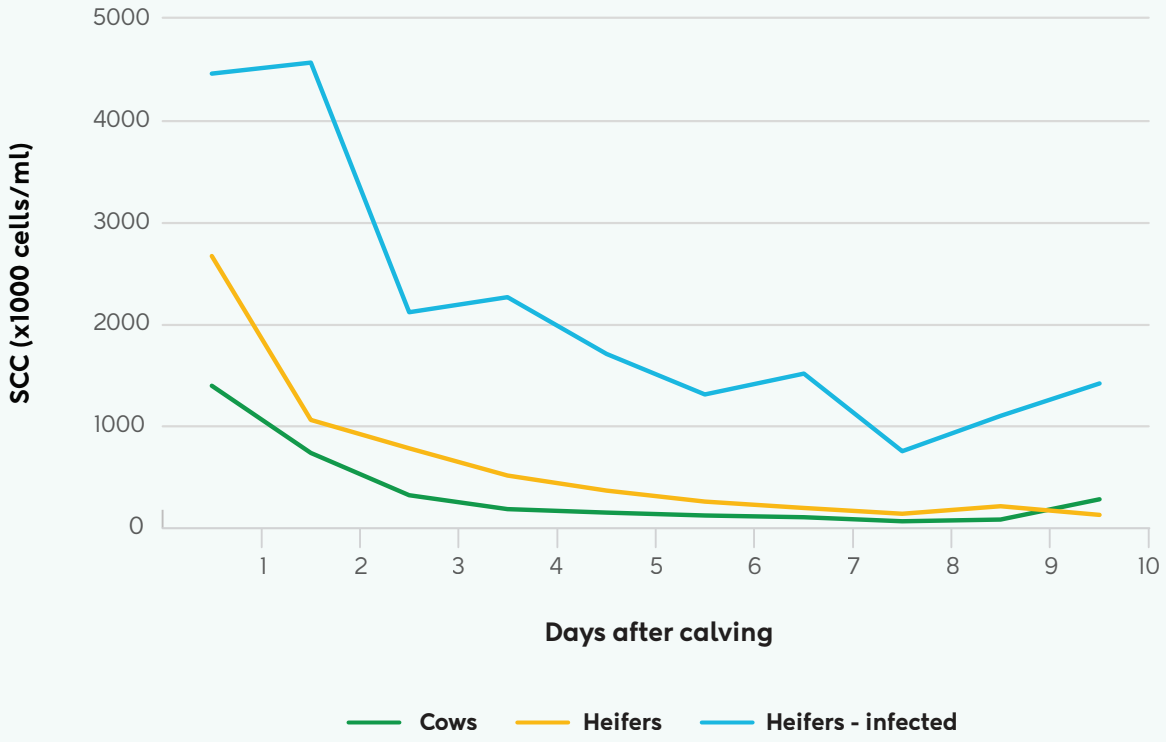
At the start of the season, when the number of cows producing milk for the vat is low (e.g. below 100 cows), cows with undetected clinical mastitis or subclinical mastitis can cause the BMSCC to increase dramatically. These increases may be sufficient to raise the BMSCC over the penalty threshold.

The SCC for cows with one or more infected glands in the colostrum period is much higher than for uninfected cows (Lacy-Hulbert 1997). Therefore, in addition to examining foremilk for signs of clinical mastitis, it is recommended that all cows are screened for subclinical mastitis using a Rapid Mastitis Test (RMT), on the last day before being transferred into the milking herd. If a positive reaction is found, milk from this cow can be withheld for a further 24-48 hours to reduce the risk of causing a BMSCC grade.

A RMT test at the 7th or 8th milking will indicate if the cow has a subclinical mastitis that may pose a SCC risk to the bulk milk.

➜ **Technote 4** describes detection of mastitis in newly calved cows.

Decline in SCC in milk for infected heifers compared to uninfected cows and heifers (Lacy-Hulbert 1997).



Milking Frequency

Many farmers now choose to milk less frequently than twice a day, for part or all of lactation, and for part or all of the herd (Eastwood *et al* 2022). This can mean that cows may be milked once a day (OAD) or three times in two days (3-in-2), from the day of calving.

Since colostrogenesis ceases at calving, the removal of IgG[1] from the udder follows an exponential curve over a few days. Williamson *et al* (2026) determined that IgG concentrations reached a constant value after approximately 80 kg of cumulative milk yield had occurred, irrespective of milking frequency. The shortest risk period for inclusion of milk into the bulk tank occurred at milking 8 (day 4) for cows milked twice daily, milking 7 (day 5) for cows milked 3-in-2 and milking 6 (day 6) for cows milked OAD.

However, to comply with regulatory requirements for supply of milk and dry cow product withholding periods (MPI, 2024), a post-calving withholding period of 4 days and 8 milkings should still be applied.

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Technote 4

Detecting and managing clinical mastitis at calving

In this technote:

1 What is clinical mastitis?

Clinical mastitis is an inflammation of the mammary gland, usually caused by bacterial infection, with associated changes to milk composition such as wateriness, clots and/or discolouration that persist for more than three squirts of milk, with or without heat, swelling, or pain in the mammary gland.

Mastitis may be categorised as:

- **mild** (i.e., only changes in milk),
- **moderate** (i.e., changes in milk and the mammary gland), and
- **severe** (i.e., changes in the milk, mammary gland and systemic signs of disease such as fever, anorexia, depression, dehydration).

Clinical mastitis remains common in dairy herds with the median lactation case rate in New Zealand being ~15 per 100 cows (McDougall *et al* 2007b). It has significant negative welfare impacts, is costly, and disrupts milking routines. Cases that are missed may markedly increase the Bulk Milk Somatic Cell Count (**BMSCC**) because they produce very high numbers of somatic cells in their milk.

The incidence of clinical mastitis is commonly highest in early lactation due to an increased risk of new infections across the dry period and immunosuppression around calving (LeBlanc 2020).

➜ **Technote 10** details how to rapidly detect and treat clinical cases in lactating cows.

Detection of clinical mastitis is improved with increased frequency of fore-stripping or use of in-line diagnostic tools. Therefore, advisers need to consider the processes used to detect mastitis when diagnosing a herd situation. Early detection and treatment of clinical mastitis may reduce the risk of severe and intractable cases developing and the transmission of infections.

The **"trigger for action"** is 5 clinical cases per 100 cows (all ages) calved within 14 days of calving. The DairyNZ **Mastitis Focus report** provides a comparison of a herd's clinical mastitis performance with triggers for action.

Note that validation of in-line and cow-side diagnostic technologies in the absence of accepted gold standards is still required in the NZ context to identify the most appropriate intervention point for antibiotics and other treatments, in cases detected by foremilk stripping, in-line tests, or other diagnostic methods.

② The cost of a clinical case of mastitis

Many studies have been performed around the world to estimate the costs associated with mastitis (Hogeveen *et al* 2011). Factors that contribute to these costs include:

- antibiotics and other supportive treatments,
- discarded milk,
- ongoing production losses including losses due to cows or quarters that have to be dried off early,
- penalties from exceeding regulatory BMSCC limits or inhibitory substance violations,
- labour costs for management of infected cows,
- costs associated with ongoing diagnoses and control,
- costs associated with reduced fertility, increased culling, unexpected deaths, and replacement of infected cows.

The DairyNZ **Mastitis Gap Calculator** allows calculation of the potential economic benefits associated with reducing BMSCC, clinical mastitis incidence and culling for individual herds.

The basic calculator assumes an average treatment period 1.5 days (i.e. three tubes at 12 hours), a three day milk withhold, average daily milk solids production of 1.3 kg cow per day, a production loss of 4% across the remaining lactation, a 3% increase in risk of culling, and a total labour cost of 15 minutes to treat the cow.

③ How to find clinical mastitis

Cows in the colostrum group (first 8 milkings) should have their teats and udders palpated, and foremilk checked at each milking, ideally at cups on and cups off. Later in lactation, visual assessment for swollen quarters, and signs of heat and pain, should occur at least daily. Identification of asymmetry amongst quarters should be followed by visual inspection of milk and palpation of the gland and teats.

The glandular tissue of the udder can be palpated superficially and deeply with the flat of the hand and fingers (Donovan *et al* 1992). Acute cases may be hot, swollen or painful but clinical mastitis cases with less obvious changes will require a more thorough examination to assess the consistency of udder tissue. Chronic changes usually manifest as fibrosis, which can be felt as firmness that is local (from pea to fist size) or diffuse (giving the quarter a firmer feel than its opposite number and usually a more nodular surface). Long-standing infections can ultimately result in atrophy (shrinking) of the mammary tissue as it becomes non-functional.

The teat can be palpated with the fingertips by gently rolling it between the thumb and first two fingers. Teat theilitis (inflammation of the internal tissues of the teat) is defined as a hardening or thickening of the internal surface of the teat sinus.

Foremilk inspections are used to detect abnormalities in the milk, such as wateriness, clots or flecks, or more obvious abnormalities such as flakes, discolouration and blood. 'Strings' of material hanging from teat-ends may also be detected; these are inflammatory debris expressed during milking and may be more obvious to the 'cups-off' operator.

Cows should be defined as having clinical mastitis (and require treatment) when there is an observable abnormality of the milk (e.g. wateriness, clots, and/or discolouration) that persists for more than three squirts of milk. To improve sensitivity of detection, strip onto a black or dark surface e.g. strip cup, dark RMT paddle, black plastic.

➜ The DairyNZ **Healthy Udder Guide** is a practical resource for farmers with step by step instructions for:

- Foremilk stripping cows
- Performing a Rapid Mastitis Test (RMT)
- Preparing teats aseptically before sampling a gland or administering treatments.

Note that:

- for cows with abnormalities in the first squirt of milk, followed by milk that is visibly normal, these should be marked and checked again for the next few milkings.
- for cows that received internal teat sealant (**ITS**) at dry off, flecks of teat sealant can be mistaken for clots. The withholding period of ITS requires that each quarter is stripped for 10-12 strips at the first milking after calving, to help reduce residues.

Before cows are moved out of the colostrum mob, every cow should also be tested with a Rapid Mastitis Test (**RMT**) to check for subclinical mastitis. This test should only be used at the last 1-2 milkings in the colostrum period as falsely high results can occur, due to presence of colostrum at earlier milkings. In the absence of clinical signs, RMT positive cows should be withheld from supply and rechecked daily.

As lactation progresses, cows at high risk of mastitis should be stripped regularly (at a minimum, weekly). These cows can be identified by leg bands or electronic records. These include cows that:

- have not milked out,
- have had a clinical episode of mastitis within the last month,
- have positive RMT quarters,
- have been identified as suspect cows using in-line detection systems, or
- have had high Individual Cow Somatic Cell Counts (**ICSCC**) recently.

➜ **Technote 5.3** describes routines for regular foremilk-stripping of the whole herd.

Mastitis Detection Systems

Commercially available in-line mastitis detection systems use technologies to detect changes in the milk, and include:

- electrical conductivity
- automated RMT
- colorimetric detection or
- algorithms based on sudden reductions in milk yield.

These systems vary widely in their sensitivity, and there is an inverse relationship with specificity (Kamphuis *et al* 2016; Bausewein *et al* 2022), meaning higher sensitivity often results in more false positives. Validation information should be sought prior to investment.

The validation of these systems is influenced by the gold standard used. Kamphuis *et al* (2016) defined clinical mastitis as the presence of clots using in-line mesh filters at two out of three sequential milkings, while Bausewein *et al* (2022) used single-time-point examinations by trained technicians. The sensitivity and reliability of these gold standards themselves are not well established, which limits the interpretation of validation results. Therefore, before investing in sensor-based mastitis detection systems, it is essential that farmers are encouraged to critically evaluate the validation methodology and performance data to ensure suitability for herd-level decision-making.

Antibiotic therapy should only be considered for cows with visible clinical signs of mastitis. All other cases should be monitored for clinical signs of mastitis over the next few days.

④ Use bacteriology tests to identify mastitis pathogens

Milk cultures and other bacteriological tests may be used to:

- define the likely aetiology of mastitis cases on a routine basis i.e., when using pathogen-based treatment protocols,
- assess likely pathogens at herd-level during mastitis investigations,
- support veterinarians when authorising antimicrobial use on-farm.

Virtually all mastitis is caused by bacterial infection. Nearly 300 different bacterial species have been isolated from milk but less than 100 are associated with clinical mastitis (Kurban *et al* 2022). Internationally the five most common clinical mastitis isolates are:

- *Escherichia coli*
- *Streptococcus uberis*
- *Streptococcus dysgalactiae*
- *Staphylococcus aureus*, and
- *Klebsiella pneumoniae.*

In pasture-based New Zealand production systems, *Strep. uberis* is the most common isolate from clinical mastitis over the dry period (McDougall and Castle 2021) and across lactation (McDougall*et al* 2007b). However, there is variation amongst herds as to the predominant pathogen so appropriate testing should be undertaken.

Testing of milk samples from clinical cases

It is not possible to determine the organisms responsible for a case of mastitis without bacteriological testing. Samples from cases of clinical mastitis can provide useful information on:

- Pathogen identification for epidemiological assessment to optimise control and therapy advice for a farm,
- Antibiotic sensitivity testing to optimise therapy.

It is good insurance to collect samples from all quarters with clinical mastitis and store them in the freezer. These can be submitted for testing if:

- a cow fails to respond to treatment,
- there is concern about the type of bacteria causing the mastitis, or
- there are a higher number of mastitis cases than expected.

Sampling strategy

The selection of cows for milk sampling depends on the purpose of the mastitis investigation and the diagnostic method used. For outbreaks of clinical mastitis in newly calved cows, samples should be taken from those clinical cases, as isolates from high SCC cows or recurrent cases may not reflect the current aetiology.

The number of samples required varies with the herd size and investigation goals. For general herd-level insights, a minimum of 20 samples is recommended. However, to confidently declare a herd free of a specific pathogen (e.g. at <5% prevalence), up to 155 cows may need to be sampled in a 500-cow herd, assuming test sensitivity of 95% and specificity of 99%.

Mastitis aetiology and antimicrobial sensitivity patterns can shift over time, so sampling should be repeated each lactation. Sampling recurrent clinical cases may help identify the original pathogen or reveal poor treatment hygiene, especially when unusual organisms like *Nocardia*, *Prototheca*, or *Pseudomonas* are involved.

Sample collection

Aseptic technique and proper sample handling are critical for accurate mastitis diagnostics. Contamination or bacterial overgrowth can compromise culture-related results, making interpretation difficult.

> A sample is typically considered contaminated if three or more colony types are isolated from a single quarter.

Common sources of contamination include water, mud, faeces, and skin contact - either from the cow or the milker. To minimise these risks, milk samples should be collected aseptically and either cooled and delivered for testing within 24 hours or frozen immediately after collection for later submission or analysis.

It is essential for advisers to ensure the milkers' sampling technique is satisfactory – a physical demonstration is often very helpful, supported by the **DairyNZ Healthy Udder guide**, which provides step-by-step instructions.

Storage and handling of milk samples

Most bacteria that cause mastitis survive refrigeration for several days or freezing for several weeks. *Nocardia* species are an exception to this general rule, as storage of samples for only a few hours or freezing can reduce the likelihood of isolating these organisms.

The survival of *Staph. aureus*, *Strep. agalactiae, Strep. dysgalactiae* and *Strep. uberis* was not impaired in milk samples that were stored in a commercial freezer at -20˚C for 6 weeks (Murdough *et al* 1996) or 16 weeks (Schukken *et al* 1989). Other studies have found a variable effect on streptococci, especially *Strep. dysgalactiae* (Luedecke *et al* 1972).

The survival of *Escherichia coli* and *Trueperalla pyogenes* can also decrease during freezing, with recovery rates for both pathogens decreasing by about 20% in samples frozen for four weeks (Schukken *et al* 1989).

Freezing may increase the detection of non-aureus staphylococci (Schukken *et al* 1989) and possibly *Staph. aureus*, possibly due to the release of intracellular bacteria after the destruction of leucocytes during the freeze-thaw process. Samples found to have no bacterial growth when cultured fresh may become positive after freezing.

Point-of-care or on-farm culture systems

Multiple culture-based point-of-care (POC) diagnostic systems have been developed to identify mastitis pathogens (Malcata *et al* 2020). These systems have supported increased farmer uptake through offering faster turnaround times, convenience, and cost-effectiveness. Importantly, their use has been associated with a 20-75% reduction in antimicrobial use (de Jong *et al* 2023). In New Zealand, two such systems have been evaluated and shown to reduce antimicrobial use by approximately 20% when used alongside defined treatment criteria (McDougall *et al* 2018b; Bates *et al* 2020).

No diagnostic test is 100% accurate. Results must be interpreted in the context of test performance, disease likelihood, and clinical findings. As Laven (2023) notes, veterinarians must avoid over-reliance on test results alone and instead integrate them with herd history, clinical examination, and knowledge of local disease patterns to make informed decisions.

Laboratory techniques

The *Laboratory Handbook on Bovine Mastitis* (Middleton *et al* 2017), published by the National Mastitis Council (NMC - The Global Milk Quality Organisation), provides detailed microbiological protocols for differentiating common mastitis pathogens and is available at **www.nmconline.org.**

Mastitis pathogen identification can be performed inexpensively through commercial veterinary pathology labs, in-house veterinary practice labs or on-farm point-of-care diagnostic systems. Care is required in interpreting data from different sources due to variation in laboratory techniques and the limitations of some tests.

Factors affecting the sensitivity and specificity of bacteriological diagnoses include:

- Methods for sample preparation, especially after freezing
- Choice of culture media
- Inoculation methods to ensure use of suitable combinations of inoculum volume and plate surface area
- Incubation temperature and times
- Tests used to differentiate isolates and laboratory definitions of bacterial genus or species
- Use of additional confirmatory tests such as MALDI-TOF or PCR (polymerase chain reaction).

Increased sensitivity of detection of bacteria where the number of colony forming units in milk is low may be achieved by increasing the inoculum volume onto the plate (e.g. streaking 25 µL or 50 µL of milk, rather than the standard 10 µL) and/

or reducing the number of colonies at which the sample is defined as test positive.

The sensitivity of conventional culture for detecting common mastitis pathogens varies among pathogens, by case definition and by sampling strategy (e.g. single vs. multiple samples across time, cow composite vs. quarter level samples)

For example, using isolation of a single colony as a definition of infection following plating of a 10 µL of milk, the sensitivity and specificity for *Staph. aureus* was 90.4 and 99.8% respectively (Dohoo *et al* 2011b), but sensitivity declined to 86.8 and 72.0% when the case definition was increased to >2 or >10 colony forming units respectively (Dohoo *et al* 2011b).

In another study, collection of two samples and interpretation in parallel (i.e. a positive being defined where the pathogen was isolated from either of the samples) resulted in a higher sensitivity but lower specificity than interpreting in series (i.e. isolate had to be present in both samples for the gland to be defined as test positive) (Dohoo *et al* 2011a).

Given these complexities, veterinarians should critically assess diagnostic results in the context of test performance, herd history, and clinical findings to guide effective mastitis management.

Reasons for 'no growth' after culture

Clinical cases of mastitis from which no growth is obtained are common. Between 10-50% of clinical mastitis milk samples have no pathogen isolated (de Jong *et al* 2023). Possible reasons can include:

- Low numbers of viable bacteria in the sample due to poor sample storage and handling. Use of a PCR assay, which does not require presence of viable bacteria, demonstrated that almost half of the samples that were culture negative contained bacterial DNA (Taponen *et al* 2009).
- Elimination of the infection by host defence mechanisms by the time that the milk sample is collected or during sample transport as milk contains many antibiotic antibacterial compounds such as lactoferrin, lysozyme, lactoperoxidase, complement and immunoglobulins. This is often suggested in the case of coliform infections.
- The number of bacteria present are below the limit of detection of the culture technique used.
- Intermittent shedding into the milk of the infective organisms e.g. *Staph. aureus.*
- Antibiotic treatment of the quarter prior to sample collection interfering with the ability to culture the infective organism. When submitting milk samples from cows that are not responding to treatment or are repeat cases, it should be noted if they have received antibiotics within 14 days of sampling.
- Contamination of the sample with disinfectant at the time of collection interfering with the ability to culture the infective bacteria.
- The pathogen may not grow under normal culture conditions. For example, standard bacterial culture conditions are unsuitable for the detection of obligate anaerobes, mycoplasma and fungi.
- The clinical signs of mastitis are due to non-bacterial causes such as toxic substances.
- Isolated bacteria may not be reported because they are not considered to be major mastitis pathogens. For example, non-aureus staphylococci are traditionally considered minor pathogens although they have been reported to cause clinical mastitis (Timms & Schultz 1987).

Antibiotic susceptibility testing

Antibiotic sensitivity tests show which drugs are not likely to be effective. Just because an antibiotic is effective at killing bacteria on agar plates in the laboratory does not mean it will have the same success in the cow.

The disc-diffusion method (Kirby-Bauer method) is the most commonly used antibiotic sensitivity test (AST) in veterinary laboratories. This involves applying antibiotic-impregnated discs to agar plates inoculated with a standardised bacterial suspension, followed by incubation for 18 hours and measurement of inhibition zones. Isolates are reported as susceptible, intermediate or resistant to the antibiotics that were tested. However, many of these clinical breakpoints are based on human isolates and human medicine treatment regimens.

Care is required extrapolating clinical breakpoints from human to veterinary medicine.

Broth microdilution testing provides specific minimum inhibitory concentrations (MIC) of antimicrobials that inhibit bacterial growth *in vitro*. This approach may provide more precise data to guide treatment decisions in the absence of clinical breakpoints relevant to a particular bacteria/antimicrobial combination.

A broth microdilution test for pooled *Staph. aureus* and *Strep. uberis* isolates from bulk tank milk is commercially available in New Zealand (McDougall *et al* 2018a) and a point-of-care diagnostic test also makes use of a similar approach (Jones *et al* 2019)

PCR testing for resistance genes involves testing isolates for the presence of genes associated with known resistance factors or enzymes. A commercially available test for the blaZ gene, associated with production of beta-lactamase by *Staph. aureus*, is currently available in New Zealand.

The correlation between antibiotic susceptibility test results and bacteriological cure varies amongst bacteria/antimicrobial combinations. For example:

- Presence of beta-lactamases, indicated by the presence of blaZ in *Staph. aureus*, was associated with poorer bacteriological cure rates with narrow-spectrum penicillins (Sol *et al* 2000; Steele & McDougall 2014).
- Bacteriological cure rates were higher for Gram-positive bacteria that were sensitive to cephapirin when treated with that compound, but across all isolates (i.e. Gram-positive and Gram-negative) there was no difference in cure rates at 14 and 28 d between sensitive and resistant isolates (Constable & Morin 2003).
- *Escherichia coli* isolates sensitive to trimethoprim/sulphonamide had a higher clinical cure than isolates not sensitive (89% vs. 75%) (Shpigel *et al* 1998).
- There was no difference in bacteriological cure rate for clinical cases treated with pirlimycin for Gram-positive isolates that were sensitive or resistant to pirlimycin (Hoe & Ruegg 2005).

Thus, AST results should be interpreted with caution, as *in vitro* inhibition does not guarantee *in vivo* efficacy.

For *Strep. uberis* there is evidence for increasing MIC for beta lactams due to mutations in the penicillin-binding proteins (McDougall *et al* 2020), but there is no evidence of reduced clinical or bacteriological cure rate following beta-lactam treatment. Hence, routine AST for individual clinical isolates may not be justified.

For *Staph. aureus*, penicillin resistance is relatively common and knowledge of penicillin sensitivity at herd level has utility for veterinary antimicrobial authorisation. Sensitivity of Gram-negative bacteria varies widely within and between species, and antimicrobial sensitivity should be tested when antimicrobial therapy is to be used.

⑤ Follow MRS T to clearly mark, record and separate cows to be treated

MRS T means:

- **Mark** – her with the herd's recognized identification system for a new clinical case.
- **Record** – her details in the recognized farm dairy system.
- **Separate** – her from the milking herd, and milk her once the delivery pipe has been removed or shut off from the vat.
- **Treat** – her with the appropriate treatment, according to the farm's Animal Health Treatment Plan.

Marking cows

Marking cows for treatment is the first step MRS T. This system greatly reduces the risk of inhibitory substances reaching the vat milk.

All milking staff should be familiar with the system used on each farm to identify cows that are to receive antibiotic treatment. Some methods for temporary cow identification are described in the Table below.

A separate identification system for marking cows that have received antibiotic Dry Cow Treatment (**DCT**) allows for easy recognition if cows re-join the herd in error and can help relief milkers or casual staff avoid making costly mistakes.

Methods of temporary identification

Method	Visibility	Durability	Ease of use
Velcro strips on legs	Excellent	Good	Easy to apply and remove
Insulation tape on legs or tail	Excellent	Good	Easy to apply and cut off NB. Tightly bound tape can cause impairment of blood circulation, resulting in tail amputation
Plastic hock strap	Excellent	Very good	Easy to apply and remove
Spray paint (non-scourable)	Variable	Good	Very simple
Tailpaint	Good	Excellent	Messy. Can paint over with new colour after treatment to avoid confusion
Paint stick/raddle	Good	Excellent	Simple; use like a crayon
Electronic ID	Variable	Good	Not be relied on as sole means

Record all details

The Ministry for Primary Industries' NZCP1: Design and Operation of Farm Dairies (MPI, 2024) describes the information to be recorded for each clinical case. Supplier contracts provided by milk processors detail their specific requirements for management and reporting of animal health treatments. Generally, these include:

- The unique animal identifier and affected gland(s),
- Condition or symptoms being treated,
- Veterinarian (if consulted)
- Treatment (name of product and dose)
- Date (and milking) treatment started, date of each treatment, and date (and milking) of last treatment,
- Date (and milking) milk returned to vat.
- Milking frequency during treatment.

Permanent records of clinical cases need to be held for up to 4 years. This can be done using paper systems or electronic systems provided by herd improvement organisations or dairy processors.

Advisers should assist farmers in developing a system, or Standard Operating Procedures (SOP), for detecting, identifying, recording, segregating and treating cows with clinical mastitis.

Advisers should also encourage dairy farmers to keep permanent records of clinical mastitis cases so they can manage individual cows and assess herd-level mastitis control. With this information, they can:

- make decisions about cows eligible for antibiotic DCT,
- make decisions about which cows to cull,
- identify 'suspicious' cows (if clots are found on the filter or bulk milk cell counts rise),
- assess the number of mastitis cases and their response to treatment,
- calculate the cost of clinical mastitis in the herd,
- identify risk periods (e.g. stage of lactation) for clinical mastitis,
- determine the main mastitis pathogen(s) in the herd, and
- review effectiveness of mastitis control and udder health on the farm.

Herd improvement databases can link clinical case information with details of a cow's age, production, ICSCC, previous clinical mastitis history, and previous treatment with antibiotic DCT and/or internal teat sealants. Use the DairyNZ **Mastitis Focus report** to analyse clinical records, in association with herd test data.

Separate cows from the milking herd before commencing treatment

Cows should be removed from the milking herd, as soon as clinical signs are detected, and before treatment commences, and at least 1 form of identification applied. Milk from these cases should be withheld from the vat and discarded (see section 10 below) according to the farm protocol.

Gloves should be worn when handling milk from cows with clinical mastitis, and when administering treatments. Gloves are easier than bare hands to rinse and sanitise after becoming contaminated with bacteria or antibiotics.

➜ **Technote 8.1** describes the benefits of hygienic milking practices, including wearing of gloves.

All treated cows should be run in a separate herd and in a secure paddock. These cows must only be brought to the farm dairy when all the milking cows have been milked and have left the dairy.

➜ **Technote 8.3** describes the advantages of segregating infected cows to reduce the spread of infection.

Prior to milking the treated cows, the operator must ensure that the milk delivery line is disconnected from the milk vat. If milk is harvested from cows under treatment or under a withholding period, and stored in a vat in the milk collection area, then this vat needs to be clearly labelled as not 'fit for supply' and the vat outlet must be locked to ensure that the milk cannot be collected by mistake.

⑥ Treat clinical mastitis with veterinarian-authorised treatments

The goal of treatment is to cure the infection (bacteriological cure), return the affected mammary glands to normal milk production (clinical cure), and minimise pain and suffering of the cow. Ideally, the treatment period should be as short as possible and there must be no risk of antibiotic residues entering the milk vat.

Staphylococci or streptococci cause more than 80% of clinical mastitis cases in the majority of New Zealand herds. Antibiotics are the basis of most treatment regimens and are administered by infusion into the affected quarter (intramammary route) or more rarely by intravenous, intramuscular or subcutaneous injection (parenteral or systemic routes).

Given the predominantly Gram-positive identity, and likely sensitivity, beta-lactam antimicrobials delivered by the intramammary route are the preferred first choice for mild to moderate clinical mastitis therapy in New Zealand. Where sensitivities allow, narrow spectrum penicillin should be the first choice. But where beta-lactamase-resistant *Staph. aureus* are likely present, broad-spectrum beta-lactam antimicrobials are required.

There is no evidence that use of highest priority or high priority antimicrobials for mild to moderate clinical mastitis associated with *Staph. aureus,* NAS or streptococci results in better bacteriological cure than 1st or 2nd generation cephalosporins, or beta-lactams (Nobrega *et al* 2020).

Non-steroidal anti-inflammatory drugs (NSAID) should be used for all clinical cases to reduce inflammation and improve cow comfort.

Supportive therapies such as oral or intravenous fluids may be warranted in severe cases. While frequent stripping out and oxytocin may aid milk removal, they have limited impact on clinical or bacteriological cure rates. However, farmers should be encouraged to milk mastitis cows twice a day to remove milk from mastitic quarters, despite the fact that antibiotics have been administered.

If clinical mastitis cases are treated without the benefit of prior bacteriological testing, treatment selection should be based on:

- severity of the case,
- history of treatment for the cow,
- previous bacteriological results for the herd,
- previous antibiotic susceptibility tests, and
- responses to treatment.

Bacteriological testing should be encouraged to establish the farm profile of mastitis-causing organisms and develop appropriate treatment and control protocols.

All treatments must follow label directions and veterinary authorisation, with strict adherence to withholding periods for milk and meat. Only use products registered for administration to food producing animals. Intramammary use of products that are not meant to be administered into the mammary gland should not be practised.

1. Intramammary antibiotics

Intramammary treatment is the preferred route of treatment due to the high concentrations of antimicrobial achieved locally and the reduced total mass of antimicrobials used (relative to parenteral treatment).

For time-dependent antimicrobials such as beta-lactams, extended therapy may be associated with higher bacteriological cure rate, particularly for hard-to-cure infections such as *Staph. aureus.* However, the trade-off is increased milk discard and treatment costs. In most cases extended therapy is not required or cost-effective for streptococcal infections.

Dry Cow Treatment preparations of antibiotics should never be used in lactating cows. Inadvertent use of antibiotic DCT requires milk to be discarded for extended periods of time.

2. Systemic antibiotics

Acute, or severe, mastitis cases may benefit from both intramammary and systemic antibiotics. Peracute cases often require systemic antibiotics and anti-inflammatory preparations, and possibly intravenous fluids. As such cases are often associated with Gram-negative infections, use of 3rd or 4th generation cephalosporins may be justified (Suojala *et al* 2013). The prognosis for peracute cases in cows with severe clinical signs (as indicated by body temperature, dehydration, etc.) is poor with the majority of cows dying or being culled, regardless of treatment (Wilm *et al* 2024).

Systemic antibiotics have the theoretical advantage that drug distribution is more consistent across the udder than intramammary infusions. However, to be effective, systemic antibiotic treatments must be absorbed from the injection site and pass from the blood into the udder. The major difficulty is penetration of the "blood-milk barrier". Experimental studies suggest that the tissue concentrations following parenteral treatment are substantially lower than those achieved by intramammary infusion (Ehinger & Kietzmann 2000; Ehinger *et al* 2006).

Only non-ionised, lipid-soluble, and non-protein-bound drug fractions cross the barrier effectively. Weak acids (e.g. penicillin G) are almost completely ionised in blood and have poor tissue penetration. On the other hand, penethamate hydroiodide achieves very high milk concentrations due to its lipophilic properties and hydrolysis to benzyl penicillin as it crosses into milk. Similarly, lipophilic macrolides like tylosin concentrate in the udder after systemic treatment and have been used for mastitis treatment (McDougall *et al* 2007a). Allowing for antibiotic sensitivity patterns, antibiotics with high milk-to-plasma ratios are most suitable for systemic administration (see Table from Anderson 1989).

A combination of systemic and intramammary therapy was found to increase cure rates amongst beta-lactam sensitive, but not beta-lactam resistant, *Staph. aureus* clinical cases (Taponen *et al* 2003), but no difference in bacteriological cure rate was observed for clinical cases due to Gram-positive infections, treated with parenteral or intramammary products (Kalmus *et al* 2014). Similarly, a randomised controlled study using culture-based therapy demonstrated noninferiority of intramammary treatment alone compared with combined intramammary and parenteral treatment with beta lactams (benzyl-penicillin intramammary and penethamate parenterally) for Gram-positive pathogens (Svennesen *et al* 2023). Given the greater antibiotic mass used in systemic therapy, routine combination treatment is not warranted.

For time-dependent antimicrobials, such as beta lactams, extending treatment duration can increase cure rates (Sol *et al* 2000; Oliver *et al* 2004; Deluyker *et al* 2005; McDougall *et al* 2022). However, extended therapy increases costs and milk discard, and modelling suggests it is only cost-effective for specific pathogens under certain economic conditions (Swinkels *et al* 2005; Steeneveld *et al* 2011).

Milk-to-plasma ratios of some antibiotics used to treat mastitis (Anderson 1989).

Antibiotic	Milk-to-plasma ratio
Trimethoprim	3.7
Lincomycin or Erythromycin	3.0
Tylosin	2.0
Tetracycline	0.7
Streptomycin	0.5
Ampicillin	0.25
Sulphadiazine	0.21
Penicillin G	0.15

3. Published cure rates of antibiotics

In a review of antibiotic treatment of clinical mastitis during lactation, Craven (1987) reported average cure rates for each antibiotic from scientific papers that stated the number of quarters treated and had rigorous bacteriological assessment. From these data it was not possible to draw firm conclusions about the relative effectiveness of different products given the wide range of cure rates for similar antibiotics.

A more recent review (Ruegg 2021) concluded there was insufficient evidence to demonstrate differences in bacteriological cure between antimicrobial products, and limited evidence for any benefit of antimicrobial treatment for mild-to-moderate clinical mastitis cases associated with Gram-negative organisms. Ethical constraints often prevent inclusion of untreated controls, obscuring the true benefit of antimicrobial therapy. Additionally, long-term outcomes such as recurrence, milk yield, and culling risk are rarely reported.

Nobrega *et al* (2020) found no improvement in bacteriological cure rate of *Staph. aureus* when using highest priority or high priority antimicrobials relative to highly important antimicrobials, suggesting no requirement for high priority antimicrobials when treating this pathogen. However, for severe Gram-negative infections, parenteral 3rd or 4th generation cephalosporins remain the preferred treatment, alongside supportive therapies (Suojala *et al* 2013).

In New Zealand clinical cure rates, defined as resolution of clinical signs, typically occur in 80-90% of cases. If more than 20% of cases require retreatment within 4 weeks, further investigation is warranted.

Bacteriological cure rates, defined by absence of the initial pathogen when sampling occurs 2-4 weeks post-treatment, occur in 70-90% of cases, with *Strep. uberis* cure rates in the order of 75-95%, and *Staph. aureus* closer to 25-35% (see Table on following page, McDougall 1998, 2003; McDougall *et al* 2007a, 2007b; Bryan *et al* 2016; McDougall *et al* 2019).

Factors that reduce bacteriological cure rate include:

- isolation of *Staph. aureus* (compared to other pathogens),
- older cow age,
- greater days in milk,
- multiple quarters affected, and
- presence of antibiotic resistance.

Bacteriological cure of clinical mastitis with different antibiotics in New Zealand

Report	Pathogen	Active ingredient	Route	Number of cases	Bacterial cure rate (%)
McDougall 1998	All	Penethamate	Systemic	157	76
		Penicillin/ Dihydrostreptomycin	Intramammary	185	85
	Strep. uberis	Penethamate	Systemic	126	82
		Penicillin/ Dihydrostreptomycin	Intramammary	151	84
McDougall 2003	All	Lincomycin/Neomycin	Intramammary	73	77
		Penicillin/ Dihydrostreptomycin		73	77
	Strep. uberis	Lincomycin/Neomycin		47	75
		Penicillin/ Dihydrostreptomycin		29	74
McDougall *et al* 2007a	All	Penethamate	Systemic	325	82
		Tylosin		334	84
	Strep. uberis	Penethamate		253	88
		Tylosin		235	90
McDougall *et al* 2007b	All	Penicillin	Intramammary	230	75
		Cefurozime		219	70
		Penicillin/ Dihydrostreptomycin		248	76
	Strep. uberis	Penicillin		117	91
		Cefurozime		92	95
		Penicillin/ Dihydrostreptomycin		115	96
Bryan *et al* 2016	All	Penicillin/cloxacillin	Intramammary	178	70
		Oxytetracycline / Oleandomycin / neomycin / prednisolone		187	63
McDougall *et al* 2019	All	Amoxicillin / clavulanic acid (3 x 12 hr)	Intramammary	75	73
		Amoxicillin / clavulanic acid (5 x 12 hr)		103	72

4. Pathogen-specific treatments

The causative bacteria are usually not known at the time of treatment so the choice of treatment is generally based on herd history, clinical judgement, and results of recent bacteriological testing.

When testing has been performed and the pathogen identity is suspected or confirmed, the antibiotic treatment selection can be more specific. Some features of treatment outcomes for specific pathogens are listed below:

Staph. aureus

- Bacteriological cure rate during lactation is low (about 30-60%) because *Staph. aureus* causes micro-abscesses in the udder, survives inside cells, and some forms are resistant to commonly used antibiotics (e.g. strains with the enzyme beta-lactamase are resistant to penicillin).
- The best hope for successful treatment is in young cows with recent infections (of less than two weeks duration) (Barkema *et al* 2006).
- Treatment of clinical mastitis may reduce *Staph. aureus* shedding, and result in milk returning to clinical normality.
- Use of extended therapy to increase cure rates for *Staph. aureus* has shown positive results (Oliver *et al* 2004; Deluyker *et al* 2005). Studies in New Zealand (Spatz Shelgren *et al* 2007), found that doubling the treatment regime from 3 to 6 tubes, administered at 12 hourly intervals, resulted in a 50% cure rate for *Staph. aureus* infections. This was significantly greater than the <30% cure rates observed for cows receiving the standard 3 tube treatment, which was not statistically different from no treatment. The economics of extended therapy in New Zealand has yet to be determined.

➜ **Technote 5** provides information on what should be considered when managing outbreaks of *Staph. aureus* mastitis.

Strep. uberis

- Bacteriological cure rates during lactation are in the order of 70-90%.
- A small proportion of cases are refractory to treatment. Research has found that field strains of *Strep. uberis* are able to invade and live in epithelial cells, which may partially explain why infections are refractory to treatment (Fessia and Odierno 2021).
- Antibiotic resistance is an unlikely explanation for refractory cases. The majority of *Strep. uberis* isolates that have been tested are sensitive to penicillin (>95%), oxacillin (>93%) and cephalothin (99%) (Petrovski *et al* 2011; McDougall *et al* 2014).
- Increases in MIC have been seen in *Strep. uberis* associated with mutations to the penicillin binding proteins resulting in lower affinity of all beta-lactams (McDougall *et al* 2020). The effect of these increasing MIC on clinical and bacteriological cure rate of *Strep. uberis* cases is currently unclear.

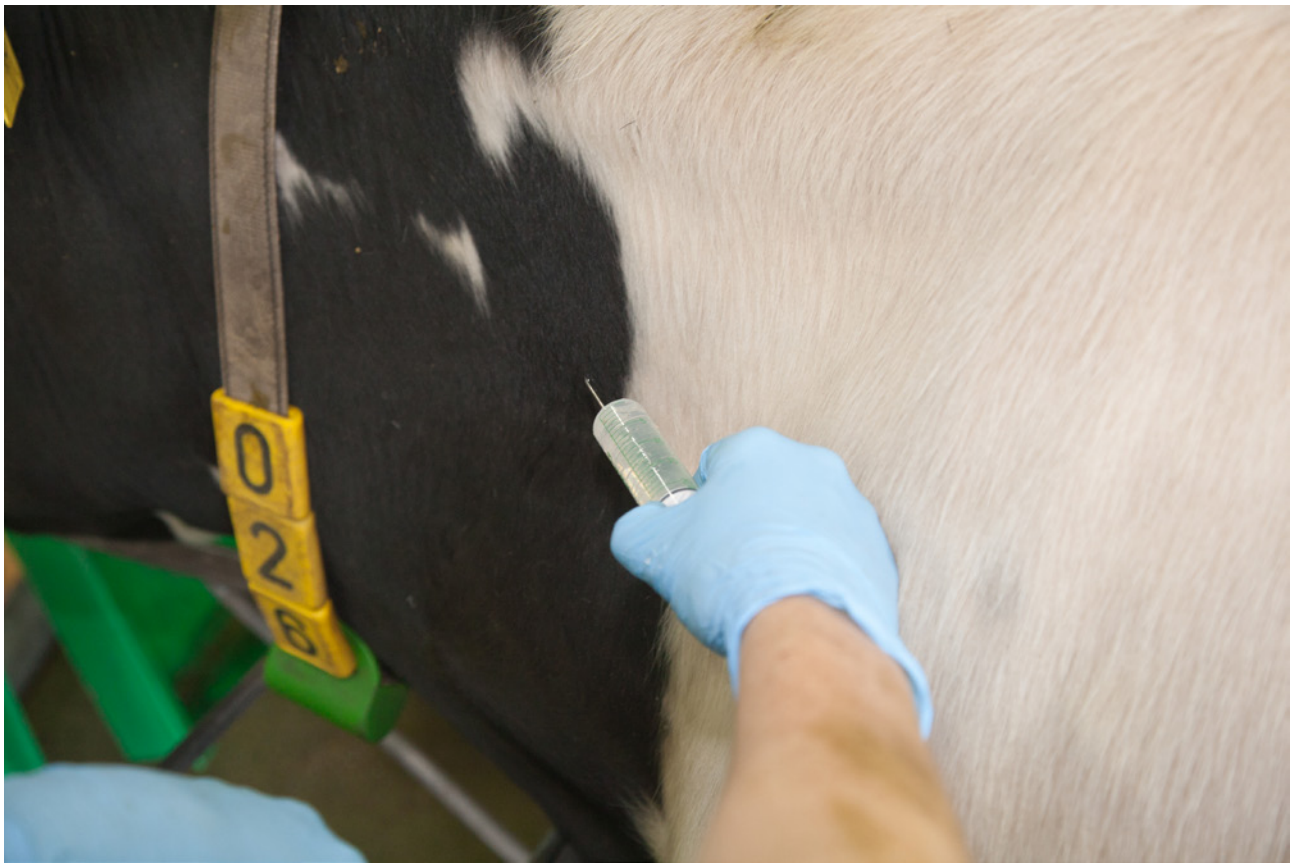
➜ **Technote 1** provides information on what should be considered when managing outbreaks of *Strep. uberis* or *E. coli* mastitis.

Escherichia coli

- Most cases due to *E. coli* will self-cure, in the absence of signs of systemic disease. Toxins produced by *E. coli* can lead to systemic involvement. To minimise the effects of toxin, use of anti-inflammatory agents and possibly intravenous fluids, may be helpful
- Prognosis remains poor for severely ill cows despite therapy, with a mean of 64% cows dead or culled in observational studies (Wilm *et al* 2024)

5. Use of anti-inflammatories

There is growing evidence to support use of non-steroidal anti-inflammatory (**NSAID**) products in the treatment of all cases of clinical mastitis, to reduce inflammation, alleviate pain, and improve cow comfort. Note however that NSAID vary in their efficacy, duration of activity, Cox 1/Cox 2 ratios, and milk withholding periods. Thus, care should be taken to not extrapolate likely efficacy derived from a randomised controlled study of one NSAID to another NSAID.



NSAID inhibit production of prostaglandins by inhibition of the cyclooxygenase (COX) enzyme. There are two isoforms of COX (COX-1, COX-2) that are constitutive (i.e. continuously produced) and induced, respectively (Lees *et al* 2004). NSAID reduce the inflammatory response, reduce pyrexia and have analgesic properties (Vangroenweghe *et al* 2005).

NSAIDs may be non-selective (i.e. inhibit both COX-1 and COX-2) or selective, that is inhibit COX-2 more than COX-1 (or vice versa). NSAID belong to different chemical groups including enolic acids (meloxicam), fenemates (flunixin, tolfedine) and proprionic acids (ketoprofen, carprofen) (Arfeen *et al* 2024). Products with label claims for mastitis treatment in New Zealand currently include carprofen, ketoprofen, tolfedine and meloxicam.

Mastitis is associated with an inflammatory response including local release of cytokines and chemokines resulting in prostaglandin release. This results in udder heat, pain and swelling, an elevated SCC, pyrexia, anorexia and reduced milk yield. Additionally, mastitis has been associated with impaired fertility associated with interruption of ovulation or luteolysis (Dolecheck *et al* 2019).

Thus, reducing the inflammatory response associated with mastitis is important.

Key findings include:

- For severe mastitis associated with *E. coli,* NSAID are the drug of choice, as there is stronger evidence for NSAID than for glucocorticoid use (Suojala *et al* 2013).
- For mild to moderate mastitis, including cases associated with Gram-positive bacteria, meloxicam reduced SCC and culling of cows compared with antibiotic treatment alone (McDougall *et al* 2009).
- For culture-negative, mild cases of clinical mastitis, treatment with ketoprofen did not improve clinical or bacteriological outcome compared to no treatment (Latosinski *et al* 2020). Ketoprofen treatment alone of clinical mastitis cases, followed by antimicrobial therapy if clinical improvement did not occur, reduced overall antibiotic usage compared to routine antimicrobial therapy at diagnosis, but resulted in reduced clinical cure at 5 days after diagnosis, lower bacteriological cure and higher risk of recurrent clinical cases within 60 days (Kromker *et al* 2025).

In summary, meloxicam used in conjunction with intramammary antimicrobials resulted in reduced SCC, improved bacteriological cure rate, increased conception rate, and reduced risk of culling amongst cows with mild-moderate clinical mastitis (McDougall *et al* 2009; McDougall *et al* 2016).

6. Use of fluids

Large volumes of isotonic intravenous fluid (25-40 L) can markedly improve the chances of survival of cows suffering from acute toxic mastitis. In the early stages of shock (for example, in cows that had a normal fluid status two hours earlier) small volumes of hypertonic saline have been used as an initial treatment to help restore the circulatory blood volume, provided that they are given with access to water, or oral supplementation of 15-20L of water.

7. Other treatments that have been evaluated

1. Oxytocin

Injection with the milk ejection hormone oxytocin may help remove milk and debris from hard, sore quarters but the value and efficacy of this approach is questionable. Oxytocin is a Prescription Animal Remedy and can only be obtained through veterinarians.

New Zealand research assessed the preventative effect of routine treatment with oxytocin following calving, and found no evidence of prevention of clinical mastitis in heifers (Williamson & Garrett 2010). In a separate study, across 204 cows with clinical mastitis on 4 farms, oxytocin was found to be a poor treatment for clinical mastitis, with a bacteriological cure rate for oxytocin observed for 42% ($p<0.01$), compared to 64% for antibiotic treatment (Williamson & Garrett 2010).

2. Increased milking frequency

A US study of increased frequency of milk out (6 x daily) accompanied by 20 IU of oxytocin found a reduced cure rate of environmental streptococcal infections, compared to antibiotic treatment alone (Roberson *et al* 2004). A combination of oxytocin and frequent milk out resulted in higher milk yield losses (230 kg) and greater economic losses (US$94) than treatment with antibiotics (Shim *et al* 2004).

A German study compared the effect of milking four times a day with twice a day, in support of antibiotic therapy and could find no difference in cure rates between the treatments (Krömker *et al* 2010).

A meta-analysis assessing nonantimicrobial treatment of clinical mastitis concluded that use of oxytocin with or without increased frequency of milking out could not be recommended (Francoz *et al* 2017).

⑦ Administer treatments as recommended

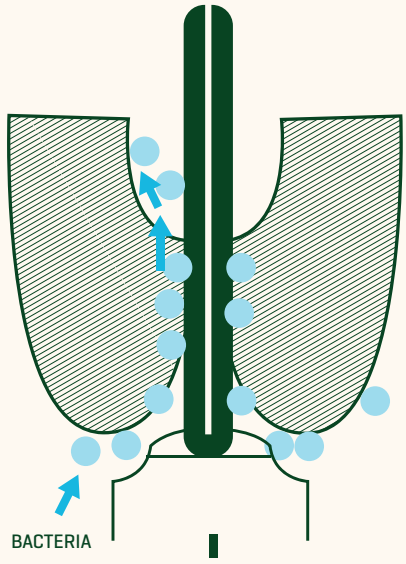
Administration of intramammary preparations

The nozzle of intramammary treatments can introduce bacteria into teats if the teat end is not properly disinfected. The DairyNZ **Healthy Udder Guide** provides step-by-step instructions on the correct way to administer intramammary treatments.

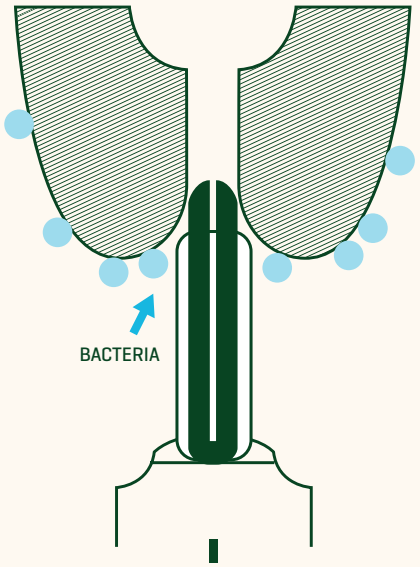
Ideally, antibiotics are given by partial insertion of short nozzle tubes just inside the teat canal (1-2mm). New infection rate following treatment was halved following partial versus full insertion of intramammary tubes (Boddie and Nickerson 1986). This is unlikely to be achieved in cows that are not used to having their teats touched and may therefore not be appropriate for many dairy herds. If an operator is not confident that short nozzle tubes will be used correctly, long nozzle tubes should be used rather than risk damaging the teat canal epithelium.

Use short nozzle tubes if available, or simply insert the tip of the tube just inside the teat canal, to a maximum depth of 3-4 mm.

Full insertion



Partial insertion



Administration of intramuscular antibiotics

Standards adopted for registration under the Agricultural Compounds and Veterinary Medicines (ACVM) Act (ACVM Act, 1997) to prevent carcass downgrades and chemical residue problems are:

- All injections are to be given into the anterior half of the neck
- Some injectable products state maximum volumes that can be injected at any one site. Refer to the label and do not exceed the maximum volume.

This is especially important for dairy cattle that may be culled within 12 months of treatment.

⑧ Use the full course of antibiotics (as specified on the label)

Efficacy and treatment courses for lactating cow formulations have been established through extensive research for registration of the products under the ACVM Act (1997).

Only affected quarters of clinical mastitis cases should be treated. As a significant proportion of cows with clinical mastitis have more than one affected quarter, all quarters should be checked at each milking during the treatment course to enable early detection and treatment of other affected quarters.

Regardless of whether a clinically affected quarter shows rapid improvement, it is important to use the full course of antibiotic treatment specified on the label to reduce the likelihood of infection recurring because of inadequate treatment, and to minimise the development of antibiotic-resistant strains of bacteria.

The development of antibiotic resistance

There is limited information on the risk of bacteria developing resistance to antibiotics commonly used to treat infections in dairy cattle. However, some associations are demonstrated from epidemiological studies such as:

- increasing use of intramammary penicillin/novobiocin DCT products was associated with increased risk of penicillin-resistant *Staph aureus* (Saini *et al* 2011),
- increased ampicillin-resistance in *E. coli* occurred with increasing cloxacillin, penicillin/novobiocin or cephapirin DCT (Saini *et al* 2013),
- there were more ampicillin-resistant *E. coli* following cefquinome or framycetin DCT use (Schubert *et al* 2021), and
- increased resistance was observed amongst faecal coliforms to cephalothin & streptomycin following cephalosporin DCT (Mollenkopf *et al* 2010).

Antimicrobial resistance occurs where a previously susceptible bacteria evolves to survive antimicrobial therapy. Resistance can occur following a *de novo* mutation or more commonly by horizontal gene transfer of an existing resistant gene. Once a resistant gene is in a herd, further antimicrobial use will select for bacteria carrying resistance genes.

The likelihood of antibiotic resistance developing broadly depends on the:

- prevalence of resistant bacteria in the animal population,
- frequency of antibiotic use in the animal population, and
- type of exposure to the antibiotics, e.g. short treatment courses of high doses of antibiotic confer less selective pressure than long-term exposure to low doses of antibiotic.

In addition to these factors, the rate of spread of antibiotic resistance within and between herds (and species) will be influenced by the opportunity for contact between animals and the host specificity of bacterial strains. It is therefore likely to vary significantly with management systems, mix of enterprise types and geographic location.

There are no comprehensive longitudinal studies of antimicrobial resistance of mastitis pathogens in New Zealand. However, analysis of laboratory submissions has found that there is a trend to a reduced prevalence of penicillin resistance among *Staph. aureus* isolates (Carman & Gardner 1997; Petrovski *et al* 2011). Similar findings have been reported internationally (Erskine *et al* 2002; Markovec & Ruegg 2003). One of the few published studies on the change in prevalence of resistant mastitis bacteria is in Finland where there was an increase of 27% in the proportion of *Staph. aureus* strains resistant to at least one antibiotic (mostly due to strains capable of producing beta-lactamase) (Myllys *et al* 1998).

MPI surveillance data from 2022/23 (MPI, 2023) found low levels of amoxicillin/clavulanic acid and tetracycline resistance, but moderate levels of resistance to cephalothin and high levels of

resistance to lincomycin/neomycin, for bovine mastitis *E. coli* isolates. There were high levels of penicillin resistance (29%), but very low levels for all other antimicrobials tested, for *Staph aureus*. A low level of resistance for cloxacillin, and no resistance for other antimicrobials tested, was observed for *Strep. uberis* isolates.

➜ The latest reports from MPI can be found at **www.mpi.govt.nz/animals**, and includes:

- NZ's Antimicrobial Resistance Plan
- Antibiotic Agricultural Compound Sales Analysis
- Antimicrobial Resistance surveys

The Ministry for Primary Industries and Ministry of Health jointly published the New Zealand Antimicrobial Resistance Action Plan (MOH, MPI 2017) and review it periodically. The plan sets out the key objectives of increasing awareness and understanding, surveillance, infection prevention and control, antimicrobial stewardship and governance, collaboration and investment.

Cattle antimicrobial use is the largest consumer of antimicrobials in New Zealand by species, hence the intense focus on reducing use of antibiotic DCT since 2016. While overall sales have been declining, the antimicrobials used for clinical mastitis have been increasing over the past 5 years (Hillerton *et al* 2024).

Veterinarians should continue to practice good prescribing principles including treating only those animals with evidence (clinical or microbiological) for infection, use of narrow spectrum antibiotics and continuing treatment for at least 48 hours beyond the end of clinical signs.

Off-label use

Off-label use refers to an unregistered use of a product. This includes any deviation from the manufacturer's recommendations, such as using:

- a different dose rate than stated on the label;
- a different route of administration;
- a different treatment interval or period; or
- a drug for a different purpose to that stated on the label.

Off-label use can only be authorised by a consulting veterinarian and only where legislation permits (McDougall & Millar 2011). It is done at the vet's discretion, taking knowledge of safety and efficacy into account, and is usually restricted to situations where no suitable registered product is available or where scientific evidence supports off-label use.

In food-producing animals, veterinarians prescribing off-label use of drugs become liable for setting appropriate withholding periods. These must be given to the client in writing. Wherever possible, the proposed treatment should be explained to the owner and informed consent obtained before treatment is started.

⑨ Observe withholding periods for milk and meat

➜ **Technote 3** covers withholding periods and residue management covers withholding periods and residue management for products used at dry off. This section summarises the key principles relevant to treatment of clinical mastitis.

Withholding periods (WHP) refer to the *minimum* time that must elapse after the last administration of a drug before an animal or its products are sold for human consumption.

The product labels provide recommended withholding periods. Antibiotic residues in milk or meat should not exceed the relevant New Zealand Maximum Residue Limit if treatments are used according to the label directions and milk or meat are withheld for the specified withholding periods.

Recommended withholding periods are based on trials that specify the:

- class of livestock, e.g. lactating cows
- dose rate, e.g. milligrams of drug per kilogram liveweight of animal
- dose interval, e.g. given once daily
- duration of treatment course
- frequency of milking, e.g. milked once or twice a day
- route of administration, e.g. intramammary infusion or intramuscular injection
- use of drugs within their expiry date
- use of drugs stored in accordance with label directions, and
- pattern of use for which they are registered, e.g. individual animal treatments.

Non-compliance

For registration purposes, the ACVM Act requires withholding periods to be based on the product sold for consumption. Consequently, withholding periods for intramammary antibiotics for lactating cows refer to cows and calves sold for meat or contributing to vats of milk.

In New Zealand, failure to observe withholding periods after treatment is the most significant cause of residue non-compliance (Beal 2002; Heuer *et al* 2003; McDougall *et al* 2004). In dairy cattle, antibiotic violations in milk are often associated with:

- failure to separate treated cows from the herd in supply
- inadvertent use of antibiotic DCT in lactating cows (note that antibiotic DCT is registered for use only immediately after a cow's last milking for a lactation)
- failure to identify treated cows
- failure to record treatment dates
- cows treated with antibiotic DCT at drying-off inadvertently re-joining the milking herd
- calving of cows treated with antibiotic DCT before expiry of the Minimum Dry Period, and
- 'off-label' drug use.

Any deviation from the registration specifications described above may lead to changes in the withholding periods for a product. Such changes are unlikely to be linear (e.g. doubling the dose cannot be extrapolated to a simple doubling of the required withholding periods) (Whittem 1997; McDougall & Millar 2011).

When giving systemic treatments for mastitis it is important to calculate the correct dose, as withholding periods for milk and meat change markedly when drugs are used at higher dose rates than specified on the label. Weights can be measured on scales or by using girth measurements and height sticks as a guide.

High dose rates constitute an 'off-label' dosage and, for any prescription drug, can only be considered with written permission from a veterinarian. They are a common cause of antibiotic violations.

Withholding periods are determined for a single product and where products are used in

combination (e.g. an antimicrobial and a NSAID), the withholding periods may be altered. However, there is a lack of data for withholding periods and care should be taken when prescribing combined products. At a minimum, an additional milking should be added to the milk withholding period where products are used in combination. Data on off label use (from a US perspective) is available at **www.farad.org/vetgram/search.asp**. Further guidelines are available to New Zealand veterinarians from the NZVA website.

Once daily milking

A number of intramammary antibiotics have specific 'on label' withholding times for use when milking cows once a day. Where herd owners are milking cows under treatment once daily, veterinarians should only prescribe registered products, to remain 'on label'.

Antibiotic residue tests

Traces of antibiotic in milk may cause allergic reactions in people and inhibit some starter cultures used in yoghurt and cheese production. National and international regulations stipulate the maximum levels of antibiotics that may be present in milk and these thresholds are often extremely low. The New Zealand limit is 0.003IU/ml penicillin or equivalent and a full list of allowable limits is available from MPI (2025).

Dairy companies perform regular screening tests to detect antibiotic residues (as inhibitory substances) in the vat milk that they collect. This occurs at several levels:

- Strips or sensors – for rapid screening of tankers before unloading. If the tanker is found to contain detectable levels of inhibitory substances then all suppliers on the tanker will be tested at the laboratory to identify the supplier or suppliers responsible.
- Growth inhibition - Screening of individual supplier milks using a bacterial inhibition assay to detect any substance that is inhibitory to the test bacteria. This is required by the MPI for every farm at least once every 10 days.
- An independent survey of bulk raw milk for antibiotic (and other) residues, called the National Chemical Contaminants Programme (NCCP). This service provides a credible monitoring system that helps the MPI sign off on European Union exports.

All dairy companies can conduct rapid tests on farm if there are concerns that antibiotics may have contaminated the vat. These tests should not be used on individual cows because they have been validated for use on bulk milk, and false positive test results may occur. Non-specific inhibitory substances present in milk of freshly calved cows or clinical mastitis cases have given positive test result on bacterial inhibition assays (Cullor *et al* 1994; Andrew 2000, 2001).

Inhibitory substances and antibiotic residue detected in an individual milk sample may not be excessive once diluted with clean milk in the vat. However, following a violation, on-farm testing of bulk milk is strongly recommended using factory screening tests.

Screening tests are relatively non-specific and vary considerably in their ability to detect all antibiotic families. A more sophisticated and expensive method for quantifying and identifying the type of antibiotic present is Liquid Chromotagraphy Mass Spectroscopy (LCMS). This test is recommended when investigating inhibitory grades where the source of antibiotics is unclear.

⑩ Discard milk from all quarters of cows that receive treatment

Even when a single quarter has been treated with intramammary antibiotic, it is possible that some antibiotic will be absorbed into the bloodstream and pass into the milk of normal quarters. The risk of antibiotic contamination is too great to include milk from treated cows in the vat. Do not use quarter milkers.

Milk that is subject to a withholding time must be harvested and stored in such a way that there is no risk of it mixing with, or cross-contaminating, milk intended for human consumption.

The withheld milk is not to be used for human consumption, and may only be fed to animals when in compliance with the Agricultural Compounds and Veterinary Medicines (Exemptions and Prohibited Substances) Regulations 2011 (MPI 2011).

The accepted best practice is to run all treated cows in a separate herd and in a secure paddock. These cows must only be brought to the farm dairy when all the milking cows have been milked and have left the dairy. Prior to milking the treated cows, the operator must ensure that the milk delivery line is disconnected from the milk vat.

If milk is harvested from cows under treatment or under a withholding period, and stored in a vat in the milk collection area, then this vat needs to be clearly labelled as not 'fit for supply' and the vat outlet must be locked to ensure that the milk cannot be collected by mistake. All operators should know how treated milking animals are identified, and the process to follow if they are accidentally milked into the vat for supply.

Consumables such as gloves, teat wipes and milk filters, must be stored in such a way that there is minimal risk of contamination with veterinary medicines.

11 Treatment failure: causes and management options

The reasons why a clinical quarter may fail to respond to treatment need to be considered when deciding the next course of action. These may include:

Inappropriate choice of active, dose, frequency or duration

For dose-dependent antimicrobials, concentrations in the udder may not reach therapeutic levels, particularly after parenteral use. For time-dependent antimicrobials such as beta-lactams, the course duration needs to be long enough to be effective.

Animal factors

Bacteriological cure is lower amongst older animals and amongst animals with a higher SCC prior to initiation of treatment. Presence of accumulations of inflammatory cells, hyperplasia of alveolar epithelium, fibrosis or formation of micro-abscesses in the udder may reduce likelihood of actives reaching concentrations above the minimum inhibitory concentration. Factors that lead to immune suppression, such as peripartum reductions in PMN numbers and function or trace element deficiencies, may result in poorer bacteriological cure.

Bacterial factors

Innate or acquired antimicrobial resistance is associated with lower bacteriological cure rate. Some bacteria may become dormant, develop into "L" or naked bacterial forms, develop biofilms or survive intracellularly. For example, *Staph. aureus* may locate within the phagolysosomes of macrophages and polymorphonuclear neutrophils. Antibiotic penetration of cells may be poor and even if they gain access to the cell, they may not distribute to the phagolysosomes, resulting in lower bacteriological cure rate.

- If a milk sample was collected and frozen before the initial treatment, it can be cultured to determine the causal bacteria and their antibiotic resistance.
- Pathogens introduced at the time of treatment (due to poor technique when giving intramammary infusions) will only be identified by resampling the quarter.

Options when there is no response to treatment

Options that can be considered when a clinical quarter fails to respond to a full course of treatment include the following:

Repeating the treatment but treating for an extended time with the antibiotic

There is evidence that 'extended' therapy (i.e. 6 to 8 treatments) with time dependent antibiotics such as the beta lactams will result in improved cure rates (Oliver *et al* 2004; Deluyker *et al* 2005; Spatz Shelgren *et al* 2007; Steele & McDougall 2014). However, economic analysis suggests that extended therapy may not be economic in all situations (Steeneveld *et al* 2011)

Some products are registered for extended therapy (generally up to 6 treatments). Individual prescriptions will be required for extending therapy with other products. Note that repeated treatments will extend the required withholding periods.

Trying a different antibiotic treatment

It is generally more effective to extend therapy, rather than change product. However, if new information comes to light (e.g. culture results), an alternative may be more appropriate.

The longer a case of clinical mastitis persists, the greater the degree of fibrosis and abscessation that may occur, and the less likely the quarter is to respond to antibacterial treatment. Some cases just do not respond to treatment, even if the bacteria are sensitive to the product.

Drying-off the infected quarter if it is not hot and swollen

This is an option if the cow is in good general health apart from the infected quarter. The only method of drying-off a quarter is to stop milking the quarter and monitor to ensure that it does not develop into an acute case of mastitis. Cessation of milking should be delayed until the end of the withholding period after administration of the last treatment.

It is important that these quarters are permanently identified to prevent accidental attachment of cups to these teats at the time of milking. Antibiotic DCT must not be used in a quarter when the other quarters are continuing to be milked. Antibiotic DCT products are not registered for use in lactating cows. Some antibiotic will be absorbed into the bloodstream and passed out in the milk from the normal quarters, so there is an unacceptable risk of antibiotic contamination of the vat.

At the end of lactation, it is not appropriate to use antibiotic DCT in a quarter that has been dried off during lactation because intramammary DCT will not be absorbed by dry glands.

Drying-off the affected cow

Drying-off early cows with quarters that fail to respond to treatment removes a source of infection to other cows in the milking herd. These cows may be treated with antibiotic DCT and the affected quarter closely monitored – if the quarter becomes hot and swollen, or the cow becomes systemically ill, treatment with non-steroidal anti-inflammatories and lactating cow antibiotic product in the infected quarter may need to be reinitiated.

Culling chronically infected cows from the herd

Culling chronically infected cows is an important component of any mastitis control programme. The recommended withholding period for meat must be observed if the cow has been treated with antibiotics.

➜ **Technote 15** describes mastitis criteria for culling cows.

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Lactation

Technotes 5–13

Technote 5

Using effective milking techniques and routines to prevent mastitis

In this technote:

1 Causes and characteristics of cow-associated mastitis bacteria

The bacteria generally responsible for 'contagious' or cow-associated mastitis are those which live on the teat skin or in the udder. Major pathogens (i.e. those responsible for clinical cases) include ***Staphylococcus aureus***, ***Streptococcus agalactiae*** and ***Strep. dysgalactiae***. Minor pathogens (i.e. those more responsible for subclinical infections) are **non-aureus staphylococci** (**NAS**, previously coagulase-negative staphylococci or CNS) and ***Corynebacterium bovis.***

Major pathogens are commonly associated with clinical cases, but can also be isolated from high SCC cows. Minor pathogen infections are more commonly associated with cows with an elevated SCC.

Spread occurs when infected milk contaminates the teat skin of clean quarters or other cows. This can be by milk on milkers' hands or teat cup liners, through splashes or aerosols of milk during stripping, and by cross flow of milk between teat cups (Phillips, 1982).

➜ See **Technote 8** for milking hygiene practices that help prevent mastitis, and **Technote 9** for the natural defence mechanisms at the teat end.

Staph. aureus may invade the udder tissue, forming micro-abscesses and scar tissue. As this makes it difficult to cure during lactation, prevention is therefore critical. By contrast, ***Strep. agalactiae*** resides in the ductal areas and responds well to penicillin, with high cure rates. It is rarely isolated in NZ herds. ***Strep. dysgalactiae*** can be isolated from sites on the animal but is often associated with teat end damage (Ericsson-Unnerstad *et al* 2009).

➜ **Technote 4.6** discusses the response to antibiotic treatment during lactation.

Non-aureus staphylococci (NAS; previously CNS) are a collection of pathogens that live on the skin and coat of the cow. They generally cause an elevated SCC but can be isolated from clinical cases. These pathogens share traits with environmental bacteria.

Corynebacterium bovis is a lipid-requiring bacteria that rarely causes clinical mastitis (Bramley *et al* 1976; Hillerton *et al* 1995). It is considered highly contagious and is often associated with poor teat disinfection. Its presence may increase the risk of *Streptococcus uberis* infection in unprotected quarters at dry off (Woolford *et al* 2001).

Streptococcus uberis has become the predominant mastitis pathogen in New Zealand. Although typically considered an environmental pathogen, it can spread contagiously (Williamson *et al* 2010), as can all infections caused by gram-negative, coliform pathogens.

➜ **Technote 1** describes characteristics of environmental pathogens and *Strep. dysgalactiae.*

Table 1. Characteristics of mastitis bacteria generally associated with infected udders

Characteristic	*Staphylococcus aureus*	*Streptococcus agalactiae*
Reservoir of infection	Milk from infected udders of cows. The surface of the teat skin, especially in cracks and sores.	Milk from infected udders of cows. Colonised teat canals, in the absence of gland infection, can be a significant reservoir.
Spread	Cow to cow at milking, via contaminated milk on liners and hands.	Cow to cow at milking, via contaminated milk on liners and hands. Spread is very rapid.
Risk of infection	All lactating cows are susceptible. Risk is increased if there is teat end damage, faulty milking equipment or poor teat disinfection.	All lactating cows are susceptible. Infection can occur in first-calf heifers before entering the farm dairy. Preventing cross-suckling may be helpful in herds with this pathogen.
Clinical signs	*Staph. aureus* is a common cause of subclinical and clinical mastitis. Signs of clinical mastitis can range from slight changes in the milk through to severe systemic illness. Occasionally gangrenous forms, with massive tissue damage and toxaemia, can occur (black mastitis).	Infection can cause high rates of clinical disease, with hard swollen quarters. Affected glands may experience recurrent acute episodes and eventually become uneven and firm with watery foremilk containing clots. Many infected quarters are subclinical with a very high SCC.
Duration of infection	Infections may become chronic. Bacteria are shed intermittently from subclinical quarters. If a single milk sample is taken from an infected quarter, there is about a 70% chance of isolating the bacteria.	Infections can be acute or develop into chronic subclinical infections. Very high numbers of bacteria are shed, especially in the early stages of infection when 100 million bacteria per mL of milk may be present.
Cow Somatic Cell Counts (SCC)	About 50% of infected cows have SCC >500,000 cells/ mL. Cell counts from infected cows rise and fall cyclically throughout lactation, typically in the range of 200,000 to over 1,000,000 cells/mL.	Most infected cows have SCC >500,000 cells/mL although SCC can fluctuate widely from below 200,000 to above 1,000,000 cells/mL.
Milk quality	Bacteria are shed in milk, but numbers in the bulk milk are low and rarely cause an elevation of the bacterial count in milk.	There is a potential for very high numbers of bacteria to be shed in bulk milk, occasionally enough to exceed bacterial count thresholds.
Management during outbreaks	Take cultures from at least 20 cases of clinical mastitis to confirm the identity of the bacteria. Correct milking machine and milking technique faults. Check teat disinfectant and application. It is essential to disinfect teats post milking and improve the health of teat skin. Because treatment in lactation may only cure a minority of infections, assign these cows to antibiotic Dry Cow Treatment (DCT) at dry off, or cull cows that have been chronic for months or years. Create a preferential culling list based on clinical history, cell count history, antibiotic DCT history, age, production, culture results and stage of lactation. See **Mastitis management – Staphylococcus aureus Factsheet** for more.	Take cultures from at least 20 cases to confirm identity of the bacteria. Cultures of bulk milk can help identify the cause. **This pathogen is rarely isolated from NZ herds**. It is highly contagious so outbreaks should be treated with urgency. Options include whole herd culture and treatment of infected cows or whole herd treatment (blitz treatment) with lactating cow antibiotics. Culture all treated cows before they re-enter the milking herd. The aim is to eradicate this infection so all factors contributing to its spread should be corrected, and affected cows treated or culled. Implement strict milking hygiene, segregate all infected cows, correct any milking machine or technique faults promptly, and ensure teat disinfection is optimised to improve teat skin health. Use Whole Herd antibiotic DCT and operate a closed-herd policy or culture milk from purchased cows.

Table 2. Characteristics of mastitis bacteria generally associated with the skin of the cow

Characteristic	*Streptococcus dysgalactiae*	*Corynebacterium bovis*	Non-aureus staphylococci (NAS)
Reservoir of infection	Infected udders and teat lesions. The bacteria can also be isolated from the environment and sites on the animal such as mouth, udder and vagina.	Milk from other infected udders. This pathogen requires lipids to grow, so is only isolated from lactating glands, where milk fat is freely available.	Skin and coat of the cow, as well as other environmental sites and infected udders. These bacteria are a collection of different species, previously known as coagulase negative staphylococci (CNS).
Spread	Cow to cow at milking, via contaminated milk on liners or on hands. Contamination of teats can also occur between milkings, from bacteria in the cow's environment.	Highly contagious, this minor pathogen spreads at milking time via contaminated milk, especially if teat disinfection post milking is poor. It can easily spread to all quarters of an individual cow, and to a large proportion of the herd.	Contamination of teat skin builds up in absence of teat disinfection, so infections often develop when cows are dry or when teat disinfection is poor. Contagious spread may also occur via contaminated milk or milkers' hands.
Risk of infection	All lactating cows are susceptible, particularly those with sore or damaged teats. Heifers are also prone to infection in the last few weeks before calving, and during calving.	All lactating cows are susceptible. Although dry cows are not susceptible to infection, quarters infected at dry off may increase the risk of a cow developing *Strep. uberis* infection in the dry period if unprotected.	All cows are susceptible to infection. These bacteria are the most common isolates from heifers prior to calving.
Clinical signs	Most infections show mild clinical signs, without systemic signs. Infections can show acute signs, similar to *Strep. uberis*.	These infections are usually subclinical. On rare occasions, *C. bovis* may be the only pathogen isolated from a clinical case.	Infections are mostly subclinical but NAS can cause clinical mastitis. Some NAS species may be more virulent than others.
Duration of infection	Most infections are short-lived unless there is persistent teat end damage. Similar to other environmental streptococcal infections, high numbers of bacteria can be shed in the milk.	These infections develop into chronic infections that can last for the rest of lactation. Achieving complete bacterial cure during lactation is difficult using lactating intramammary antibiotics.	Chronic infections can be established and last for long periods (months). In other cows, infections may be short-lived and disappear within a few days.
Cow Somatic Cell Counts (SCC)	Similar to other streptococcal infections, most infected cows have SCC higher than 500,000 cells/mL.	Depending on the number of quarters infected within a cow, the cow SCC will vary from 150,000 and 300,000/mL.	Infections by NAS tend to have mild to moderate impacts on cow SCC, unless the infection develops into clinical mastitis.
Milk quality	Clinical cases have been rarely reported to contribute to bacterial count of the bulk milk.	This pathogen can be detected in bulk milk but is unlikely to contribute to bacterial count. Main impact is on bulk milk SCC.	These bacteria can be isolated from bulk milk but are unlikely to contribute to bacterial count of the bulk milk.
Management during outbreaks	Improve quality of post milking teat disinfection. Correct possible cause(s) of teat end damage e.g. milking machine faults or other management issues.	This pathogen is considered sensitive to intramammary antibiotic treatment, but the risk of re-infection is high. Prevent infection through good post-milking teat disinfection technique.	Prevent infection through good post-milking teat disinfection and appropriate use of antibiotic DCT and internal teat sealants at dry off – see **Technote 14**.

② Managing cow behaviour during milking

Human-animal interactions significantly influence the behaviour and productivity of dairy cows (Hemsworth 1997). Standardised milking routines can improve production outcomes (Hemsworth 2002). Successful machine milking relies on the cow's cooperation throughout the process. Stressful handling when being brought in from the paddock, handled in the yard or encouraged into the bail, can cause a cow to become nervous or frightened. This triggers an adrenaline release which blocks the oxytocin release and prevents the milk ejection reflex. This block can last for up to 30 minutes and prevents milk let-down.

A calm, consistent milking environment improves milk yield, shortens milking time, reduces stripping volumes, and lowers the frequency of urination and defecation. Seabrook (1994) demonstrated that cows exposed to 'pleasant handling' entered the dairy more quickly and dunged less frequently than those exposed to 'aversive handling'.

Cow behaviour during milking can be assessed by the frequency of kicks and steps (the 'KiSt response'), although interpretation must account for environmental factors such as flies, or machine/operator interactions (Mein 1997; Meyer *et al* 2021). Highly fearful cows may not show overt behaviours, instead entering a 'tonic', immobility phase.

➜ **Technote 6.2** provides more on 'KiSt response' to assess cow behaviour.

Australian research shows that frequent negative interactions (e.g., hitting with plastic pipes) increase cow fear, while positive interactions (e.g., patting, talking and slow deliberate movements) reduce it (Hemsworth *et al* 2000). Elevated fear of humans correlates with reduced milk yield (Hemsworth *et al* 2002) and lower conception rate to first insemination (Hemsworth *et al* 2000).

When handling cows, positive behaviours should be encouraged and negative behaviours actively discouraged – it is important to recognise that even moderate slaps and hits, used repeatedly, will result in cows becoming fearful. Where cow flow is an issue, a review of facilities and milker routines should be undertaken to identify contributing factors. When a cow is behaving as required, positive reinforcement should be used where possible.

Introducing heifers to the milking shed early, either before they calve, or by calving them early, before the older cows, can ease their transition. Early familiarisation is recommended to reduce fear and improve milking outcomes (Bremner 1997).

➜ See **Technote 2.3** for guidance on training heifers in the milking area, and the DairyNZ **MilkSmart** programme for practical tips on managing cow flow.

③ Foremilk strip cows to detect abnormal milk

Foremilk stripping is a practical tool for detecting clinical mastitis. It is most valuable at the start of lactation when infection rates are highest and cows are being conditioned to the milking routine. Early detection and prompt treatment of new intramammary infections improves cure rates (Milner *et al* 1997).

Stripping involves the removal of 2-4 squirts of milk from each quarter before milking, and checking for abnormalities such as clots, wateriness, or discolouration. Changes that persist for more than three squirts suggest clinical mastitis and are considered eligible for treatment. Quarters with a few flecks should be monitored and rechecked at the next milking.

➜ **Technote 4.1** defines the signs that a cow has clinical mastitis and should be treated.

Effective technique involves rolling the thumb down while holding the top of the teat closed, and stripping onto a black surface (e.g., strip cup or dark paddle) to aid visual detection (see the DairyNZ **Healthy Udder Guide**).

Foremilk stripping also helps identify blood in milk or milk unsuitable for the vat. Cows that received internal teat sealant at the end of the previous lactation may still show small residues in the first days after calving (Swinkel *et al* 2024). Foremilk stripping of 10-12 strips at their first milking after calving may mitigate this.

NMAC (National Milk-Quality Advisory Committee) strongly recommends foremilk stripping of all quarters of all cows in the colostrum mob at least once a day.

Routine stripping of freshly calved cows is increasingly adopted in NZ, particularly in the first few weeks of the lactation. A survey of 40 herds found the majority stripped once daily, although only 22% stripped every cow at every milking in the colostrum mob (Compton & McDougall, 2008, unpublished).

The benefits of stripping increases during high-risk periods, such as calving, when *Strep. uberis* infections are more common, as early detection improves treatment outcomes.

Routine foremilk stripping is recommended when:

- clinical new infection rates are high,
- bulk milk SCC is approaching penalty thresholds, or
- clots are found on the milk filter.

When clots are found on the filterand the cause is not established, every quarter of every cow should be checked before machine milking. For large herds, this can be spread over multiple milkings to ensure a thorough inspection (see Table 3). Farmers should consider systems to allow continuation of regular foremilk stripping all season.

Table 3. Routines for implementing foremilk stripping of the whole herd

System	Description	Comment
Strip all 4 quarters prior to every milking.	All four quarters foremilk stripped prior to every milking.	Very effective when clinical incidence rate is high. When low, this method is time consuming and labour intensive.
Strip all 4 quarters once a week.	All four quarters foremilk stripped prior to milking, at one morning milking per week.	Can be unsettling as cows tend not to become accustomed to having teats touched. Requires additional labour and/or prolonged milking time.
Strip 2 quarters at two milkings each week.	Two quarters foremilk stripped at one milking and the other two at the next milking, once a week (e.g. both fronts at morning milking, both backs at evening milking).	Milkers should be able to handle this method without extra labour but milking routine will be slowed on that day.
Strip 1 quarter at four milkings each week.	One quarter foremilk stripped at a milking. All quarters stripped over 4 milkings, in rotation. Can be done either across two days at morning and evening milkings, or across 4 milkings (usually morning).	This system requires no extra labour and has least impact on milking routine. Tends to be less unsettling to cows as teats are being touched more regularly. Sensitivity of detection will be less accurate than stripping all 4 quarters but method is more practical when clinical incidence is low to moderate.

Role of SCC and other tests for detecting mastitis

The **Rapid Mastitis Test** and **individual cow somatic cell counts (ICSCC)** are useful tools for identifying problem cows (i.e. glands or cows with high SCC). They can be used alongside foremilk stripping to confirm clinical signs.

Current knowledge does not support general treatment of subclinical mastitis i.e. those with no visual signs, with lactating cow antibiotic therapy. These tests were designed to detect subclinical mastitis, and not all test-positive cows need to be managed as clinical cases. These tests help identify suspicious quarters for closer visual examination for clinical signs, and can assist in decisions around excluding cows from factory supply during milk quality grading investigations.

Hand-held conductivity meters, which detect ionic changes in milk, may help identify suspect glands but are less useful for SCC-related decisions, as they do not measure somatic cells.

Point-of-care (POC) tests enable identification of the likely pathogen associated with subclinical or clinical cases. They offer rapid, on-farm diagnostic support and complement existing tools for mastitis detection and management. Their integration into routine herd health protocols can enhance decision-making, particularly in high-risk or grading situations.

➜ **Technote 4.4** provides more information on POC diagnostic tests.

In-line filter systems, fitted in the long milk tube between clawpiece and milkline in a position where they can be easily read, are designed to trap clots and aid in mastitis detection. However, their effectiveness depends on consistent checking after every cow and the passing of clots in the milk, rather than watery milk (Blowey & Edmondson 1995). Filters must be cleaned regularly to maintain visibility and function.

Automated mastitis detection systems are improving, especially when integrated with cow ID and data processing (Mein 2010; McDougall *et al* 2024). These systems should be able to support three key tasks:

- early detection of clinical cases (especially in early lactation)
- identification of 'millionaire' cows (ICSCC >1 million cells/mL) to manage BMSCC
- selection of cows for antibiotic dry cow therapy based on late-lactation SCC.

While no system is 100% accurate, they can help narrow down suspect cows and reduce false positives.

④ Pre-milking teat preparation and hygiene

Mastitis risk is closely linked to bacterial load at the teat end. Keeping teat ends clean and dry is essential to reduce new infection rates. An udder hygiene scoring system developed by Dr. Pamela Ruegg (Schreiner & Ruegg 2003) offers a practical, validated method for assessing udder cleanliness and has shown strong correlations with bulk milk SCC and mastitis rates in US herds.

Despite climatic differences, the tool is valuable for NZ herds, providing a quick (≤20 min) and quantitative way to evaluate cow environment and management strategies. Ward *et al* (2002) found a strong link between cow cleanliness and mastitis due to environmental pathogens like *E. coli* and *Strep. uberis* in British herds.

In NZ, increasing levels of milk production per cow and greater stocking intensity of cows within herds, elevates the risk of faecal contamination of teats, and therefore, environmental mastitis. NZ research (Lacy-Hulbert *et al* 2002) found high rates of clinical and subclinical mastitis in zero-grazing systems with total mixed rations. The combination of a high starch content in the diet, coupled with high faecal contamination in the environment, led to heavy bacterial loads on teats. This necessitated thorough washing and drying of teats before each milking, especially in wet weather, to prevent new infections.

➜ **Technote 1.6** describes how to fix areas that make udders muddy.

Teat cleaning before milking

Milking wet, dirty udders can increase the risk of mastitis and milk quality issues. Research in the US and UK (Galton *et al* 1986; McKinnon *et al* 1983) found that wetting any portion of the udder above the teats without subsequent drying will result in dirty, bacteria-contaminated water draining into the top of the teat cup liner during milking. This in turn reduced milk quality, through increasing bacterial counts, and increased mastitis risk, especially from environmental pathogens such as coliforms and *Strep. uberis* (Smith & Hogan 1997).

However, research in Australia with pastured cows (Hubble & Mein 1986) reported little benefit of washing and drying all teats, compared to tactical washing of dirty teats alone. No issues arose when the teat washing phase was suspended for cows milked in automated systems (Davis *et al* 2008).

In NZ, the risk management programmes operated by most dairy processors requires milk to be harvested in accordance with the NZ Animal Products Notice: Production, Supply and Processing (MPI, 2025) and NZ Code of Practice (NZCP1; MPI, 2024).

A practical guide to comply with these codes is:

- if it's clean, cup it,
- if it's dry/dusty, wipe it
- if it's wet and dirty, wash and dry it.

Relatively clean, but dusty teats can be cleaned without water, using a gloved hand or a single, disposable cloth per cow.

Wet and dirty teats should be washed using a low-pressure water supply, combined with manual cleaning and drying by the operator. This results in much less water ending up in unwanted places on the cow (udder, legs, underside and flanks). High pressure hoses **should not** be used for udder washing.

Tactical washing is recommended in high-risk environments (e.g., housed systems or heavy faecal contamination). All contaminated teats should be washed and dried prior to cup attachment until the environmental source of contamination is controlled.

Wearing gloves improves milker comfort and hygiene, as gloved hands are easier to clean and less likely to transfer bacteria (Olde Riekerink *et al* 2008). Gloves should be rinsed regularly under running water to maintain cleanliness during milking.

➜ **Technote 8** describes the importance of hygiene at milking time and the benefits of wearing gloves.

Pre-milking teat disinfection

Pre-milking teat disinfection in NZ is encouraged for cows in the colostrum mob but is generally prohibited for cows once they join the milking herd.

It is widely practiced overseas where environmental mastitis is more prevalent. The typical protocol involves:

1. **Pre-clean** teats as necessary.
2. **Strip** – Foremilk strip to check for clinical signs
3. **Dip** – Apply registered pre-dip and allow contact time.
4. **Dry** – Wipe off teat dip with single-use towels or cloths.
5. **Apply** – Attach teat cups.

Pre-milking teat disinfection has three recognised effects:

1. Milk quality

Pre-milking udder preparation can reduce bacterial counts and sediment in milk if performed properly (Galton *et al* 1984, 1986). However, poor wiping with iodine-based disinfectants can lead to significant iodine residues in milk. Effectiveness of pre-milking disinfection is also reduced if cows' teats are wet and dirty. These should be washed and wiped before the pre-milking disinfectant is applied.

2. Udder health

Evidence for reducing mastitis risk is mixed. Some studies show reduced mastitis risk from environmental pathogens (Pankey *et al* 1987; Galton *et al* 1988), while others found no reduced risk (Hillerton *et al* 1993).

NZ research found no added benefit of pre-milking disinfection alongside post-milking teat spraying for controlling *Strep. uberis* infections in early lactation (Williamson & Lacy-Hulbert, 2013). Only approved products should be used, and manufacturer instructions followed to avoid milk contamination.

3. Milk let-down

The role of udder preparation in stimulating milk let-down response is not well understood in NZ. Research shows minimal benefits of foremilk stripping prior to applying the cups, for shortening milking duration (Edwards *et al* 2013a).

Dairy water quality

Good quality water must be used in dairies for teat preparation, making up teat disinfectants and cleaning the plant and equipment. NZ dairies must meet the water quality standards for Farm Dairy Water set out in the MPI Animal Products Notice: Production, Supply and Processing (MPI, 2025). This requires that all water that may come into contact with raw milk intended for manufacture of dairy products must meet the following criteria:

- does not result in microbiological, chemical and physical contamination of the raw milk;
- has *E. coli* absent in 100ml; and
- turbidity of maximum 5 NTU (Nephelometric Turbidity Unit) or clarity that is equivalent to 5 NTUs when tested.

➜ **Technote 7.5** discusses water quality for teat disinfectant solutions.

Udder and tail clipping

A major source of bacteria and organic matter that enters the bulk milk is from the teat, udder and tail switch. Hair is a good base for organic matter to collect and accumulate. Clipping the tail switch helps reduce contamination on the udder.

A hairless udder also collects less manure and dirt and is easier to clean. Significantly more water accumulates on a hairy udder than on a smooth one. Udders are easier to clean, and keep clean, if udder hair is kept short by clipping.

5 Teat cup attachment technique and timing

Cows respond well to consistent routines. Visual and auditory cues in the dairy can trigger milk let-down, especially in early lactation. Consistency and gentle handling are key to cow comfort and milker safety. The golden rule is to choose a set of procedures that support each milker to be consistent at every milking.

Overseas research has debated the timing of cup attachment to support more efficient milking, better teat condition, and potentially higher milk yields per cow (Hamann & Dodd 1992; Reneau *et al* 1994). The optimal window is considered to be 60-90 seconds after initial teat stimulation (Reneau *et al* 1994), and the main purpose is to prevent teat cup crawl during the first minute of milking. This is where cups crawl up the teat before full milk ejection has occurred and potentially restrict milk flow once peak milk flow has finished.

However, the impact under NZ conditions remains unproven. NZ research on pre-milking preparation found that delaying cup attachment by up to 45 seconds did not affect yield or milking time, and foremilk stripping reduced milking time by only 18 seconds (Edwards *et al* 2013a, 2013b).

The first touch by the milker (the signal to trigger milk ejection) can be one of the following:

- foremilk stripping;
- pre-wiping teats;
- brief manual palpation of each quarter (to feel for hot or hard quarters); or
- brief rub-down of each teat to remove loose dirt.

Identifying early cup attachment

As a simple check, watch the claw bowls during the first minute of milking. When teat cups are applied too soon, milk flow into the claw bowl typically slows or stops after about 15-20 seconds of initial flow, then full flow does not start (or restart) until about one minute after cups on.

Cup attachment technique

Minimising air admission during cup attachment helps maintain vacuum stability and prevents cluster slip. Sudden air inrushes can create milk slugs, reducing milkline carrying capacity and causing vacuum fluctuations. These irregular vacuum fluctuations may be severe enough to cause other clusters to slip or fall. The sizing of milklines has changed to improve the effective carrying capacity of the milkline, thereby improving stability of the milking vacuum during cup attachment. The relationship between air admission and the carrying capacity of milklines is acknowledged in international guideline tables for sizing milklines (ISO, 2007).

➜ DairyNZ **MilkSmart** describes different cupping techniques and procedures.

6 Machine stripping and its effect on udder health

Machine stripping refers to the practice of applying weight to the milking cluster at the end of milking to reopen the connection between the udder cistern and teat sinus, potentially removing residual milk.

The relationship between completeness of milking and mastitis risk is debated. Older publications reviewed by O'Shea (1987) suggested increased mastitis when machine stripping was omitted, while more recent research found no increase in infection rates when small amounts of milk were left in the udder (Rasmussen 1993; Burke & Jago 2010), and in some cases, higher SCC counts were associated with machine stripping (Clarke *et al* 2008). This may be due to sudden air admission during vigorous machine stripping, which can destabilise the vacuum and increase cluster slip, leading to impacts and elevated mastitis risk.

Additional weight on the claw can unbalance the cluster, increasing the likelihood of cup slippage and vacuum fluctuations. New Zealand studies (Jago *et al* 2010b; Edwards *et al* 2022) show that truncating milking time of the slowest milking cows does not adversely affect milk yield or mastitis incidence, suggesting that complete milk removal may not be necessary for udder health (see section 8).

7 Correct teat cup removal

For optimal cow comfort the recommended method for manual removal, as outlined in the **Healthy Udder Guide**, involves:

1. **breaking the vacuum** by kinking the long milk tube or closing the clamp near the cluster,
2. **waiting a couple of seconds** for the vacuum to break and
3. **gently twisting the cluster** to ensure all four teat cups release simultaneously.

Automatic cup removers (ACRs) can also provide a consistent and gentle detachment process.

The technique used when removing teat cups is often more important for mastitis risk than the timing of removal.

8 Selecting an appropriate end-of-milking time

There are many misconceptions about the timing of cup removal and how this may affect mastitis risk. The main goal of efficient milking is to find a balance between removing milk from the majority of glands in a time-efficient manner whilst minimising production losses through leaving too much milk behind.

Shorter milking times can be achieved by increasing the milk flow rate threshold at which the automatic cluster removers (ACR) cups are activated and/or by using a time-based approach, by applying a preset maximum machine-on time, to truncate the milking of a proportion of the slower milking cows.

Both methods reduce the duration of cups-on time, especially when teats are likely to be exposed to the full milking vacuum, with minimal milk flow. This process contributes to 'overmilking', which can lead to teat end congestion and damage if applied for more than 2 minutes (Edwards *et al* 2013c). Severe teat end damage and hyperkeratosis can increase the risk of new infections (Neijenhuis *et al* 2001; Pantoja *et al* 2020) but the degree to which incomplete milking increases mastitis risk has not been proven.

➜ **Technote 6** details how to monitor and maintain milking machine function during lactation.

Milk in a time-efficient manner

Milking in a time-efficient manner helps reduce cups-on time for individual cows, as well as overall milking time. Studies that altered ACR threshold settings reported no difference in milk yield, mastitis or SCC when flow-rate thresholds were raised:

- from 200 to 400 mL/min in short-term studies in Denmark (Rasmussen 1993)
- from 200 to 400 mL/min for a whole lactation study in NZ (Jago *et al* 2010a)
- from 300 to 800 mL/min to achieve incomplete milking in cows with sub-clinically infected quarters in Australia (Clarke *et al* 2008)
- from 0.2 kg/min to 0.8 kg/min in short-term studies in NZ cows (Edwards *et al* 2013a, 2013b).

Studies using a pre-set maximum milking time to achieve shorter milking times also achieved similar results (Jago *et al* 2010b), whereby the maximum milking time was set at the 70th percentile of a group of cows, ordered from shortest to longest milking time.

Minimise losses in milk production

Under milking (i.e. incomplete milking) means that an unacceptable amount of milk is left in the udder after teat cups are removed, in the majority of glands. Milk left in the ducts or udder cisterns is referred to as 'available milk' or 'strippings' and can be removed through hand stripping after the teat cups are removed, or by reattaching the milking machine. Milk left in the clusters of secretory cells (alveoli) is referred to as 'residual milk' and requires an intramuscular injection of oxytocin to allow collection, by machine stripping or by hand-stripping. This milk typically represents 1-3 kg or about 10-20% of total milk in the udder.

Completeness of milking can be assessed by visual assessment of the udder shape, by measuring the volume of milk that can be machine-stripped from the udder after re-attaching the milking machine, or by hand-stripping individual quarters and measuring the volume, or counting the number of 'easy' strips that can be removed in 1 minute (Meyer *et al* 2019).

➜ **Technote 6.2** gives guidelines for assessing completeness of milking of individual cows, including definitions of good, poor and uneven milk out.

Published evidence on the relationship between completeness of milking and production losses has evolved. Early work indicated a reduction in lactational milk production of about 3% when 0.5 kg of milk was left in the udder after milking (Dodd & Griffin1979). This compared to an estimated <0.25 kg strippings per cow to remain if clusters are correctly designed, maintained and applied (Mein & Reid 1996).

Increasing strip yields to 530 mL from 300 mL per milking did not affect SCC or milk production for cows with infected or uninfected quarters (Clarke *et al* 2008). In fact, higher stripping volumes tended to be associated with higher SCC quarters, rather than be a cause of high SCC quarters.

Applying substantial levels of incomplete milking (i.e. 25% of the quarter yield) from 5 days in milk was sufficient to prevent the rise in milk volume typically observed as cows approach peak production (Penry *et al* 2017), in a split udder experiment. Changes in milk composition from quarters that were incompletely milked were indicative of changes induced by switching to once daily milking, and not necessarily an increase in mastitis.

Identifying herds where under milking is problematic cannot rely solely on assessment of strip yields in individual cows. Incomplete milking may be a symptom of a poorly operating milking system, rather than a direct cause of a mastitis problem. Conducting a full milking time investigation is the preferred approach for identifying herds with problematic under milking.

➜ **Technote 13** and the **Mastitis Investigation Kit** provide a systematic approach for conducting a full milking investigation.

With the large amount of research conducted on adoption of shorter milking times, the completeness of milking has become less relevant, although gross or unbalanced milking between the different glands within the udder should be noted.

Minimise over-milking and risk of mastitis

Milking in a more time-efficient manner helps to reduce the degree of over-milking experienced by some or all cows in a herd. Over-milking can lead to increased risk of teat end damage, which in turn, can lead to an increased risk of new infections.

Over-milking occurs when teat cups remain attached to the teats after milk flow has fallen below an arbitrary 'end-point of milking', (commonly 200 mL/min in NZ, or a 'dribble in the bowl'). Some over-milking is inevitable because individual quarters milk out at different times. Both field experience and research studies indicate that:

- A moderate amount of over-milking (say 1 or 2 minutes) has minor effects if the milking system is functioning correctly.
- Over-milking for 5 minutes per cow induced marked changes in the firmness of teats after milking (Hillerton *et al* 2002) and an increase in mastitis risk when applied in conjunction with pulsation failure (Mein *et al* 1986).
- Regular over-milking can lead to thickening of skin at the external teat orifice and increased teat congestion and oedema (Hamann 1987, Hamann *et al* 1994, Olney & Mitchell 1983).
- Higher ACR thresholds of ≥400 mL/min led to improved teat condition and cow behaviour for high-producing herds in the US (Rasmussen 1993). Fewer cows developed clinical mastitis in the early detachment group.

Situations most at risk of excessive over-milking are those with large numbers of bails per operator and no ACRs. These can be solved through:

1. **changing milking routines** (see **dairynz.co.nz** for MilkSmart tips on cupping procedures that reduce over-milking) or
2. **changing machine and/or ACR settings** (see an NZMPTA-registered milking machine consultant for assistance).

➜ **Technote 9.2** describes the changes to teats associated with over-milking.

Shorter milking times

Research in Australia and New Zealand arising from Rasmussen's research has identified no adverse effects when setting a maximum time limit for milking slow cows, with marked reductions in the time required to milk herds. The initial goal, set for Australian conditions, was to remove clusters from about 80% of cows at a flow-rate threshold of 0.4 kg/min while truncating the milking time of the slowest 20% of cows, thereby inducing some under milking in these cows.

The Australian studies reported:

- Up to 35% of normal milking time of slow milking cows could be saved when maximum milking durations were applied, with no adverse effect on daily milk yield, milk composition, teat condition or cow behaviour (Clarke *et al* 2004).
- No effects on clinical mastitis incidence or SCC for healthy quarters or those sub-clinically infected with *Staph. aureus* or *Strep. uberis* when early termination of milking was applied (Clarke *et al* 2008).

Subsequent studies in New Zealand confirmed and extended these results:

- Truncating the milking of slow cows could be started before cows reached peak lactation (Jago *et al* 2010a)
- More aggressive application of shorter milking times, by truncating the milking time of 30% of cows, had no detrimental effects (Burke & Jago 2011; Jago *et al* 2010b)
- Increasing flow rate thresholds from 0.2 to 0.8 kg/min shortened milking duration of affected cows by 18-25% and increased strip yields but had no detrimental effects on SCC or milk production (Edwards *et al* 2013a, 2013b)

A herd's Maximum Milk-Out Time (MaxT) depends on the average milk production per cow per milking.

- For example, 80% of cows in a typical herd, where cows are producing an average of 10 L at a single milking, will be milked in 6.3 minutes.
- If MaxT is applied at the suggested target of 80%, then the slowest 20% of cows in that herd will have their milkings truncated when clusters are removed after 6.3 minutes (6 minutes, 15 secs).

The following guidelines can be used for setting MaxT for herds at different production levels (see Table 4).

Table 4. Guidelines for milking times for cows of different production levels

Average milk yield at a single milking	Time in which 80% of cows should have completed milking (min:sec)
10 L/milking	6.3 minutes (06:15)
12 L/milking	7.2 minutes (07:10)
14 L/milking	8.0 minutes (08:00)
16 L/milking	8.7 minutes (08:45)
18 L/milking	9.5 minutes (09:30)
20 L/milking	10.2 minutes (10:10)

Practical guidelines for setting MaxT

Fixed time cluster removal can sometimes feel hard to implement in the farm dairy so training posters are available to help apply MaxT. In a herringbone dairy, set cluster removal at a Fixed Time that allows about 80% of the cows to finish milking. Follow routines such as:

- Not waiting for all the cows to row up before cupping
- Cupping cows in batches of 5-10 cows, working from exit to entry, teat spraying as you go
- Being brave and letting the row go once beyond the half-way point in the row.

In rotaries, select a platform rotation time and apply a strict policy of no 'free riders' - no cow goes around twice unless there is a specific reason (e.g., the cluster had been kicked off).

In summary, guidelines to avoid under and over-milking, and shorten herd milking times include:

1. Aim to milk **most** cows as completely as possible, within a reasonable time, at every milking. This assumes a minimum ACR threshold setting of 400 mL/ min for herds milked once or twice daily.
2. Aim to milk **all** cows out as evenly as possible. This is important as uneven milk-out contributes to uneven distribution of milk yield between quarters, leading to less uniform udder conformation, which reduces the ease and efficiency of machine milking.
3. Don't wait around for slow cows to finish milking. Instead, remove clusters from slow-milking cows based on the herd's expected MaxT, or remove clusters from the last 10-15% of cows milking in any one batch.

➜ Posters for the farm dairy are available at **dairynz.co.nz** to support farms applying MaxT for more efficient milking.

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Technote 6

Monitoring and maintaining milking machine function

In this technote:

It is important to remain vigilant throughout lactation to ensure milking machines operate correctly and are used properly. Poorly functioning machines can contribute to new intramammary infections, either directly or indirectly (O'Shea 1987; Mein *et al* 2004; Upton *et al* 2025), through:

- spreading bacteria between teats and cows;
- damaging teat health and natural defence mechanisms; or
- reducing efficiency of milking and udder evacuation.

Milking machines are designed to harvest milk efficiently while maintaining healthy teats. Teats spend 50-100 hours attached to the machine per lactation, so understanding how the machine affects teat tissues highlights the importance of regular maintenance.

Components of a milking machine are described in the Figure on page 3.

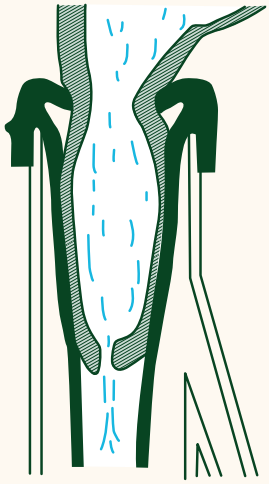
① Milking machine function and its effect on udder health

Milk flow phase of each pulsation cycle

During the milk-flow phase, the teat is drawn into the liner and stretches to conform to the internal dimensions of the liner. The vacuum in the mouthpiece cavity of the liner keeps the liner in position.

Stretching of the teat walls, and movement of milk due to the pressure difference between the teat sinus and open liner of the teat cup, causes the teat canal to open and milk to flow (Figure 1). The teat end is constantly exposed to vacuum, and fluid accumulates in the blood vessels and tissues around the teat end.

Figure 1. When the liner is open

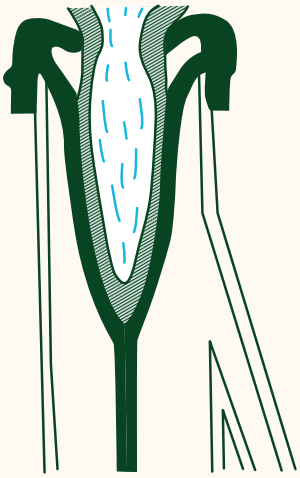


Machine milking creates a pressure difference that causes milk to flow, and the teat canal to open.

Closed phase of each pulsation cycle

Closure of the liner compresses the teat. As the 'compression' phase commences, the collapsing liner places most of its compressive force on the teat end and very little on the teat barrel (Figure 2). This massage phase helps redistribute fluid drawn into the teat end under vacuum, back up through the teat tissues, thereby reducing teat end congestion.

Figure 2. When the liner is closed



Pulsation provides a massaging action to keep the teat healthy

End of milking

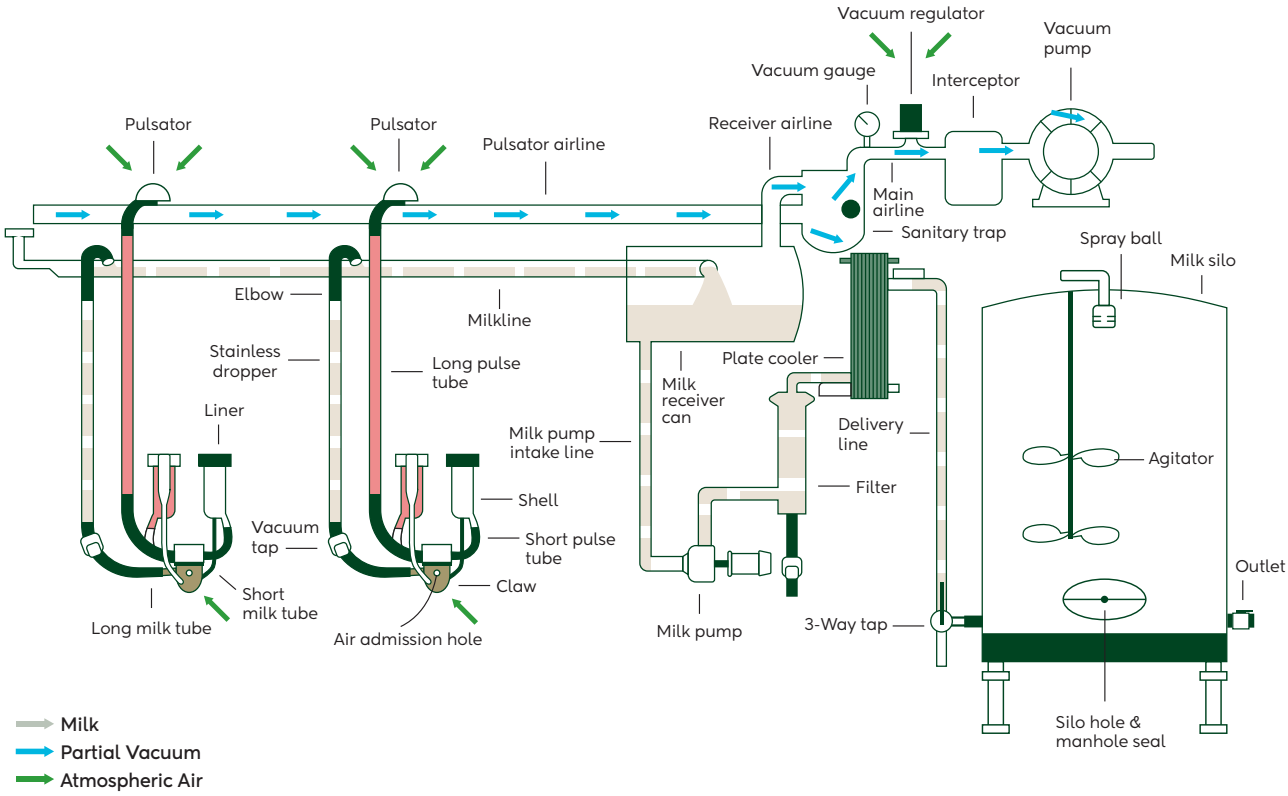
Each cluster has a small vent that admits air into the claw bowl during milking. This air admission hole is especially important at the end of milking, to allow the vacuum to equalise with atmospheric pressure, when the milkline is pinched shut or closed during cup removal. Blocked holes prevent the vacuum from equalising and can increase the risk of teat impacts, or rapid movement of milk droplets towards teat ends during cup removal.

Optimal milking machine operation must *"balance speed, chosen completeness of milking, and gentleness on teat tissue to support efficient milk removal and optimal udder health"* Upton *et al* (2025).

Field experience shows that mastitis problems are often resolved by fixing simple problems such as unsuspected high vacuum, pulsator or liner problems, or by clearing blocked air vents. Furthermore, teat condition is usually improved by greater attention to minimizing overmilking.

A regular, detailed and comprehensive analysis of milking machine function is necessary to define and correct problems.

Figure 3. Components of a milking system



Definitions of the components of milking machines are given in ISO 3918: 2007 Milking machine installations – Vocabulary. (ISO 2007a)

② Use the daily, weekly and monthly guides to check machine function

Inadequate routine maintenance of mechanical components and rubberware will, in time, cause the milking machine to function poorly, leading to a greater risk of mastitis. Regular, systematic checks (see Table below) aids early detection of problems, encourages preventive maintenance and enables basic trouble-shooting (Mein 1997).

Recommended daily, weekly and monthly checks of milking machine function

Daily checks[1]	Weekly checks[1]	Monthly checks[2]
Check air admission holes (vents).	Check for twisted liners.	Check regulator function.
Check the vacuum gauge.	Check rubberware for damage.	Check for perished and damaged rubberware.
Listen to the pulsators.	Check filters on pulsators or on filtered air supply lines.	Assess completeness of milking and milking times.
Watch milk entering the receiver can to ensure minimal slugging.	Count cup squawks and slips requiring correction by milker.	Check for damaged teats. Assess teat skin condition and teat end scores.
Check teats as cups come off.		
Note cow behaviour.		

[1] These tasks should be assigned to members of the regular milking team.

[2] These tasks should be the responsibility of the herd manager, with a trusted adviser.

Milking-time tests

These daily, weekly and monthly checks of milking machine function align with five milking-time tests that monitor teat condition, cow behaviour, average milking time, completeness of milking, and frequency of slipping or falling teat cups. A detailed description of each milking time test is given below.

1. Machine function and teat condition

Teats should be as soft and supple after milking as before milking. Teat tissue undergoes both short-term and long-term changes in response to the forces experienced during milking. Generally, changes in the teats due to machine milking are most obvious at the teat end:

- Teats that are slightly swollen or hard (due to congestion or oedema) or slightly blue or purple in colour (cyanotic) after milking result from machine-induced circulatory impairment.
- Teats that are thicker (with fluid) after milking may be due to use of wide-bore liners, or milking at high vacuum level (Hamann *et al* 1994).
- Cyanosis or oedema around the teat end or lower barrel indicates a pulsation failure such as insufficient collapse phase of pulsation, short teatcup liners or liners with insufficient tension.
- Cyanosis or oedema around the upper barrel of the teat may be due to liners with hard mouthpiece lips or high mouthpiece vacuum (Hillerton *et al* 1998, Ramussen 1997) or to overmilking or prolonged milking.

Machine milking can aggravate all types of teat lesions. It is the main cause of hyperkeratosis (teat canal or orifice), radial cracking, petechial haemorrhages (tiny blood-blisters) near the teat end, and may exacerbate teat chapping. Secondary infections that establish within teat lesions may present as 'black spot'.

➜ **Technote 9.2** describes how to assess teat skin and teat ends.

Early signs, like oedema and small haemorrhages heal quickly but may be early warning signs of a machine problem and increasing mastitis risk. Even 5 minutes of overmilking for 4 milkings can cause tissue damage (Hamann *et al* 1994), and significant changes in hyperkeratosis were detected when 5 minutes of overmilking was applied over a 6 week

period, compared to 2 minutes (Edwards *et al* 2013c). Regular checks of vacuum level, pulsators and liner suitability will help avoid teat damage.

2. Machine function and cow behaviour

Signs of cow discomfort or nervousness during cup attachment or removal can signal issues with milking machine function (Hillerton *et al* 1998). Shorter milking times, achieved through lifting the threshold for automatic cup removal, can also lead to reduced kicks and steps (Upton *et al* 2023). The frequency of stepping or kicking (the Kick Step or KiSt response) indicates levels of comfort/discomfort with the machine, and can be monitored objectively:

Guidelines for observing cow behaviour:

- **Step:** Hoof lifted clear of the floor. This involves a significant and deliberate shift in weight for the cow, making it easy to observe and record.
- **Kick:** A hoof aimed at cluster or operator or deliberate attempts to remove the cluster.
- One observer can monitor the rear legs of up to four cows at any one time, provided they stand out of the way.
- Kicks/steps with time stamps are recorded as the 'KiSt response' during specified events such as:
  - Waiting in the stall or bail to be milked - indicates issues with the environment such as flies or poor stall design.
  - Udder preparation, cup attachment, reattachment and cup removal or at post-milking disinfection – indicates issues with interactions between operator/cow, or machine/cow.
  - First and last 2 minutes of milking – indicates issues with milking machine function.
- Analyse the data as proportion of cows exhibiting 0 or 1, 2-4, 5-10, or >10 'KiSt' responses at different periods of milking.

A video camera, set up to record 1-2 hours of milking, can be used *in lieu* of direct observations. This can provide an effective means of demonstrating and analysing behavioural responses with minimal interruption to the normal milking routine. The sensitivity of teats to being touched can also be assessed by manual palpation just after milking (Hillerton *et al* 1998). But results in commercial herds will depend on how much cows are accustomed to being touched after milking.

➜ **Technote 13** provides more information on how the **Mastitis Investigation Kit** enables objective assessment of cow behaviour at different stages during milking.

3. Milking time guide

Field studies in France (Billon 1993) and the United States (Stewart *et al* 1993; Thomas *et al* 1993) show significant, consistent regressions between average milking time and average milk yield per cow per milking.

A way to assess machine function is to measure the average time taken to milk a sample of cows, where average cow milk yields are estimated from vat yield divided by the number of cow-milkings in the vat.

For herds operating without automatic cup removers (ACR) or operating with ACR at 200 mL/min, 80% of cows in a typical Australian or New Zealand herd should milk out within a particular time, related to the average yield. These yields and milking times are summarised in the Table below.

Guidelines for milking times for cows of different production levels

Average milk yield at a single milking	Time in which 80% of cows should have completed milking (min:sec)
10 L/milking	6.3 minutes (06:15)
12 L/milking	7.2 minutes (07:10)
14 L/milking	8.0 minutes (08:00)
16 L/milking	8.7 minutes (08:45)
18 L/milking	9.5 minutes (09:30)
20 L/milking	10.2 minutes (10:10)

Under these circumstances the expected strip yields, after cluster removal, should be 100 mL or less per gland. For herds with higher ACR settings, e.g. 400 mL/min, larger strip yields and/or shorter milking times will be observed.

➜ **Technote 5.8** describes the effects of under and overmilking and how to achieve shorter milking times in herds.

MaxT and shorter milking times

Research has shown that taking the cups off at a pre-determined Maximum Milk-Out Time (MaxT) saves time without affecting milk production, quality, mastitis or SCC (Clarke *et al* 2008; Jago *et al* 2010 a, b; Edwards *et al* 2013a, b; Upton *et al*, 2023).

A herd's MaxT depends on the average milk production per cow per milking. So if MaxT is applied at 80%, then the slowest 20% of cows would have their milkings truncated by removing clusters after 6.3 min.

4. Completeness of milking

Assessing completeness of milk-out of individual quarters helps identify machine or technique issues. With shorter milking times and MaxT showing benefits for mastitis risk and SCC, reducing overmilking is now more important than concerns about minor undermilking. The focus should therefore be on detecting poor milk let-down or gross undermilking of specific quarters, rather than residual milk volume.

The standard approach involves hand-stripping each quarter of an udder into a measuring container after cup removal and recording the volume of milk. Practical alternatives are described in the Table below.

- The qualitative assessment provides a practical alternative for herds where hand-stripping would be impractical or too risky, due to cows being unaccustomed to having their teats handled after milking.
- The semi-quantitative approach, involving partial hand-stripping helps improve diagnosis when used in combination with the qualitative assessment.
- Machine stripping, by reattaching the cups and holding down on the claw until milk flow stops may be possible where milk meters are permanently installed. This can provide a more reliable and repeatable measurement method compared to the more qualitative methods.

➜ **Technote 5.8** discusses the effect of incomplete milking (poor milkout) on mastitis and yields.

Guidelines for assessing completeness of milk-out as an alternative to full hand stripping

Record milk-out as:	Qualitative assessment	Semi-quantitative (hand-stripping of individual quarter)	Machine-stripping (based on whole udder)
G (Good)	Quarter is visibly wrinkled	5 or fewer easy strips (equating to <50 mL per quarter)	Less than 500 mL per udder
P (Poor)	Quarter appears slightly plump, possibly indicating unharvested milk	10 or more easy strips (equating to more than about 100 mL per quarter)	More than 500 mL per udder
U (Uneven)	One particular quarter appears plumper and less wrinkled, relative to the other quarters		One particular quarter appears plumper and less wrinkled, relative to other the quarters

Inconsistent strip yields in rear versus front quarters, or between quarters on the right side versus left side, usually indicates a problem of poor cluster positioning and/or cluster weight balance.

The most common causes of incomplete milking are:

- poor type or condition of the liner,
- clusters that do not hang evenly on the udder because the connecting hoses are too long, too short, twisted, or poorly aligned in relation to the cow,
- cup crawl caused by e.g. clusters that are too light when a wide bore liner is used or the vacuum is set too high,
- high or low milking vacuum levels; and
- a mismatch between the claw inlet and the short milk tube causing partial closure of the short milk tube where this tube joins the claw.

5. Frequency of slipping or falling teat cups

A slipping teat cup, or liner slips or squawks, disturbs the milking routine and may lead to problems with vacuum stability. Early research suggested slips could lead to 'impacts', the propelling of bacteria-laden milk droplets back towards the teat end of adjacent teats, due to vacuum fluctuations.

Early experimental studies by O'Shea (1987) demonstrated a link with new infection rates but larger scale trials could not support this. Cluster designs that specifically prevented impacts, such as fitting of deflector shields or one-way valves between the short milk tube and claw led to a reduction in new infection rates (Griffin *et al* 1980; Binde *et al* 1989) but the benefits were not sufficient for commercial adoption.

Improvements in cluster design and weight, and larger bore, long milk tubes have all improved vacuum stability (Upton *et al* 2025) and likely reduced the consequences of liner slip. Nevertheless, the need for a person to manually adjust a slipping teat cup disturbs the milking routine, adding to milker dissatisfaction with milking (Wieland &f Sipka 2023), and potentially affecting cow flow and risk of overmilking. It may also lead to adjustments in the milking vacuum to compensate, which may create another risk factor for mastitis.

The incidence of slipping or falling teat cups can be assessed by careful observation. Mein & Reid (1996) suggested that slips or falls requiring correction by the milker(s) should be fewer than 10, and preferably fewer than 5, per 100 cow-milkings. Liner slips or falls early in milking often result from:

- poor cluster alignment (including uneven weight distribution in the cluster),
- low vacuum,
- poor liner condition,
- mismatch between liner type or shape and cluster weight, bowl volume, or teat shape,
- blocked cluster air admission holes.

Liner slips late in milking are more associated with rough cup removal and not allowing the vacuum to equilibrate.

Documentation of monthly checks of machine function

Regular documentation ensures early detection of issues before they impact teat health or mastitis risk.

Results of the monthly checks should be recorded so trends can be assessed regularly. A standard place, such as an exercise book, wall calendar, pocket book, electronic file or dairy company record-keeping system may be used.

Monthly checks will help detect subtle changes due to wear and age in rubberware and equipment. For example, checking the effective reserve of the vacuum pump and regulator function can be achieved by keeping a monthly record of the vacuum with one or two milking units open. This is a simple method to test for possible deterioration in the reserve vacuum pump capacity (due to pump wear, air leaks, or regulator performance). More complex, automated milking systems may require checks that sensors are still working as expected.

③ When to call a milking machine technician

Refer to a milking machine technician, registered and certified by the NZ Milking and Pumping Trade Association (NZ MPTA), if concerned about the functioning of the milking machine.

They can test the following:

- Ensure the vacuum levels and airflows are appropriate for the machine
- Check pulsators are working properly and service faulty ones
- Check sensors and help correct faults promptly.

④ Change liners as per recommendations

Teat cup liners are manufactured from natural or synthetic rubber (commonly nitrile) or silicone, and are designed to:

- form an airtight seal at both ends of the shell,
- fit a range of teat sizes and shapes through different mouthpiece and barrel dimensions,
- minimize liner slips and cluster fall-off,
- allow rapid, complete milk-out, while minimising teat congestion, discomfort and injury, and
- be easy to clean.

During milking, liners flex and collapse with each pulsation, massaging the teat. When correctly matched to the teat cup, liners should be stretched 5-16% beyond their original length. Some liners include two or more 'tension notches' to accomodate shells of slightly different lengths. Over-stretched liners may provide good milking characteristics but are more likely to cause teat damage (Hillerton *et al* 2003).

Once in use, liners progressively lose tension, absorb milk fat, and harbour bacteria. Deterioration is accelerated by mechanical tension, exposure to sunlight, heat, cleaning chemicals and ozone (e.g. near motors). Material type, storage, cleaning, and usage patterns all influence liner lifespan.

Poor storage can result in liners being effectively expired before first use, e.g., when new liners are fitted before dry off and left under tension for the entire dry period. Perished liners reduce milking speed and completeness, increase teat-end damage, and increase the risk of mastitis spread.

Recommended liner replacement intervals are:

- **Rubber liners : ~2,500 cow milkings**, or 5 months, whichever comes first.
- **Silicone liners: ~5,000 cow milkings**

Despite their longer life, silicone liners are more prone to tearing and puncture, particularly if stepped on by the cow.

Because liner deterioration is often underestimated, regular monitoring is essential. Daily, weekly and monthly checks of milking times, milking completeness, teat-end condition, and cup squawks or slippage help identify liner-related problems early.

➜ Information is available on the DairyNZ website to help farmers calculate the life of rubber liners in their herd. An example is available at **Teat cup liners - DairyNZ**

"If you notice a difference when you renew liners, then the old ones were on too long."
- Graeme Mein

Choose liners that are compatible with shells, claw inlets, jetters and teats

When selecting liners, **choose liners that are part of a manufacturer's chart of recommended matching combinations**. This strategy minimizes potential compatibility problems and warranty issues.

Key aspects to consider (Fox *et al* 2009) include:

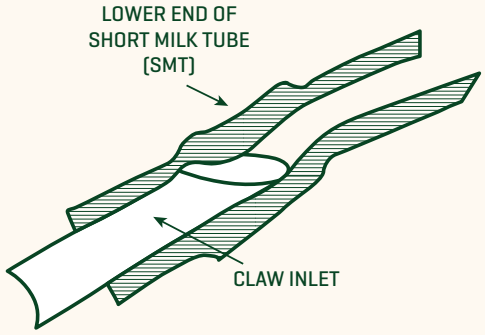
1. **Ensure that liners fit the shell**

- Liners should seal airtight in the shell, resist twisting and the barrel can be stretched between 5-16% of its original length when mounted in the shell. The liner mouthpiece should not distort. Check that the size and shape of the mouthpiece lip does not change substantially when mounted in the shell.
- Check the liner is held firmly at the bottom of the shell, without air leaks or easy twisting of the liner in the shell. Make sure the internal diameter of the short milk tube (SMT) is not pinched where it connects with the shell - hold the liner up to the light and look through it to ensure that the shell does not noticeably constrict the SMT.

2. **Ensure that liners fit the claw nipples**

- Check manufacturer's tables for the SMT recommended for the teat cup.
- The internal diameter or bore of the SMT should be 2-3 mm narrower than the external diameter of the claw inlet or nipple.
- Excessive stretching of the SMT will make it more prone to 'stress cracking' and splits if a cow kicks or steps on the cluster.
- An overstretched SMT may also restrict milk flow from the SMT into the claw as illustrated in the Figure.
- Check that the vacuum cut-off region in the SMT is compatible with the shape of the claw inlet. Some combinations prevent the milking vacuum from being shut off when the teat cups hang down, during cup attachment.

Restriction to milk flow that can occur at the claw inlet



Note the milk flow path from the teat cup into the claw is partially restricted at the point where the flexible SMT is connected to the rigid claw inlet.

3. **Ensure that liners are compatible with the jetters**

- Try before you buy. The liner needs to stay in or on the jetter during the wash cycle without substantial leaking of air so the CIP (cleaning in place) system can operate effectively.
- Watch out for mouthpiece distortion if the liner mouthpiece does not match the jetter correctly.

4. **Ensure that liners match the average teat size for a given herd**

- As a general rule, select liners that favour younger cows rather than older ones. Using for example, large bore liners to get faster milking of old cows, will be self-defeating, causing teat stress or discomfort for younger cows.
- Liner bore. As a general guide, medium bore liners, with a mid-barrel bore of 21.5-24.5 mm measured 75mm below the mouthpiece lip, are suitable for average teat diameters of about 23.5 mm, which is typical for most NZ herds.
- **Effective length of a liner when mounted in its shell**. Early research identified that pulsation often failed on cows with long teats, causing them to be pulled too deeply into the teat cup, leading to insufficient squeeze of the teat end, and more mastitis. Liners with longer effective length were developed to avoid this problem of pulsation failure. Nowadays dairy breeding

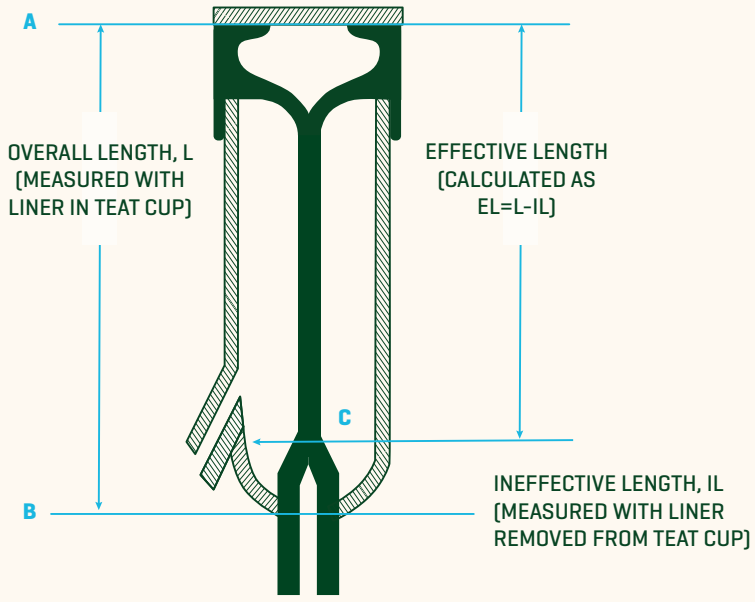
and selection programs have resulted in shorter teats for NZ cows and it is rare to see teats that are more than 75 mm long now, however, it is still useful to know how to calculate the effective length of a given liner (see Figure below). Assuming that 95% of teats are not more than 75mm in length, then a minimum effective length of about 135mm would be adequate for most liners and herds.

- **Mouthpiece ineffective length.** If the mouthpiece or lip cavity is too deep (>25 mm), very short teats do not get adequate support from the liner barrel when it is open, or a proper squeeze from the closed liner. These teats receive insufficient relief from the milking vacuum.
- **Compressive load.** The effects of compressive load applied by the closed liner is illustrated in the Figure on next page (Mein & Reinemann, 2009), and involves an interaction between vacuum, pulsation settings and liner design (Penry *et al* 2018). Very short teats get little or no squeeze, especially if the mouthpiece cavity is too deep. Some long teats also get little or no squeeze because the liner cannot collapse beneath the teat-end

Final selection of the 'right' liner

Final selection is always better done on the farm. Check the milking performance of liners on your 'short list' using the five key milking-time observations described in this Technote.

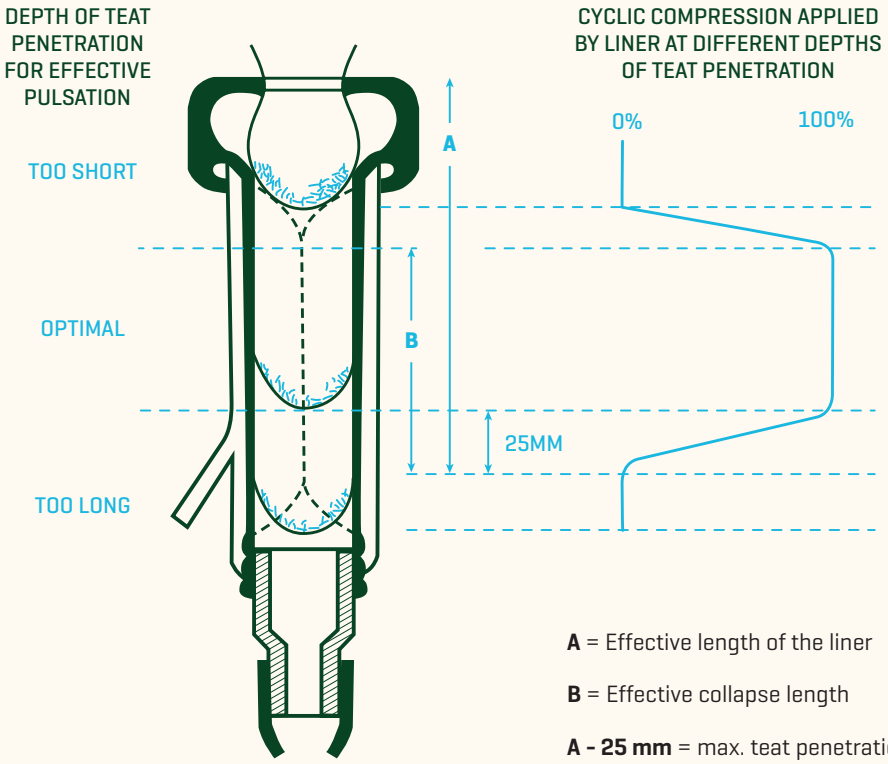
Measurement of the effective length of a teat cup liner



Effective length of liners (EL=L-IL)

Ineffective length (IL) can be measured by removing one liner from its cup and connecting it to the milking machine vacuum while sealing the mouthpiece (e.g. with the palm of a hand). Mark the lowest point on the liner barrel where the two sides are flattened against each other (point C). Measure the distance from point C to the point on the liner tensioning ring (point B) which will be in contact with the bottom of the teat cup shell.

Degree of compression applied by a closed liner around teats that penetrate to different depths within a liner. Effective pulsation occurs when the teat end remains in the 'Optimal' region.



A = Effective length of the liner

B = Effective collapse length

A - 25 mm = max. teat penetration for effective pulsation

A - B = min. teat penetration for effective pulsation

5 Milking machine testing and servicing

Regular testing and servicing are essential to maintain effective machine performance, optimise milking speed and completeness, and reduce mastitis risk. Routine monitoring of key milking-time indicators, such as teat condition, cow behaviour, milking time and completeness, teat cup slips and falls, provides early warning of emerging problems.

Do not rely **solely** on an annual service. Most milking machine servicing companies offer in-season test procedures for liners, vacuum and pulsators. Additional testing and service should be carried out immediately if:

- cows milk slowly or incompletely;
- teat cups slip or fall frequently;
- teat condition deteriorates; or
- cows show signs of discomfort during milking.

⑥ Use a milking machine technician who tests to NZMPTA standards

Machine tests should be performed and reported by technicians holding a current New Zealand Milking and Pumping Trade Association (MPTA) testing certificate.

Milking machine tests have been classified into five types (International Dairy Federation, 2000):

1. Physical measurements

This is conducted without the machine running and assesses system dimensions and component specifications, such as length, diameter and slope of pipelines, and weight and volume of clusters. It should be performed during an installation, after a major upgrade, or to ensure compliance with a contract of sale or service.

2. Dry test

This is performed with the machine running but not milking and involves assessment of vacuum and airflow measurements. This type of test has been described loosely, but incorrectly, as 'static testing'. It includes tests of vacuum levels and fluctuations in various parts of the system, vacuum pump and reserve capacity, and testing of pulsators. The standard MPTA test procedure is a comprehensive series of dry tests plus some physical measurements.

3. Wet test

This is performed with the machine running, with air and liquid (water, milk, or artificial milk) flowing through the machine. Equipment manufacturers or testing authorities typically perform wet tests in a laboratory, to assess vacuum level and fluctuations in pipelines and clusters, vacuum drop across components, and performance of automatic detachers and milk pumps.

Some wet tests may be suitable for on-farm diagnostics, for example, use of an artificial udder connected to one or more milking units to diagnose problems with slow milking or frequent cup falling, or to optimise system vacuum settings (Stewart *et al* 1996).

4. Cleaning-time or wash test

Wash tests or cleaning in place (CIP) tests assess wash system performance for the milking machine or bulk tank. They include tests of temperature, chemical concentration, water quality, flow rates and cycle times, and should be conducted when a new cleaning system is commissioned, or when quality grades or cleaning problems arise.

5. Milking-time or performance test

Milking-time tests describes observations made during milking and provides the most direct indicator of performance of any milking system (Mein 1992).

In NZ, performance testing is often undertaken by an NZMPTAregistered technician in collaboration with a veterinarian trained in milking performance and teat condition assessment.

Key machine-related tests include:

- mean vacuum and fluctuations in the milkline.
- vacuum and fluctuations in or near the receiver (unless milkline vacuum recording indicates changes of less than ±2 kPa); and
- claw vacuum during peak milk flow.

Practical assessments of the machine-cow interaction include:

- teat condition score immediately before and after milking
- cow behaviour:
  - any signs of discomfort (Kick Step or KiSt response) during cup attachment or removal?
  - are teats unusually sensitive to touch after milking?
- frequency of liner slips and cup falls requiring corrective action
- average milking time per cow relative to yield
- amount of 'available' milk remaining when cups are removed.

➜ **Technote 9** summarises changes in teat condition that may be seen when milking machines or liners are not performing optimally.

Use the **DairyNZ Mastitis Investigation Kit** record sheets to systematically record milking time observations. Practical vacuum measurements should be undertaken:

- within one month of commissioning a new system;
- after major servicing or upgrades; and
- whenever problems with milking speed, completeness, teat condition or cow behaviour are reported.

7 Obtaining a technician's report

In NZ, milking machines are tested using a dry test, modified from the recommendations in ISO 5707:2007 (ISO 2007b). This involves carrying out basic testing, then disassembling the machine into its separate components. As the machine is re-assembled, airflow tests are conducted as each component is re-connected. At the completion of the test, the machine should be fully re-assembled and working as it would normally.

The tester's reports should include:

1. Visual Faults Check

The Visual Check involves assessment of the way the plant has been installed, compared with industry and OEM (original equipment manufacturers) guidelines. It should include the way the machine is mounted, pipeline sizes, liner/shell compatibilities, milkline slope, drain points, obvious maintenance problems and obvious safety problems. Faults are marked with a cross (X) and comments or recommendations carried forward to the Summary form.

2. Test Report

The Test Report is used to record required performance tests, such as airflow and vacuum readings, vacuum pump and releaser milk pump tests and tests of the machine's vacuum gauge for comparison with industry and OEM standards. The Test Report should also include pulsation tests, with graphs attached.

3. Summary

The Summary form is used to provide clear recommendations for each fault identified. These should be brief but clear enough for either the farm manager or a subsequent machine technician to understand and rectify.

Ensure that identified faults are fixed promptly and the date and details recorded for future reference.

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Technote 7

Applying effective post-milking teat disinfection

In this technote:

Effectiveness and correct application of post-milking teat disinfection

Milk from infected quarters contains bacteria that can contaminate teat cup liners and transfer pathogens to the teat skin of 5 to 6 subsequent cows (Phillips 1982). More bacteria on the teat skin increases the risk that some will gain entry to the gland, increasing the mastitis risk.

Post-milking teat disinfection is the most effective mastitis control measure (Hillerton 1997), by:

- Reducing the bacterial load at the teat orifice and on teat skin and
- Maintaining the teat skin in healthy condition.

Field trials show post-milking teat disinfection reduces new infections by ≥50% for *Staph. aureus* and *Strep. agalactiae* (Bramley 1992), with NZ studies showing similar reductions for *Strep. uberis* (Williamson & Lacy-Hulbert 2013).

In New Zealand, most farmers use spraying as it is considered quicker and easier (Woolford 1995), but teat coverage is critical for efficacy (Pankey & Watts 1983). Dipping is more common in Europe and the US as it is considered more effective for achieving good coverage. It is important that the entire teat barrel (everywhere the liner has touched) is disinfected and not just the teat end.

Investigation of mastitis problems usually requires an assessment of the whole teat disinfection process, including the product used, preparation, storage and handling on farm, and the method and efficiency of application to teats (Ryan 1991). Milking time assessments on 200 poor performing NZ herds revealed only 12% were achieving good teat spraying practices (Joe *et al* 2010). Typical on-farm problems include:

- failure to mix to label recommendations
- failure to measure components accurately
- addition of inappropriate emollients, and other additives
- use of poor quality water
- incorrect or prolonged storage of teat disinfectants
- inadequate coverage of the teat skin.

The presence of *Corynebacterium bovis* in a herd signals inadequate teat disinfection (Bramley *et al* 1976). A high number of cows affected by this minor pathogen can impact the bulk milk SCC (Hillerton *et al* 1995) and can increase the risk of *Strep. uberis* new infections in unprotected glands at dry off (Woolford *et al* 2001). Effective post-milking disinfection can control the spread of *C. bovis* (Pankey *et al* 1996; Hillerton *et al* 1999), although established infections may require an appropriate antibiotic DCT at dry off.

Best practice involves:

- Disinfecting the entire teat barrel (not just the orifice).
- Ensuring appropriate product selection, preparation, and application technique.
- Evaluating disinfection protocols during mastitis investigations.

➜ **Technote 5** provides more information on control of *Corynebacterium bovis.*

① Use a registered teat disinfectant

Teat disinfectants are designated as a veterinary medicine under the ACVM Act (1997).

The Agricultural Compounds & Veterinary Medicines (ACVM) team, administered by the Ministry for Primary Industries (MPI), is the regulatory body that controls the importation, manufacture and sale, and use of agricultural and veterinary chemicals in NZ. Chemicals used in agriculture in NZ must be registered with ACVM unless they meet the criteria for exemption from registration or have another type of authorisation for use (such as approval under a special circumstance approval or trial approval). Note that products applied to the teats of lactating animals are never exempt from registration.

Registered products are assigned a unique ACVM Registration Number that must be displayed on all product labels and advertising materials. The wording required by ACVM is in the form: "Registered pursuant to the ACVM Act 1997, No. A####."

MPI maintains a list of registered veterinary medicines, agricultural chemicals and vertebrate toxic agents on its website. Consumers may also contact the ACVM industry liaison group to obtain information on the registration details of specific products, via e-mail: approvals@mpi.govt.nz

Product registration

The product registration process involves the review of trial data and technical information to provide an assurance of efficacy and safety with respect to human and animal health, environmental impact and its likely impact on trade relating to the use of the product within the NZ dairy industry. The ACVM standards and guidelines for evaluation of product efficacy, target animal safety (animal welfare), and residue profiles can be downloaded from the MPI website.

The assessment process is both comprehensive and rigorous in scope, covering:

- Chemistry, toxicology and manufacture of the product and its ingredients, including conformance to Good Manufacturing Practice (GMP) and approval of the manufacturing site(s)
- Efficacy of the product in reducing mastitis risk specific to causal organisms and environmental conditions in New Zealand
- Animal welfare with particular focus on irritancy of teat skin under 'normal' and adverse climatic conditions
- Milk residues and milk quality (taint) issues stemming from product use

All claims regarding product efficacy require validation according to the ACVM Standards and Guidelines.

Companies invest considerable resource in registering products and their compliance with ACVM Good Manufacturing Practice standards is regularly assessed through manufacturing plant audit and registration.

Off-label use of registered products

Registered products are assessed for efficacy, target animal safety, and residues when used as stated on the approved label. Use of registered products in a way that is contrary to the label, or "off-label" use, can put animals at risk if the product does not work as intended, and can put farmers at risk of fines covering consequential risk or loss by dairy processors. Examples of such practices include:

- Mixing of a teat disinfectant in a non-compliant fashion e.g. by mixing at a different concentration than what is stated on the label, or with something other than an emollient and water.
- Use of a post-milking teat disinfectant product for pre-milking teat disinfectant, which has not been registered for this use.

Note that product labels carry a regulatory statement that says: "It is an offence for users of this product to cause residues exceeding the relevant MRL in the Food Notice: Maximum Residue Levels for Agricultural Compounds".

➜ **Technote 4.8** describes the off-label use of products under veterinary supervision.

Unregistered products

Unregistered products can be identified by the fact that they have no ACVM Registration Number on the label and are not on the ACVM database. Farmers using unregistered products risk applying ineffective treatments, having chemical residues in milk or meat, and causing harm to the environment, human health or animal health. Supply of un-registered product for sale is an offence under the ACVM act. MPI does not undertake routine inspection to detect unregistered products but relies on reports from industry and the public.

There are cases where there is no registered veterinary medicine that may fit the treatment needs of the animal when used either as approved or off-label. In these cases, an unregistered product can be used, but only when a veterinarian authorises that use under an ACVM exemption (use of human medicines, or specially compounded veterinary medicines) or with an ACVM Special Circumstances approval (trade name product not registered in New Zealand).

Reporting adverse experiences with products

The ACVM act makes provision for surveillance of and enforcement of the regulatory requirements relating to product registration. It is the responsibility of the public, industry stakeholders and other regulatory agencies to notify MPI's ACVM team whenever a breach of registration is suspected or identified. This can include any breach that poses a risk, including risks caused by product inefficacy, safety or animal welfare risks, and residue compliance risks. The conditions regarding enforcement and response are detailed on MPI's website.

② Active ingredients in teat disinfectants

More than 10 different disinfectant active ingredients have been used in teat disinfectants throughout the world since the early 1980's. The **NMC (The Global Milk Quality Organisation**) reviewed and summarised all peer-reviewed literature on teat disinfectants published between 1980 and 2009 (National Mastitis Council 2012).

Most products rely on one active ingredient but there are products that use a mix of active ingredients. Active ingredients currently registered in NZ include:

- iodine
- chlorhexidine
- acid anionic compounds (dodecyl benzene sulphonic acid)
- chlorine and Chloramine T
- lactic acid.

Iodine-based disinfectants

Iodine-based teat disinfectants (or iodophors) contain organic iodine complexes combined with surfactants, detergents and emollients. The antimicrobial spectrum includes bacteria, viruses and fungi. Iodine kills microorganisms through oxidation/reduction reactions that disrupt protein synthesis, nucleotide actions and structure of lipid membranes. Free iodine also reacts with organic material, so the bactericidal activity is reduced when exposed to dirt and milk residues.

Iodine chemistry is complex. Only a small fraction of iodine is present as free iodine (typically 2–3 ppm), which is the bactericidal form. The remaining iodine is bound within complexes to hold it in solution and replenish the free iodine as it is consumed. Measurements of total available iodine do not directly reflect antimicrobial performance, as free iodine is difficult to quantify.

Products must be acidic (pH <6.5) to maintain iodine stability, which can irritate teat skin, so emollients and humectants are commonly included. Surfactants are also added to aid wetting on teat skin and penetration into organic matter and bacterial cells. Iodine-based teat disinfectants have no residual antimicrobial activity once dry, and effective killing may require up to 10 minutes of contact, though activity begins immediately on application.

> Measurement of total iodine concentrations is possible in the field using simple test kits available from teat disinfectant suppliers.

Chlorhexidine

Chlorhexidine gluconate is a colourless, odourless organic compound that is readily soluble in water. A colouring agent is commonly added to aid visibility. Antimicrobial activity is primarily against bacteria, with limited efficacy against viruses and fungi. Some Gram-negative environmental pathogens (e.g. *Pseudomonas*, *Serratia*) show reduced sensitivity to chlorhexidine.

Chlorhexidine binds to lipids in teat skin, where it can accumulate and provide residual protection. It kills bacteria by disrupting bacterial membranes. As a cationic molecule, chlorhexidine reacts with negatively charged ions (e.g. carbonate, phosphate, chloride) present in hard water or chlorinated water, forming inactive complexes. This necessitates higher use rates in hard water. Optimal activity occurs at pH 5.0-8.0 and emollients are commonly added to support teat condition.

Acid anionic compounds (e.g. DDBSA)

Acid anionic disinfectants use anionic surfactants as active ingredients. They have rapid bactericidal action (~30 seconds) against many bacteria, with moderate efficacy against some viruses and fungi. However, at least one active ingredient (dodecyl benzene sulphonic acid, DDBSA) does not effectively control *Corynebacterium bovis* or coagulase negative staphylococci (now non-aureus staphylococci; Pankey *et al* 1984; Pankey *et al* 1985)

The bactericidal action is thought to result from disruption of the cell membranes, causing leakage and cell death. Optimal efficacy occurs at a pH

of 2.0-3.0 with effectiveness rapidly declining as the pH rises above 4. Water hardness has minimal impact except in extremely hard water (>400ppm). Emollients are added to mitigate the skin irritating effects of low pH.

Chlorine-based disinfectants

Chlorine compounds provide rapid, broad-spectrum antimicrobial activity. Their effectiveness depends heavily on correct mixing and fresh preparation, as activity declines with storage.

- Acidified sodium chlorite systems generate chlorine dioxide via a chemical reaction between Part A, citric acid and Part B, sodium chlorite.
- Chloramine T (toluenesulfonylamide sodium or Tosylchloramide sodium) is slightly alkaline (pH at or above 8.5) and releases hypochlorite when added to water. This rapidly oxidises bacteria and viruses on contact.

Both forms are highly effective but require strict adherence to manufacturers' instructions.

Lactic acid

Lactic acid is an organic acid produced by fermentation that has been used as a bio-preservative in fermented products and foods. It is also a normal by-product of human and animal metabolism.

Its antimicrobial activity is through acid stress and free radical damage to bacterial cell walls and is most effective against Gram-positive bacteria, particularly when combined with surfactants or other actives. For this reason, lactic acid is often used in multi-active formulations.

A practical consideration is that lactic acid can be particularly corrosive to steel and spray equipment, requiring appropriate material selection and maintenance.

Sensitivity to disinfectants

Bacterial resistance to teat disinfectants is not recognised as a problem at present in NZ although there is some evidence that certain bacteria, particularly Gram-negative organisms, have the capacity to be more resistant to certain disinfectants. The link between use of disinfectants and antimicrobial resistance remains uncertain (van Dijk *et al* 2022).

➜ Key characteristics of these different actives are compared in the Table on the next page. See **section 7** for more on addition of extra emollients to disinfectants.

Characteristics of different active ingredients of teat disinfectants in New Zealand

Characteristics	Iodine	Chlorhexidine	Acid anionics
Mode of Action	Oxidizing agent	Oxidizing agent	Non-oxidative surfactant, disrupts membranes
Gram-positive efficacy (e.g., *Staph. Strep.*)	Excellent	Excellent	Good
Gram negative efficacy (e.g., *E. coli, Serratia*)	Excellent	Moderate (*Serratia* and other Gram negative pathogens can be resistant)	Moderate (less potent than oxidizing agents)
Speed of kill	Rapid (within 30 secs)	Rapid (within 30 secs)	Seconds to <1 min
Organic load tolerance after milking	Moderate (reduced in heavy dirt)	Moderate	Low to moderate
Optimal pH range	4.0 – 5.5	5.0 – 7.0	2.5 - 4.5
Skin conditioning	Requires emollients	Good with added emollients	Requires emollients
Mixing requirements	Simple dilution with water (+/- added emollient). Mix daily or as required	Simple dilution with water (+/- added emollient). Mix daily or as required	Simple dilution with water.
Stability	Good (protect concentrate from heat and sunlight)	Good	Highly stable in concentrate and dilute form

Characteristics	Chlorine dioxide	Chloramine-T	Lactic acid
Mode of Action	Oxidizing agent	Oxidizing agent	Lowers pH, disrupts membranes
Gram-positive efficacy (e.g., *Staph. Strep.*)	Excellent	Excellent	Good, when combined with other actives
Gram negative efficacy (e.g., *E. coli, Serratia*)	Excellent	Excellent	Good, when combined with other actives
Speed of kill	Rapid (within 30 secs)	Rapid (within 30 secs)	Seconds to <1 min
Organic load tolerance after milking	High, even in dirty environments	Low – improved with emollient	Moderate
Optimal pH range	5.0 – 7.0	8.0 - 10.0	3.0 – 4.5
Skin conditioning	Good with added emollients	Good with added emollients	Excellent, often with emollients
Mixing requirements	Requires daily mixing of two products, plus emollient	Mix a powder with water each milking	Simple dilution with water (+/- added emollient). Mix daily or as required
Stability	Working solution stable for 1-3 days. Stable concentrates	Working solution stable for 1-3 days. Concentrate powder very stable	Highly stable in concentrate and dilute form

③ Selection of a teat disinfectant on farm

Farmers should regularly review their satisfaction with the teat disinfectant they are using and avoid making arbitrary decisions about product selection at the time of purchase. Factors to consider are:

Effectiveness:

The industry relies on ACVM's registration process to establish that all products available on the market are effective in New Zealand dairying conditions. Published information on product efficacy is usually available from the product manufacturer.

Particular recommendations may be made by advisers in special circumstances. For example, a herd experiencing a mastitis outbreak with a pathogen such as *Serratia* may be advised to avoid using a chlorhexidine product.

Suitability for a specific farm:

The equipment used to mix and deliver teat disinfectant, the water quality available on farm to mix teat disinfectants, and the ability to store concentrate out of direct sunlight and extremes of cold and heat, which all impact the effectiveness of teat disinfectants.

Section 7.5 summarises the impact of water quality on different products, **section 7.8** the different delivery approaches, and **section 7.10** the service and maintenance requirements.

Occupational health issues:

Adverse reactions in milking staff such as skin reactions (on the hands and exposed skin), respiratory and eye sensitivity problems may be the result of an allergic response to an ingredient in a product, or may result from heavy exposure due to faulty settings, siting of spray equipment or poor operator technique.

The method in use should be assessed, and the type of disinfectant may need to be changed if staff members have adverse reactions. A review is appropriate whenever new staff begin milking.

Teat skin reactions:

Teats should be regularly checked to ensure the skin is supple and in good condition. Corrective changes may involve altering the concentration of emollient or changing the product. It is important to monitor changes closely whenever a new product is used.

If any changes are noted, it is important to report it to ACVM as an adverse event report to help support ongoing post-registration product monitoring and management.

Visibility:

Teat disinfectants which are visible on the teat skin enable operators to more easily assess their success in achieving good teat coverage. Section 7.9 describes how to assess teat coverage. outlines the issues to be addressed regarding application.

Price:

There is considerable variation in the shelf price of teat disinfectant products. To compare prices, it is helpful to calculate the cost per cow per milking.

For manual spraying application, 20 mL per cow per milking is the recommended use rate, so 20 L of made-up solution should be sufficient to spray 250 cows for 4 milkings.

Using this scenario, the cost of teat spraying a cow per milking can generally vary between 2 and 5 cents but can be as high as 10 or 15 cents, depending on the product used, volume of stock purchased, and recipe used.

Shelf life:

When purchasing teat disinfectant products, farmers should ensure that the quantity purchased will be finished prior to the expiry date specified on the label.

Remember to remove expired products to avoid accidental use.

Milk residues:

The ACVM's registration process also ensures that no product available on the market should leave unacceptable milk residues when used according to the label directions.

There have been no problems identified in NZ of residues in milk under normal use of post-milking teat disinfectants.

Problems have been identified when disinfectants have been used in an off-label fashion.

④ Teat disinfectant preparation and storage

Dairy farmers in NZ prepare the majority of teat disinfectant solution from products purchased as concentrates. Only one product is available in NZ as a ready-to-use (RTU) product.

Whether the concentration of the active ingredient in a teat disinfectant's final mix is maintained for hours or days, depends on a complex interaction of factors, including the amount of water in the mix, the quality of the water used, the product chemistry and active ingredient, and the ambient temperature and the ambient temperature.

Some solutions remain stable for long periods under excellent storage conditions. In the case of iodine, the rate of loss of iodine is doubled when the mixed solution is stored at 40°C compared with 30°C or less. The level of available iodine is also reduced if containers are not well sealed to prevent ingress of contaminants, water quality is poor, inappropriate emollients are added, or if the solution is contaminated with milk, dirt or other organic matter.

Water with very high iron and manganese content can affect the stability of prepared teat disinfectant solutions. For this reason, it is strongly recommended that teat disinfectants are made up with water that is used for food contact surfaces in the farm dairy. Farm dairy water standards are defined in the MPI Animal Products Notice: Production, Supply and Processing (MPI 2025). The standard defines limits for acceptable microbiological quality and nominal physical contaminants, as measured by turbidity.

To ensure the stability of teat disinfectants mixed on farms, it is recommended that either:

- Products are mixed in-line so that fresh product is constantly available, or that
- Fresh teat disinfection solutions are made up for use within 3 days, or as recommended on the label.

General requirements for making up teat disinfectant solutions include:

- Use a clean, rinsed container for storage,
- Use a clean, rinsed, dedicated measuring container,
- Only use water sources approved for milk contact surfaces,
- Cover securely to prevent accidental or environmental contamination,
- Store inside, out of direct sunlight and in a cool area; do not store at temperatures >40°C,
- Store stock solution out of direct sunlight and in cool areas.

5 Use high-quality water for mixing

Because teat disinfection is such a key part of mastitis prevention, the water used to mix disinfectants must not reduce their effectiveness. Several water quality factors can interfere with the bacterial killing power of teat disinfectants:

- **Alkalinity:** This a measure of the buffering capacity of water and is expressed in parts per million of calcium carbonate ($CaCO_3$). Water with high alkalinity (>500 ppm $CaCO_3$) reduces available iodine in iodine-based disinfectants and alters pH in acid anionic disinfectants.
- **Hardness:** Hard water, containing high levels of cations (such as calcium, magnesium and sometimes manganese) should be avoided as it can reduce disinfectant activity. Hardness is expressed as the concentration of calcium cations (Ca^{2+})
- **Organic Matter:** Water should be clear, odour-free, and free of sediment and suspended solids, as per MPI Animal Products Notice: Production, Supply and Processing (MPI 2025). Organic matter and moderate bacterial loads consume free iodine. Chlorhexidine forms insoluble salts with organic acids and tannins.
- **Chlorine:** High chlorine levels form insoluble salts with chlorhexidine, whilst iodine-based and acid anionic disinfectants are less affected.
- **Iron/Manganese:** These are common in bore water and can interfere with chlorine-based disinfectants and can cause deposits on equipment. For this reason, it should not be used to make up teat disinfectants.

Farm dairy water that is tested regularly and shown to be compliant with the regulatory requirements for water that comes into direct or indirect contact with raw milk is appropriate for mixing teat disinfectants.

Any concerns about water quality should be discussed with the teat disinfectant provider.

Always use dedicated containers for teat disinfectants to avoid contamination from other farm dairy detergents or chlorine residues.

Farm dairy water standards are set out in MPI Animal Products Notice: Production, Supply and Processing (MPI 2025). This requires that water:

- Does not result in microbiological, chemical or physical contamination of raw milk
- Has *E. coli* absent in 100mL
- Has turbidity less than 5 NTU, or equivalent
- Satisfies an approved hazard identification analysis.

When assessing water quality reports, check the parameter being described as both alkalinity and hardness are measured using the same units (parts per million $CaCO_3$). The buffering capacity of a solution is expressed as carbonate content (CO_3) and its hardness is expressed as the concentration of calcium cations (Ca^{2+}).

Testing the final mix of teat disinfectant solutions

For teat disinfectants that are mixed on farm, it is important to be able to regularly check the recipe and procedures for making it up. Automatic mixing systems also require regular maintenance. On farm testing of the final mix is possible - see the teat disinfectant provider for support.

Concentration of the active ingredient in the final mix can also be affected by factors that affect performance of the concentrate, such as temperature-related changes in viscosity, which affects pump delivery systems, incorrect storage conditions, i.e. avoid direct sunlight or extremes of hot and cold, or expiry dates.

⑥ Mix products according to the label directions

Mix teat disinfectants according to label directions. Products have been designed to provide the correct level of active ingredient at the recommended use concentrations. The ACVM registration process for teat disinfectants places a high weighting on performance, and testing is done at the manufacturer's recommended use concentrations.

Often, label statements refer to different application rates relative to weather conditions. These variations relate to the greater level of emollient required for teat condition in adverse weather conditions. More concentrated solutions provide more emollient and greater antimicrobial protection. It is important that on each farm the steps for mixing teat disinfectant are clearly established and the task of mixing is allocated to staff that understand how to do it. Field examination of 200 problem farms (Joe *et al* 2010) found that only 33% of 200 farms were able to make up their teat disinfectants correctly.

The availability of automated mixing systems now provides an option for farms that experience difficulties in mixing solutions consistently. Expiry dates and storage of the stock concentrate out of direct sunlight and away from temperature extremes should also be considered.

The viscosity of some products can vary with ambient temperature, which affects the volume delivered through pump systems in auto-mixing systems. This may mean that less concentrate is drawn into the mixing vessel in winter when the temperature is cold and the product is more viscous, and the opposite can occur in summer. Contact the teat disinfectant equipment supplier for support.

If testing shows the concentration of the active ingredient in the final mix is incorrect, check that:

- the mixing rate used on farm is correct
- components are measured accurately
- the type and amount of emollient used is appropriate
- the water used is visibly free of organic matter and colloid
- the water used is not alkaline or hard
- the stock product is within expiry date
- the stock product is sealed and stored appropriately
- the mix is made up freshly
- the containers used to mix the teat disinfectant are clean.

➜ The DairyNZ **Healthy Udder Guide** provides tips and reminders on the correct way to mix up teat disinfectants.

⑦ Maintain teat condition, by adding additional emollient if required

An emollient is a compound used to soften or condition teat skin. The addition of emollients to teat disinfectant can improve teat skin health and so reduce the likely reservoir of mastitis pathogens in teat sores and cracks, including hyperkeratosis. They have an important role in mastitis control for these reasons.

Many teat disinfectants contain emollients when they are sold, especially those formulated with relatively low pH where skin irritation would be expected without some additional protectant.

Emollients registered for addition to specific teat disinfectants on farms can be found on the ACVM list of registered products, available here on the **MPI website**. Common emollients include food-grade glycerine and sorbitol. Other unapproved materials should not be used.

The overall performance of a teat disinfectant depends on:

- the bactericidal activity of the disinfectant component,
- the skin conditioning properties of the emollient, and
- effective delivery through the teat spray system.

Studies found that:

- addition of up to 9% glycerine in an iodine-based teat dip led to an improvement in teat skin condition in 30 dairy herds in the UK but no further benefit was observed at 24% (Bramley 1981);
- formulations with 10% additional glycerine in an iodine-based teat dip helped reduce *Staph. aureus* colonisation and was associated with faster healing of teat chapping lesions in the US (Fox *et al* 1991, Fox 1992); and
- skin condition in a Danish research herd milked robotically was significantly better when the teat spray contained 8% glycerol compared with 2% glycerol (Rasmussen *et al* 2002).

Addition of emollients has been reported to reduce bactericidal activity, but the evidence is not consistent. Using emollient at a concentration higher than 15% is more likely to affect the viscosity and interfere with delivery of a product through the spray system.

It is recommended that the concentration of total emollient in the final solution should be no more than 15%

Many registered teat disinfectants are marketed with some emollient incorporated. More emollient may be added to bring the concentration in the final mix up to a maximum of 15%, with instructions provided on the label. This should occur in situations of high challenge i.e. when teats are exposed to adverse weather and muddy conditions, and the risk of new infections is high (see Table on next page).

➜ **Technote 9** describes the evaluation of teats and teat lesions.

Recommendations for adding extra emollient

	High challenge	Low challenge
Examples of different conditions	• Wet and cold weather • Muddy pastures • High degree of teat dryness • High level of teat end damage • Bulk milk SCC above herd target • Clinical case rate above target	• Dry and warm weather • Dry pastures • Little teat dryness • Little teat end damage • Bulk milk SCC below herd target • Clinical case rate below target
Emollient concentration	Add extra emollient (5-10%) to provide a total maximum emollient concentration of **15%** in the final mix.	Check if extra emollient is required, to provide an emollient concentration of **5%** in the final mix.

Guidelines for adding emollient

1. As a practical guide, 'no teat spray currently on the market can cope with a NZ spring without extra emollient'.
2. Calculating the amount of emollient to add requires knowledge of:
   - Total volume of made-up teat spray required
   - Concentration of emollient in the teat spray concentrate
   - Final total concentration in the final mix
3. Additional emollient should displace some of the water, not teat spray concentrate.
4. Contact your teat disinfectant supplier to determine emollient concentration in the teat spray concentrate.

➜ The DairyNZ **Healthy Udder Guide** provides tips and reminders on the correct way to make up teat disinfectants.

Example calculation:

Total volume required = 20 litres of made-up product. This is sufficient to spray 250 cows x 2 milkings x 2 days at 20 mL per cow per milking.

Concentrate Product Y contains 23 g/litre iodine and 300 g/litre glycerol, labelled to mix in the ratio of 1 litre concentrate to 6 litres of water (1:6).

When mixed according to label, the solution contains 0.34% of iodine and 4.5% of glycerol (300 g/L x 1/7 of glycerol = 45 g/L). In 20 L of mix, the total amount of glycerol will be 900 g (45 g/L x 20 L).

To bring the emollient concentration up to 15% in the final mix (equivalent to 3000 g in 20 L), add a further 2000 g (approximately 2 L) of glycerol.

Reduce the water by the volume of glycerol added i.e. less 2 L. Volumes in the final mix to achieve 20 litres with 15% emollient and 0.34% iodine are:

3 litres Product Y
2 litres glycerol
15 litres water
= 20 litres total

8 Teat disinfection methods and application

The quality and consistency of application is the single most important determinant of effective teat disinfection. Incomplete teat coverage of every cow at every milking is the most common cause of poor performance.

Achieving consistently good coverage is challenging and depends on both operator technique and equipment choice and maintenance.

Operator factors can be improved by:

- Training all operators on why and how teat disinfectants work
- Ensuring safe access and visibility so teats can be disinfected properly
- Designing work routines to support consistent technique throughout milking.

Equipment factors can be improved by:

- Selecting a disinfectant and delivery system appropriate for the dairy layout
- Regularly checking, cleaning and maintaining the equipment to ensure correct delivery and coverage.

Despite the common saying that 'it is the drip at the end of the teat that's important', coverage is not considered adequate unless there is disinfectant on the whole surface of the teat.

Spraying

Spraying is the most widely used method in NZ, as it integrates easily into the milking routine. Key requirements for effective spraying include:

- Spray from below with a circular motion to coat all sides of all teats.
- Use vertically-directed spray nozzles as they achieve better coverage than horizontally-directed jets.
- Solid-cone spray patterns achieve better coverage than hollow-cone patterns.
- The nozzle openings can become blocked and corroded. They should be checked regularly for blockages and delivery of an even cover of droplets, spreading to ~10 cm diameter when sprayed upwards onto paper from ~10 cm.
- Droplets should not be excessively fine (<10 micrometres in diameter), as drift reduces effectiveness.

Spray systems may be:

- **Manual pressurised units** with approx. 2L capacity, suitable for about 100 cows
- **Semi-automatic systems** where delivery is via a pressurised line, with one or more suspended wand applicators in the milking area
- **Fully automated systems** which are installed at or near the exit bail or under each bail in a rotary, or just after the exit in a dedicated lane, for a herringbone dairy.

Automated systems can produce variable coverage and typically require higher disinfectant volumes. Regular checking is required to ensure teats, and not udders and legs, are being sprayed.

Dipping

Teat dipping involves hand-held dip cups, typically 200-400 mL in size, often with a squeeze bottle and a one-way valve to deliver fresh solution. Immersion of each teat usually ensures full coverage of the teat barrel, provided cups are deep enough and adequately filled. Dip cups should be emptied before refilling rather than topped up.

Dipping can facilitate better and more reliable teat coverage and reduces exposure of operators to aerosols. However, it generally requires more time than spraying when preparation, refilling, and application are considered, so for this reason, it is not commonly used in NZ.

Auto-dipping

Automated dipping systems are emerging in NZ. These systems apply teat disinfectant within the teat cup, immediately before cup removal. The cups are then flushed with sanitised water

(e.g. containing peracetic acid) before being made ready for attachment to the next cow. Some systems may discard a small volume of milk to prevent residues entering the vat.

Studies in the US have shown that automated systems can outperform manual dipping when cows' teats were heavily challenged with mastitis pathogens (e.g. *Staph. aureus* or *Strep. uberis*) immediately before milking (Galton 2004). Commercial systems in the UK (Olde Riekerink *et al* 2012) have shown benefits for reducing bulk milk SCC and individual cows SCC.

Volume required

As a general rule, the volume required to achieve good coverage varies by application method:

- Hand dipping – requires **10 mL** of solution per cow per milking
- Hand spraying – requires **20 mL** of solution per cow per milking
- Auto spraying – requires **30-40 mL** of solution per cow per milking
- Auto dipping – requires **14 mL** of solution per cow per milking.

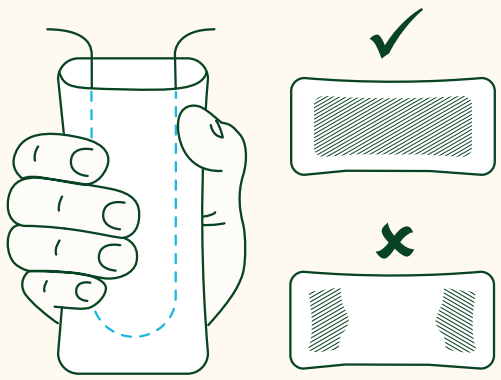
9 Check teat coverage regularly

Careful operators and well-adjusted automated systems can both achieve very good teat spray coverage, but both can perform poorly if technique or equipment is suboptimal. Encourage milking staff to regularly assess their own and others' teat spray coverage. Simple checks include:

- Visual assessment of teat condition for signs of inadequate teat disinfection
- Visual inspection of several cows to confirm if all sides of the teat barrel are being covered.
- Use the paper-towel test to check coverage by wrapping a paper towel around the barrel then carefully removing it to examine the wet or stained area.
- Check the volume of disinfectant used per cow:
  - at least 20 mL per cow per milking for hand spraying
  - 30-40 mL per cow per milking for automated spraying.
  - Calculate by measuring total disinfectant used over two milkings and dividing by total number of cows milked.
- Check application time by, for example, measuring how long it takes to fill an empty 20 mL syringe barrel and comparing this with the time taken for an operator to spray a cow.
- Test the spray pattern of automated or walk-over systems by holding a piece of white card, filter sock or inflated white glove, horizontally at the level of the udder while the sprayer operates.

Regular review of teat disinfection performance with an adviser reinforces correct technique, supports staff training, and maintains awareness of the importance of this task for effective mastitis control.

Checking coverage with a paper towel



⑩ Regularly service teat spray equipment and review use

Encourage farmers to clean and check teat spraying equipment on a regular basis, as some equipment may require daily or weekly checks.

Routine checks for maintenance of teat spraying equipment include:

- ensuring spray nozzles are not blocked or worn,
- checking filters for blockages in the spray line,
- inspecting tubes for any cracks or leaks. Stains on the floor underneath the spray line may alert users to a problem,
- examining each individual spray unit for dirt, damage or corrosion,
- ensuring that the container of stock solution of teat disinfectant does not contain sediment and is protected from environmental contamination.

Encourage farmers to regularly review (e.g. annually) their satisfaction with the teat disinfectant they are using and avoid making an arbitrary decision at the time of purchasing new stock.

Factors to be considered when selecting a product include:

- Skin reactions on the hands and arms of milking staff. Hands should be wetted before being exposed to teat disinfectant, to reduce irritant properties. The type of disinfectant may need to be changed if it has caused dermatitis on hands of any staff in the farm dairy. Products should be reviewed when there are changes in staff. People who wear gloves will have less skin exposure to disinfectants.
- Reaction of teat skin to disinfectants. Teats should be regularly checked to ensure the skin is supple and in good condition. Corrective changes may involve altering the concentration of emollient or changing the product. It is very important to monitor changes whenever a new product is used.
- The concentration and/or choice of active ingredient for the herd situation. Published information on product efficacy is available from the product manufacturer.
- The method of application. If there is a problem with teat coverage, check the equipment and operator technique. Consider changing the method of application (e.g. from auto teat spraying to manual teat spraying) if the problem continues.
- Facilities available for safe and appropriate storage of concentrated products, and correct mixing and storage of the working solution.

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Technote 8

Practicing good hygiene during milking

In this technote:

The routine used to milk cows, especially those with clinical mastitis, provides important clues about how well farmers or milkers understand and follow hygienic principles and procedures.

Bacteria in milk from infected quarters can spread to other quarters by splashes and aerosols of milk during stripping, by milkers' hands, by teat cup liners, and by cross flow of milk between teat cups.

The risk of infection spreading through a herd is markedly reduced if cows with mastitis are milked last. This includes clinical cases and can include cows that have subclinical mastitis infections (i.e. high SCC) when dealing with a grading or problem situation.

➜ **Technote 5** describes contagious mastitis and good milking technique.

1 Wear gloves and maintain a clean milking environment

The risk of transferring contaminated milk or bacteria from cow to cow is greatly reduced if hands and the milking area under the cows are kept as free as possible from dirt and contaminated milk. Wearing of gloves during milking provides an easier surface to decontaminate after stripping cows and protects milkers' hands from the drying effects of repeated exposure to dirt, water and manure.

Low pressure, high volume washing water should be used to sluice away manure. High pressure hoses should be avoided directly beneath or around cows, as these can form aerosols of bacteria-laden droplets that settle onto the cows.

When disinfecting hands or gloves in the farm dairy, ensure that the product is acceptable for use in the farm dairy. A practical solution is a small amount of dilute teat spray.

Hand contamination during milking

In the 1960s, studies at the National Institute for Research in Dairying in England showed that 50% of milkers' hands were contaminated with mastitis bacteria before milking, and 100% of hands were contaminated after milking (Dodd *et al* 1966). Washing hands with disinfectants reduced contamination (although there were still 30% positive swabs) whereas washing without disinfectant left 90% of hands contaminated (Neave *et al* 1962).

Effective hand hygiene during milking is nearly impossible. Rather than attempting bare-handed milking with frequent hand disinfection, it is better to advise farmers to wear gloves and maintain excellent milking technique to minimise contamination risk.

Glove use during milking

Gloves should always be used when searching for, or dealing with, clinical cases of mastitis, and ideally, for all milking activities.

A study in Holland (Olde Riekerink *et al* 2008) across 27 farms found that use of gloves reduced bacterial contamination of hands by 75% compared to bare hands. Although disinfecting hands with a teat wipe reduced bacterial counts by 85%, gloved hands were easier to disinfect and had a bacterial count that was 98% lower than bare hands. In another study, farmers operating in a clean and precise manner had lower bulk milk SCC levels and less clinical mastitis cases than farmers who operated in a 'less careful' manner (Barkema *et al* 1999).

Wearing gloves begins with an attitudinal change to milk harvesting. If milking is viewed as harvesting a fresh, pure food, then keeping operators' hands clean becomes just as important as keeping cows' teats clean. In a practical sense, it is difficult for a dairy farmer to achieve very clean hands in the course of a normal day. Use of disposable or reusable rubber or latex gloves is a simple way to improve the quality of the contact surface, while also improving skin condition of the operator's hands, particularly in winter.

In human medicine, gloves have been found to be superior to most handwashing attempts, and in all cases, gloves are superior to no handwashing (Lynch *et al* 1987).

Types of gloves available

There is a wide range of gloves now available from agricultural suppliers for milking purposes. Some are meant for a single task or milking, others are reuseable. Options include:

- **Nitrile** (rubber) gloves – these tend to be the most comfortable, moulding to the shape of a milker's hands in less than 10 minutes. Nitrile is more durable, more elastic and stronger than other, thinner glove materials.
- **Latex** gloves do not mould to the hands but can be thinner and more flexible than rubber gloves. A small number of people may experience adverse skin reactions (allergies) so powder-free and hypoallergenic types are available. They are available in different thicknesses, depending on need for durability.

With all gloves it is worthwhile wearing elasticised cuffed plastic sleeves to prevent water draining from the arms into the gloves during milking. In this way it is easy to keep clean during milking and still maintain operator comfort.

② Cleaning hands, gloves and clusters between cows

To clean gloves, rinsing with running water for about 30 seconds provides a physical wash but is only as good as the microbiological quality of the water. Dipping in a disinfectant solution, such as a small amount of teat disinfectant, provides a sanitising effect.

> Hands or clusters should always be rinsed before being dipped in disinfectant to avoid a 'soup' of bacteria in the bucket.

Cluster flushing

The liner is a common source of pathogens for dairy cows. One infected cow (clinical case or subclinical case with high bacterial numbers) has the potential to infect the next 5-6 cows milked on that cluster (Phillips 1982).

Cluster flushing systems, whereby a small volume of water (usually containing a sanitiser) is flushed back through the liners after milking each cow, has been promoted to reduce the spread of contagious mastitis. Commercial systems that provide delivery of post-milking teat disinfection immediately after milking also enable flushing of the liner with a sanitiser before attachment to the next cow (Galton *et al* 2004).

Under artificial conditions, a flushing system reduced bacterial contamination of the liner by 99.9% (Hogewerf *et al* 2008). When compared against manual teat dipping, the system achieved similar coverage and iodine residue levels in milk (Hogewerf *et al* 2008), and dramatically reduced milking times in 4 of the 5 herds (Ohnstad *et al* 2012).

Under field conditions in the UK, installation of an auto teat dipping and flushing systems had beneficial effects on bulk milk SCC and proportion of cows with elevated SCC compared with herds that continued with dipping or spraying methods to apply teat disinfectant (Olde Riekerink *et al* 2012). It is unproven whether use of a flushing system associated with an automated teat dipping system reduces the incidence of new mastitis cases under NZ conditions.

③ Segregate and milk infected cows last

Clinical cases

Low bulk milk cell counts have been associated with herds that milk clinical mastitis cases last (Hutton *et al* 1991). Since many infections are spread during milking in the dairy, uninfected cows should be milked prior to, and independently of, all cows suspected to have mastitis. This principle can be extended to include cows with chronic infections i.e., those with multiple high individual cow cell counts.

Cows with newly detected clinical mastitis should be drafted out and milked last, after the milking herd has been milked. Cows under treatment with antibiotics should also be milked last, in a separate mastitis herd, once the milkline has been disconnected from the vat. The whole milking machine should then be washed with a full hot water wash to remove any residues of milk contaminated with bacteria or antibiotics.

If it is not possible to run a separate herd, treated cows should be well marked and drafted out before being milked, then held back until the end of milking, and milked once the delivery line has been removed from the vat. Running them in the milking herd and milking them on test buckets is no longer accepted by dairy companies.

➜ The DairyNZ's **Healthy Udder Guide** provides useful tips on applying MRS T for managing cows during antibiotic treatment.

High SCC cows

Segregating cows that are more likely to be infected and milking them last, or after a 'clean' herd can be an effective tool for reducing spread of infection, especially when dealing with a mastitis outbreak. This can apply to mastitis due to environmental pathogens (Lacy-Hulbert *et al* 2012) as well as contagious or cow-associated pathogens (Wilson *et al* 1995; Middleton *et al* 2001).

Wilson *et al* (1995) found that for herds with a high prevalence of *Staph. aureus* infection, segregating bacteriologically positive cows, either by milking them last or by milking them with separate milking units, reduced the prevalence of infection with this pathogen from 29.5% to 16% of cows, over a 6 to 24 month interval, and observed almost a 50% reduction in bulk milk SCC. Herds that did not segregate such cows maintained a similar prevalence of infection and had a bulk milk SCC that remained higher than herds that segregated infected cows.

The viability of running a separate mastitis herd as a control option depends on the number of mastitis cases, the farm layout (laneways and paddocks etc.), and the calving pattern in the herd. Electronic identification systems may allow automatic drafting so that the cows can be managed as a single herd, yet still milked separately.

➜ **Technote 4.5** discusses MRS T and the importance of separating out infected cows before commencing treatment for mastitis.

Acknowledgements

DairyNZ acknowledges the valuable input of veterinarians, milk quality advisers, and industry stakeholders who contributed to the development and review of these resources. Most are representatives of the National Milk-Quality Advisory Committee (NMAC) and have given generously of their time and expertise for the technical review.

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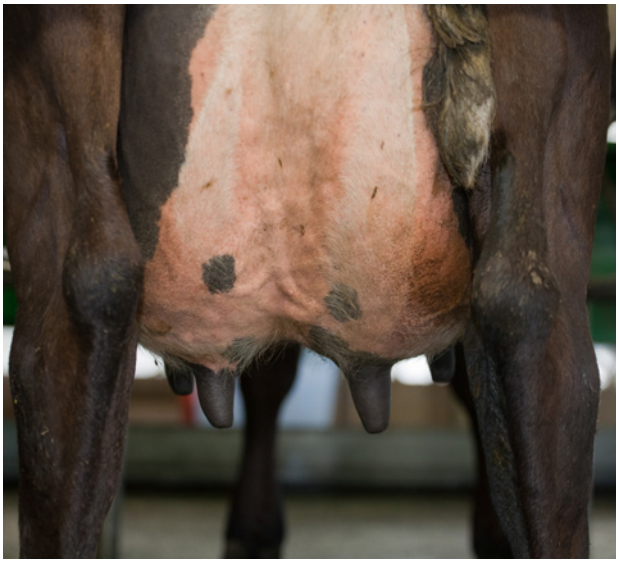
Technote 9

Preventing and managing teat sores and cracks

In this technote:

Maintaining healthy teat skin is essential for effective mastitis control. Teat condition reflects the quality of environmental hygiene, milking management and performance of the milking machine, and is a useful indicator of intramammary infection risk.

Mastitis risk increases as bacterial load at the teat end increases. Teat sores and cracks provide sites for bacterial growth and are painful, leading to increased kicking and defecation during milking, and poor milk let-down. By contrast, healthy, undamaged teat skin is easier to keep clean and reduces the risk of new infections.



① Defence mechanisms of the teat canal

Mastitis occurs when bacteria enter the mammary gland, typically through the teat canal. Four physical components of the teat canal protect against bacterial invasion:

- tight closure and sealing of the teat canal between milkings;
- adherence of bacteria to the keratin lining;
- shearing and removal of keratin during milk flow; and
- drying and re-sealing of the canal post-milking.

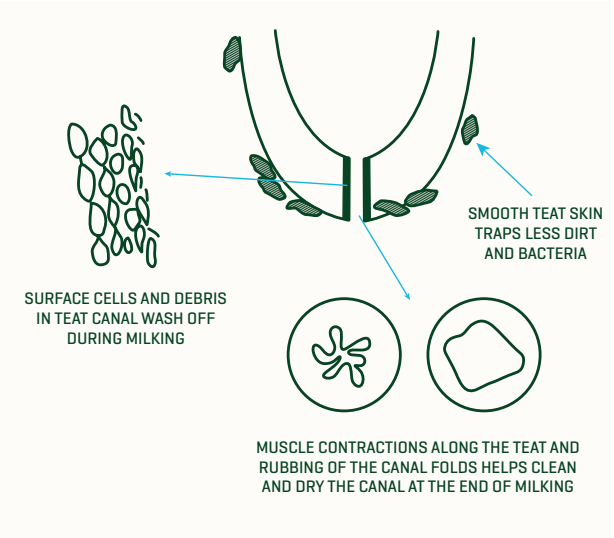
Disruptions to any of these increase susceptibility to infection.

The teat canal, about 10-12 millimetres long and highly folded when closed, is lined by a modified epithelial layer, continuous with teat skin. It is the first and most important barrier to bacteria entering the udder, and new infection risk is increased if:

- the teat canal is relatively wide, indicated by a high peak milk flow rate. Teats with high milk flow rates had higher infection rates in the dry period (Dodd & Neave 1951) and in lactation, when exposed to high bacterial challenge (Grindal & Hillerton 1991).
- the teat canal is shorter than average (Grindal *et al* 1991; Lacy-Hulbert & Hillerton, 1995).
- the keratin fails to seal the canal effectively between milkings or in the dry period (Williamson *et al* 1995). Artificial removal of keratin at the end of milking led to higher infection rates when exposed to high bacterial challenge (Capuco *et al* 1992).

Keratin is a wax-like substance produced by the cells lining the teat canal. It serves as a temporary seal between milkings and a more permanent plug throughout the dry period. Keratin is a protein complex that contains lipids, and is a major structural component in skin, hair, nails and hoof cells. It can trap bacteria and help them to be removed at each milking.

Defence mechanisms of the teat end



Physical mechanisms help resist bacterial penetration through the teat canal (Williams 1984; Williams & Mein 1985; Lacy-Hulbert & Hillerton 1995; Paulrud 2005). At a microscopic level:

- a lipid film in mature keratin layers aids easy opening and cleaning during milking, and
- effective re-sealing after milking prevents bacterial migration.

Keratin cells, held loosely in this lipid film, trap bacteria (see Figure above). During milking, milk flow and liner pulsation flushes away keratin and bacteria, while the lipid film is replenished continuously from the underlying epithelium. After teat cups are removed, muscle contractions 'wring' the teat canal dry, disrupting milk columns and preventing capillary movement of bacteria through the teat canal.

Practical consequences include:

- During normal milking, the milk stream under vacuum has sufficient force to shear and remove the outer layer of mature keratin cells lining the teat canal, helping keep it clean.
- Liner pulsation applies cyclical pressure around the teat end, physically loosening keratin debris so it can be flushed away in subsequent pulsation cycles. Approximately 40% of mature keratin cells are removed with normal pulsation, compared with about 25% without pulsation (Capuco *et al* 1994).

- Milking without pulsation results in accumulation of keratin within the teat canal and is associated with higher rates of new intramammary infection, likely due to prolonged retention of contaminated keratin (Lacy-Hulbert *et al* 1996).
- Keratin's highly convoluted, lipid-coated surface can entrap lipophilic bacteria such as *Staph. aureus*, *Strep. dysgalactiae* and *Corynebacterium bovis*. These pathogens may colonise the teat canal and use lipids and milk residues to support growth (Mamo *et al* 1987; Calvinho *et al* 1996).
- Most mastitis pathogens are non-motile and rely on passive movement of milk within the teat canal. Resealing and mild dehydration of keratin between milkings may reduce movement of contaminated milk toward the gland.
- Components of keratin may possess intrinsic antimicrobial properties, contributing to the natural defence of the teat canal (Smolenski *et al* 2015).

These natural defence mechanisms likely explain why more frequent milking lowers the risk of mastitis infections, by regularly flushing the teat canal.

By contrast, the higher infection risk in the early dry period may be due to the absence of this flushing mechanism, allowing pathogens to persist in the teat canal.

➜ **Technote 14** describes the importance of the keratin plug in the teat canal at drying-off.

② Assess teat skin and teat ends systematically

Systematic assessment of teat skin and teat ends is essential, as changes in teat tissue integrity of the barrel, teat end and canal, can compromise udder defence mechanisms. Farmers, veterinarians, and other advisers require simple and reliable methods for evaluating teat health during milking, especially when initial observations suggest potential problems (Ohnstad 2010).

➜ Use Sheet I of the DairyNZ **Mastitis Investigation Kit** to record teat condition scores – see **Technote 13** for more information.

Teat Club International, an informal group of udder health researchers and advisers, developed a protocol for systematic examination of teat condition, along with guidelines for interpreting observations (Hillerton *et al* 2001, 2002a; Mein *et al* 2001; Neijenhuis *et al* 2001c; Reinemann *et al* 2001). Later work expanded these guidelines to include:

- effective management changes or machine settings that provide successful solutions,
- expected timelines for improvement, and
- confidence levels for each recommendation (Ohnstad *et al* 2007).

These guidelines form the foundation of this Technote.

Teat condition can be influenced by multiple factors, which can be broadly grouped into three categories:

- milking-induced (machines and management),
- environmental, and
- infectious causes.

Table 1 summarises the main conditions in the first two categories, and discussed further in Sections A and B, with infectious causes addressed separately in Section C below.

Table 1. Teat conditions arising from milking-induced and environmental effects in Australia and New Zealand.

Milking-induced	Environmental
Discolouration	Skin dryness and chapping
Firmness or swelling	Teat orifice roughness and hyperkeratosis
Wedging of the teat end	Abrasions and cuts
Openness of the teat orifice	Photosensitisation, sunburn, frostbite
Petechial haemorrhages	Chemical damage
Hyperkeratosis (thickening of the skin at the teat orifice)	Allergic reactions
	Insect bites

A. Short-term, milking-induced changes in teat condition

Short-term changes are those that occur in response to a single milking. Primarily due to faults in milking management or machine function, they may present as:

- discolouration - reddened, bluish, purplish or very pale teats seen immediately after milking;
- firmness or swelling of the teat or "ringing" around the upper barrel;
- wedging of the teat end;
- excessive openness of the teat orifice.

Specific causes or contributing factors are summarised in Table 2.

Generally the teat takes some hours to recover its full integrity even under good milking conditions (Neijenhuis *et al* 2001b). Improvements in teat condition should therefore be evident immediately after the milking at which the specific fault or faults have been correctly identified and fixed.
Full resolution may take one or more days.

Table 2. Primary causes (1) or exacerbating influences (2) on short-term changes in teat condition induced by milking.

	Teat colour	Swelling at teat base	Firmness/hardness of teat end		Orifice
Observation	**Red/blue**	**'Ringing'**	**Hard**	**Wedged**	**Open**
Machine factors					
High milking vacuum	1	1	1		1
Faulty pulsation	1		1	1	
Prolonged b-phase			1		
Short d-phase	1		1		
Long d-phase				1	
Liners:					
• Wide bore liner with tapered barrel	2	2	2		
• Aged (i.e. stiff or very pliable walls)	2	2			
• High tension (i.e. stiff walled liner)	2		1	1	1
Mouthpiece:					
• Deep chamber	2	2			
• Small diameter	2	2			
• Stiff mouthpiece		2	2		
Mismatch of liner and teats	2	2			2
Milking management					
Long dribble times (flow below 1L/min per cow)	1	1	1		
Overmilking (flow below 400 ml/min per cow)	1	1	1		1
Teatcup crawling	2	2	2		

Evaluating machine-induced, short-term changes

1. Colour changes

Some teats show redness at the teat end or over the entire teat after cluster removal. Others may appear white and feel cold initially, then redden within 30-60 seconds. More severe cases show blue or purple discoloration. These changes may be worse for short, slender, or oedematous teats that are poorly supported by the liner.

Reddish discolouration, or congestion is exacerbated by over-milking, especially with wide-bore liners or tapered liners with wide upper barrels, or by excessive cluster weight, high milking vacuum, faulty pulsation or a mismatch between type of liner and average teat size.

Bluish discolouration, or cyanosis, may result from liners with a small mouthpiece diameter relative to the internal diameter of the barrel, or liners mounted at unusually high tension.

Highly pigmented or black teats cannot be evaluated reliably and must be excluded from colour-based evaluations. Colour changes are classified according to the proportion of light-coloured teats which, when examined within one minute of cluster removal, are:

- **Normal** - pink.
- **Red** - part of, or the entire teat, may be reddened.
- **Blue** - part of, or the entire teat appears to be tinged with blue or purple.

Because the causes of reddened or bluish teats may differ, red and blue classes should be recorded separately. However, analysis is simplified by combining changes into a single category **'Red or Blue'**.

➜ **Technote 6** provides more information on liner selection and matching liners to clusters.

2. Swelling at or near the teat base

When examined after milking, some teats may show a visible line or swelling around the upper part of the barrel, where they were in contact with the liner mouthpiece. This may appear as a palpable thickened ring. Cows with udder oedema or within one week post calving should not be assessed, as the swelling may be physiologically normal.

Common causes include: high mouthpiece vacuum associated with wide-bore liners; over-milking, especially with wide-bore liners or tapered liners with wide upper barrels; liners with a large mouthpiece chamber; teatcup crawling; or liner mouthpiece lips that are unusually stiff or narrow in relation to teat size.

Swelling at or near the teat base when examined within one minute of cluster removal is classed as:

- **Normal** – no ring, little or no swelling, and teats that have a visible mouthpiece lip mark or 'garter mark' (Hillerton *et al* 2000).
- **Swollen** – if there is marked swelling or a palpable thickened ring.

Excessive teatcup crawling occurs when a teat cup moves so far up the teat that the passage of milk from the udder to the teat is obstructed.

3. Firmness at or near the teat end

Teats should feel soft and pliant after milking. Some may contract as the cups come off, or in response to touch. Teats that feel swollen, firm, hard or cold are an indicator of congestion. Factors commonly responsible include: over-milking, wide-bore liners, high vacuum, pulsation failure, insufficient rest phase (d-phase) or prolonged open-phase (b-phase) during pulsation.

Teat ends may appear flattened or wedge-shaped after milking. Wedging describes the flattened shape of the teat end due to the compressive load applied by the opposing walls of a collapsed liner. Typically, this wedging will be slight but severe wedging may occur with hard liners, high liner tension, prolonged d-phase or failure of liners to open fully.

Teat ends are classified by visual examination, with palpation, as:

- **Normal** – soft and supple.
- **Firm** – firm, swollen or hard or noticeably wedged.

4. Openness of the teat orifice

Immediately after milking, the teat orifice may appear fully closed, slightly open or in extreme cases, has a funnel-shaped opening about the size of a match-head.

Factors associated with short-term, post-milking openness of the teat orifice include: high milking vacuum, over-milking, heavy cluster weight, or high liner tension.

Teat orifices are classified by qualitative assessment within one minute of cluster removal as:

- **Closed**
- **Open** – more than 2 millimetres wide or deep.

When estimating the degree of openness, it may be helpful to mentally compare the width and depth of an open orifice with that of a common object such as a match-head (~3 mm in diameter) or the shaft of the match (~2 mm). Flicking the teat end or blotting away milk residue with a clean paper towel may assist assessment.

B. Medium to long-term, milking induced or environmentally induced changes in teat condition

Medium-term changes refer to teat tissue changes that develop over several days or weeks. Specific causes, and exacerbating influences, are summarised in Table 3.

Medium-term changes take longer to resolve than short-term changes. While some improvement may be visible within a few milkings once the underlying cause is corrected, full recovery can take several weeks.

Table 3. Primary causes (1) or exacerbating influences (2) on medium to long-term changes in teat condition induced by milking or environmental factors.

	Teat skin		Teat end
Observation	**Rough/scaly skin, cracks or lesions**	**Haemorrhages**	**Hyperkeratosis**
Duration	**Medium-term**	**Medium-term**	**Medium-long term**
Machine factors			
High milking vacuum		1	1
Faulty pulsation		1	
Liners: • Wide bore liner with tapered barrel		1	
• Aged (i.e. stiff or very pliable walls)		1	1
• High tension (i.e. stiff walled liner)		1	1
Milking management			
Long dribble times (flow below 1L/min per cow)			1
Overmilking (flow below 400 ml/min per cow)		2	1
Chemicals (or insufficient emollient)	1		2
Environmental factors			
Cold, wet, windy weather	1		2
Mud/manure (e.g. from intensively grazed or stand-off areas)	1		
Sunburn or forage-related photosensitisation	1		
Infectious skin lesions	1		

Evaluating medium to long-term changes

1. Petechial haemorrhages

Petechial, or more extensive haemorrhages, indicate vascular damage to teat tissue. Machine-induced haemorrhages of the teat skin may take several days to become evident and are commonly associated with pulsation failure, shortened d-phase, high vacuum or prolonged overmilking. Chronic cases are usually linked to extended periods of over-milking (see Table 3). Incidence is lower in herds milked with narrow-bore liners, at low vacuum, and/or with automatic cluster removers.

Improvement generally requires optimisation of vacuum and pulsation settings to improve teat end massage during pulsation, alongside correction of cluster position and tubing support. Where cluster position is poor, eliminating vacuum and/or pulsation faults may not provide a complete solution. Some improvement should occur within a few milkings but full resolution may take up to 4 weeks.

Petechiae (on lightcoloured teats) are classified by close examination of the teat end as:

- **Normal** – no evidence of petechial haemorrhage
- **Mild** – Small pin-prick red spots in discrete areas or very diffuse across the teat end.
- **Moderate** – Dense red spots, affecting a discrete area.
- **Severe** – Coalescing spots forming a bruise or sore, with or without open lesions.

2. Teat skin condition - environmental factors

Healthy teat skin has a protective fatty acid layer that suppresses pathogen growth. Damage removes this layer, allowing colonisation by pathogens such as *Staph. aureus.* Cold, wet or windy weather can cause dryness, roughness or chapping, leading to formation of cracks that provide sites for infection. Severe winter weather can have an immediate effect on teat skin roughness, with teat skin cracking occurring within 1-2 days (Timms 2004). At more moderate temperatures (-3 to 24°C), use of a teat spray containing more emollient (8% compared to 2%) improved teat skin condition significantly over 4 weeks (Rasmussen & Hemling 2002).

Environmental factors such as cold, wet or muddy conditions can lead to hardening or thickening of the teat skin by impairing circulation or drying the skin surface, potentially progressing to teat end hyperkeratosis (see below). Poor teat skin condition is usually most obvious immediately after cluster removal.

Factors that exacerbate environmental skin damage include:

- low emollient concentrations in the teat disinfectant
- poor teat spray coverage
- older style or poorly maintained milking equipment
- over-milking
- new installations lacking quality control of the set-up (Hillerton *et al* 2000, 2002b).

In the absence of cracks and sores, dry teat skin does not increase new mastitis infection rates (Rasmussen & Larsen 1998).

Teat skin condition is classified as:

- **Supple** – smooth, soft, healthy skin.
- **Dry** – scaly, flaky or rough skin but with no cracking.
- **Lesion** – any open lesion, chap or crack on the barrel or teat end (See section C below).

The dryness of black teats tends to be over-estimated by observation alone. Evaluation is improved by lightly rubbing the teat skin with a finger, when wearing a latex glove.

3. Teat skin condition - chemical irritation

Chemical irritation of the teat skin may show as reddening, drying or roughening of the teat skin, typically on the teat barrel rather than the teat end. Aggressive chemicals may induce epidermal hyperplasia or a temporary thickening, scaliness or leathery appearance (Hillerton *et al* 2002a).

Chemical irritation may arise from disinfectant type, concentration, or inappropriate emollient content, often worsening the effects of harsh weather. Emollients act as humectants (moisturisers) or reduce evaporation from the skin to restore teat skin condition (Hemling 2002). Severe irritation can peak after 1-3 days and may require 3-5 weeks to heal (Fox 1992), with more moderate cases resolving in 10-14 days (Rasmussen 2003).

Modern iodine disinfectants (pH ≥3.5) are less irritating than earlier formulations and produce little evidence of teat irritation with appropriate use of emollient. Sensitivity is extremely rare. Chlorhexidine solutions are mild in most cases and unlikely to have an adverse effect on teat skin.

Classification of this condition is described in section 2 above.

4. Teat skin conditions – photosensitisation

Photosensitisation primarily affects nonpigmented, hairless teat skin exposed to sunlight. Early signs include restlessness (including kicking at the udder and abdomen), teat irritation, and reddened, oedematous skin. As the condition progresses, affected skin becomes dry, leathery, or sloughs off in sheets.

Primary photosensitisation occurs when photodynamic plant compounds are retained in the bloodstream rather than being excreted in the bile. Spring eczema is one example, linked to grazing of lush spring pasture.

Secondary (hepatogenous) photosensitisation arises from liver damage that limits its ability to clear photodynamic chlorophyll break-down products from the bloodstream. Common causes include ingestion of facial eczema spores, or blue-green algae, or grazing certain plants such as St. John's Wort, lantana, ragwort or lupins (see "Diseases of Cattle in Australasia" by Parkinson *et al* 2010 for more).

Treatment involves removing the source of irritation, providing shade, adjusting the diet and using topical sunblocks or barrier creams to alleviate symptoms. If liver damage is present, it becomes the primary focus of treatment e.g., oral zinc oxide supplementation.

Sunburn can also occur on light-coloured teat surfaces and should be distinguished from photosensitisation. Good teat spray coverage and use of teat salves or sun blocks after milking can prevent progression to mastitis.

Classification of this condition is described in section 2 above.

5. Teat end hyperkeratosis

Teat end hyperakeratosis (HK) is variously described as roughness, thickness, teat rings and fronds at the teat end. It is rare in heifers but common in machine milked animals (Sieber and Farnsworth 1981; Neijenhuis *et al* 2000).

The amount of HK varies over lactation, typically increasing from calving to peak production and decreasing towards drying off. It also increases progressively with parity (Shearn & Hillerton, 1996; Neijenhuis *et al* 2000), and longer, slender or pointed teats are more prone, suggesting a genetic influence.

Hyperkeratosis is often influenced by seasonal cold, wet weather conditions (Table 4), likely due to reduced blood circulation. Skin thickens in response to mechanical forces applied to it. Exposure to prolonged low milk flow periods (<1 L/min) at start and end of each milking increases HK development. Milking related issues that also affect HK include:

- inappropriate vacuum
- high liner compression
- prolonged machine-on time, leading to overmilking.

Note that hyperkeratosis is not associated with faulty pulsation. Chemical irritation by disinfectants can exacerbate HK but high-emollient disinfectants may not reliably improve it (Britten *et al* 2004).

Teat Club International recognises that a small amount of HK may be a normal adaptive response to machine milking but more severe forms increase the risk of:

- new intramammary infections (Neijenhuis *et al* 2001a, 2001c; de Pinho Manzi *et al* 2012)
- teat canal colonisation with *E. coli* (Paduch *et al* 2012),
- prevalence and incidence of *Staph aureus* infections (Pantoja *et al* 2020), and increased SCC (Guarín *et al* 2017).

Hyperkeratosis is classified according to the teat end scores described in Table 5 below.

Noticeable improvements in teat ring roughness take about 4 weeks after elimination of the specific cause.

Table 4. Major risk factors affecting teat end hyperkeratosis

Risk factor	Reason for increased likelihood of teat end hyperkeratosis
Pointed teats	The load applied by the closing liner is on a smaller area of teat surface
Increasing age	The 'wrinkle factor' in all species
Higher production	Cups are on for longer
Peak lactation	Cups are on for longer
Udder washing	Water and chemicals reduce skin moisture and elasticity
Cups on before let-down	Longer period of milk flow below one litre per minute
Low thresholds for Automatic Cluster Removers (ACRs)	Longer period of milk flow below one litre per minute
Over milking	Longer period of milk flow below one litre per minute
High vacuum	Greater stress on teat tissues – more stretched in the open liner and squeezed in the closed liner
Stiff liner mouthpiece	The lip acts like a tourniquet which slows or restricts outflow of blood from the teat wall when the liner is collapsed
Liners mounted at high tension	The region of greatest local pressure is applied just above rather than at the teat end. This restricts outflow of blood from the teat tip (acts like squeezing a grape until the skin splits)

Table 5. A scoring system for teat end hyperkeratosis (from Mein *et al* 2001)

Score	Description	Illustration
N	**No ring** The teat end is smooth with a small, even orifice. This is a typical status for many teats soon after the start of lactation.	
S	**Smooth or slightly rough ring** A raised ring encircles the orifice. The surface of the ring is smooth or it may feel slightly rough, but no fronds of old keratin are evident.	
R	**Rough ring** A raised, roughened ring with isolated fronds or mounds of old keratin extending 1-3 mm from the orifice.	
V	**Very rough ring** A raised ring with rough fronds or mounds of old keratin extending 4 mm or more from the orifice. The rim of the ring is rough and cracked, often giving the teat end a 'flowered' appearance.	

C. Teat conditions due to infectious agents

Infectious teat skin lesions provide an important indication of overall hygiene, mastitis control practices and milk quality management on a farm. Any decline in teat skin integrity can negatively affect milk quality, milk safety, and udder health, and some infections pose health risks to staff.

Most infectious lesions are caused by viruses, pus-forming or necrotising bacteria, or fungi, and may affect the teat end, teat barrel or udder skin. Typical lesions are summarised in Table 6 and the more common conditions are described further below.

Table 6. Summary of the typical features of infectious agents that can affect teat condition.

Organism type	Condition or agent	Typical lesion
Virus	Pseudocowpox*	Local, red angry lesions in the early stages that develop over a couple of days into small, raised, circumscribed lesions with dark red centres. A characteristic ring or 'horseshoe' shaped scab may be seen when crusts fall away. People are occasionally infected with purple 'milkers' nodules on their fingers.
	Bovine herpes mammillitis*	Numerous, raised, oedematous plaques about 1-2 centimetres in size. Lesions can cover a large part of the teat surface. The skin sloughs off leaving raw ulcers that are subsequently covered with dark coloured scabs.
	Teat warts/papilloma*	Appearance varies with strain of virus from 'rice grain' in appearance, to fronds.
	Foot and Mouth Disease (exotic)	Occasionally, the virus causes vesicular lesions and erosions on teats (exotic) before they appear in the mouth or hoof.
	Vesicular stomatitis (exotic)	Lesions are similar to, and need to be differentiated from, Foot and Mouth Disease.
Bacteria	*Staph. aureus,* *Strep. dysgalactiae* *Trueperella pyogenes*	Primary bacterial infections present as pustules. They may be necrotising, especially when *Staph. aureus* is involved. Secondary bacterial infections may cause significant changes in the appearance of other lesions, making diagnosis difficult.
	Blackspot* or *Fusiformis necrophorum*	Lesions look like craters with raised edges and have a black spot of ulceration or scab in the centre. They often involve the teat end.
Fungi	Ringworm or *Trichophyton spp.*	A characteristic grey-white encrustation. The infection may spread to milking staff.

** See page 13 for images of these conditions.*

1. Viral infections of teat skin

Viral teat infections vary in severity and infectivity but are generally uncommon in dairy industries where good udder hygiene and routine post-milking teat disinfection is practiced. Early low-pH iodine disinfectants were virucidal, and modern disinfectants plus emollients reduce skin damage that enables virus entry. Multi-use ointment containers are a frequent source of spread; single-use containers and clean gloves are recommended.

Some exotic diseases can cause lesions on teats (Hillerton *et al* 2001; Parkinson *et al* 2010). Differential diagnosis for unusual teat lesions should include:

- Foot and Mouth Disease (FMD),
- Vesicular stomatis (VS),
- Bovine herpes mamillitis (BHM),
- Ringworm (fungal).

Pseudocowpox

Pseudocowpox, a paravaccinia virus, causes acute infections in young cows after calving or cows introduced to a herd that has the virus. Spread of infection can be relatively slow. Immunity is short-lived, lasting four to six months, leading to some herds developing chronic infections.

Early lesions are painful so affected animals do not enjoy being milked. The characteristic ring or 'horseshoe' scab (Table 6) usually heals without scarring in 3-6 weeks. Milkers may develop localized lesions on their hands, i.e. 'milkers' nodules'. There is no specific treatment, so management relies on minimising spread by milking infected cattle last, glove use, and thorough teat disinfection.

Teat warts or papilloma

Six papillomavirus strains cause teat warts. Some form flat, smooth 'rice grain' warts (BPV-5) whilst others produce more frond-shaped warts with epithelial projections, up to 1 cm in length (BPV-1 or BPV-6). Young animals are most susceptible to papilloma viruses and typically develop immunity after joining the milking herd. Most warts regress within 5-6 months. Warts spread via liners and hands, and infect skin abrasions.

Some may interfere mechanically with liner function or obstruct the teat canal. Damaged warts, particularly the frond type, can become infected with *Staph. aureus*, *Truperella pyogenes* or *Strep. dysgalactiae.* Frond-type warts can be surgically removed or snipped. Teat disinfectants containing chlorohexidine or iodine are generally virucidal and may help reduce spread. Salicylic acid dips have been used on heifers overseas.

➜ **Technote 7.2** provides more information on the antimicrobial spectrum of active ingredients of teat disinfectants available in NZ.

2. Bacterial infections of teat skin

Bacteria cause primary lesions or colonise existing lesions caused by machine-induced damage, environmental factors or viral infections.

Staph. aureus, *Strep. dysgalactiae* and *Truperella pyogenes* are ubiquitous on the skin of dairy cows and can be a major source of new intramammary infections and clinical mastitis, in lactating and non-lactating cows.

Historical studies demonstrated strong associations between teat lesions and high new infection rates and clinical mastitis (Dodd & Neave 1970; Kingwill *et al* 1970). Even small lesions significantly increased risk of mastitis, particularly when located near the teat canal (Agger & Willeberg 1986).

Teat disinfectants are effective in reducing bacterial load and promoting healing, and postmilking disinfection of all teats remains a cornerstone mastitis control measure.

➜ **Technote 7** describes the characteristics of effective teat disinfectants and emollients.

Blackspot

Blackspot is a secondary infection of a teat-end lesion by the anaerobe *Fusiformis necrophorum*, under poor hygiene conditions. The resulting scab is pigmented black by the bacteria and the teat orifice may become blocked, leading to incomplete and very slow milking.

If more than 2-3% of teats are affected, herd hygiene and milking machine function should be reviewed, as blackspot is associated with short teat cup liners, failure of pulsation, excessive vacuum or over-milking.

Management involves:

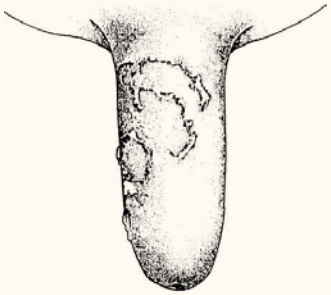
- treating lesions with iodine (or hydrogen peroxide);
- routine teat disinfection to minimise bacterial infection of lesions; and
- checking and correcting milking machine function.

3. Fungal infections of the teat skin

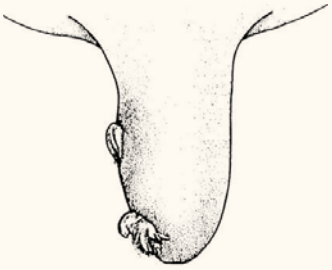
Fungal infection is most commonly caused by *Trichophyton* spp. and may involve the teat, but usually presents elsewhere on the body as greywhite, ash-like crusts (ringworm). The infection is highly contagious and may spread to milking staff (zoonotic). Herd immunity usually develops, though re-infection is common when susceptible animals enter the herd or when animals are immunosuppressed, as spores can survive in the environment for several years.

Few treatments are recognised and generally the disease is self-limiting over several months. In some countries, vaccines are available for calves to reduce incidence.

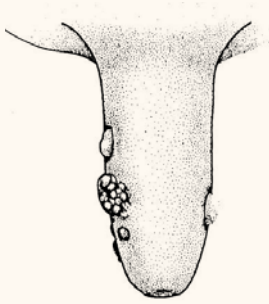
Examples of teat conditions associated with infectious conditions



Pseudocowpox

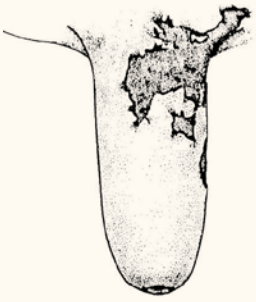


Filiform warts



Nodular warts

Blackspot



Bovine herpes mammillitis

Image by Dairy Australia

D. Systematic evaluation of teat condition in commercial herds

1. Deciding how many teats to observe

The most common weakness of teat evaluations is using sample sizes that are too small. Teat Club International (Reinemann *et al* 2001) recommended scoring all teats in the herd where possible, or assessing at least **80 cows or 20% of the herd** (whichever is greater).

In NZ, two approaches are supported:

- **Screening test to indicate issues:** assess 50 randomly selected cows to quantify potential issues and decide whether expert advice is needed.
- **In-depth assesment:** assess a larger, representative sample for diagnosing system faults or causes of teat damage.

NMAC (New Zealand Milk-Quality Advisory Committee) recommendation for investigations:

1. Assess all teats on **at least 100 randomly selected cows**, drawn from across mobs and throughout milking
2. Record results for **all four teats per cow**, where practicable
   - In some situations, cow-level recording may be preferred.
   - Table 7 compares these 2 methods.

Table 7. Evaluation methods involving cow or quarter level recording for a mastitis investigation

	Quarter-level recording	Cow-level recording
Procedure	1. Examine all teats of selected cows. 2. Score all non-normal quarters 3. Record cow and quarter details for each issue.	1. Examine all teats - score only **worst teat** per cow. 2. Assign this score to the cow. 3. Record scores (cow ID optional) 4. Note any patterns of damage (e.g., front vs rear, left vs right)
Benefits	• Measures prevalence accurately, at quarter level. • Enables reexamination of affected cows following intervention. • Valuable for detailed investigations, research, and quantifying response to management change.	• Faster, simpler and lower cost • Works for larger herds or rapid screening **NB Always produces higher prevalence estimates than quarter-level scoring**
Disadvantages	• Time-consuming • May require more labour • Quarters within a cow are not truly independent, so more quarters must be assessed to achieve statistical confidence.	• Less diagnostic detail, especially for quarter-specific problems. • Cannot reliably re-examine individual cows if no ID • Does not give a true teat-level estimate of prevalence, only the proportion of cows with **at least one quarter** affected

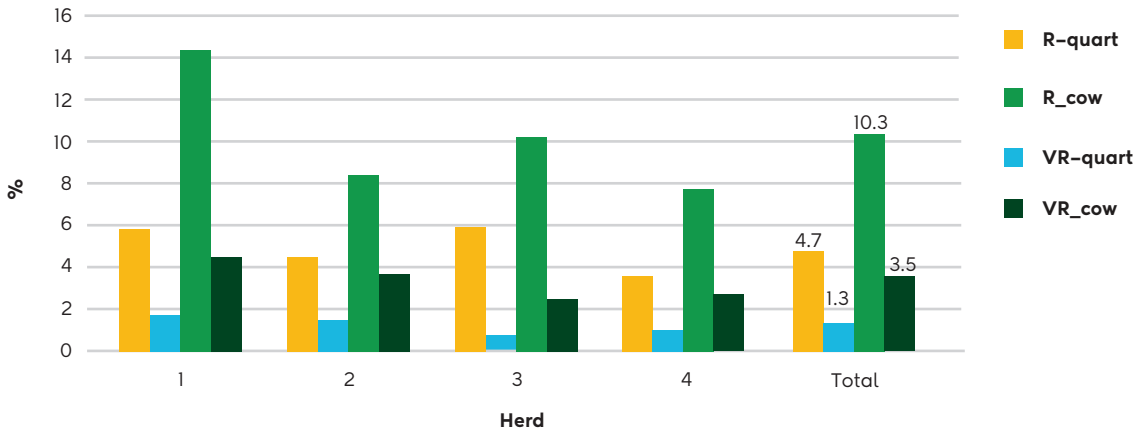
Interpreting prevalence: cow- vs quarter-level recording

Cowlevel scoring is a **parallel interpretation** of the four teats, meaning the cow is considered positive if **any** teat is affected. This inevitably produces higher prevalence estimates than quarter-level interpretation.

For example (Adamson, McDougall & Roberts, unpublished; see figure below), prevalence of damaged teat ends across 4 herds, involving 9,169 quarters and 2,202 cows was assessed as:

- Quarter-level prevalence:
  - Rough (R) teat ends = **4.7%**
  - Very rough (VR) teat ends = **1.3%**
- Cow-level prevalence (worst teat per cow):
  - At least one R teat = **10.3%**
  - At least one VR teat = **3.5%**

Variation in prevalence of rough (R) and very rough (VR) teat end scores when calculated at quarter or cow level across 4 herds.



2. Making the observations

Teat condition should be evaluated immediately after cluster removal and before teat disinfectant is applied. If a more detailed assessment of skin condition is needed, observations should be made before milking.

Practical guidelines for Teat Scoring:

- Handle cows carefully, especially in herds where animals are not accustomed to teat manipulation.
- Follow a consistent pattern to observe and record teats to avoid missing teats.
- Begin with visual assessment without touching the teat.
- Remove milk residue or debris with a clean paper towel if it obscures the teat end.
- Use proper lighting. Gently grasp the teat above the end and view from the side and end. If shed lighting is inadequate, use a headlamp for handsfree and safer assessment.
- Select a representative sample across all age and management groups. For herds with multiple mobs, include cows from all mobs. Sampling should occur throughout the milking, not only at the beginning or end.
  - Example: In a 400 cow herd where 50 cows are needed, examine every 8th cow (400 ÷ 50 = 8).
- Use efficient recording methods. A voice memo app on a smartphone is useful for solo observers; with two people, one can observe while the other records. A teat-scoring app can further streamline data capture (e.g., the UW-Madison **Teat End Scorer** app.
- Capture images. A smartphone or camera is valuable for documenting unusual lesions, supporting discussions with farmers or udder health experts, and for before and after comparisons (Reinemann 2007).

3. Interpreting the results

Once teat condition data has been collected, the prevalence of each condition should be calculated at either cow or quarter-level, depending on the recording method used.

Thresholds for intervention or **Triggers for Action** have been developed based on extensive field experience across multiple countries (Reinemann *et al* 2001). These thresholds vary according to:

- Which teat condition is being evaluated.
- Level of interpretation:
  - Cow-level prevalence of teat conditions is typically ~2.5 times higher than quarter-level prevalence, because a cow is counted as abnormal if *any* of her four teats is affected.
- Herd-specific circumstances including seasonal conditions, which may justify adjusting thresholds.

If the values for a particular teat condition exceed the thresholds in Table 8, further investigation of milking machine performance, management, environmental exposure or infectious causes is warranted

Use prevalence as a guide

Thresholds should not be treated as absolute rules. Some herds with teat abnormalities may fall slightly below the threshold because:

- The sample was not fully representative of the herd.
- The estimate lies near the lower 95% confidence limit of the threshold (see Table 8).

If there is uncertainty, or if other teat health or machine problems have been identified, more cows should be evaluated before reaching final conclusions.

Focus on Teat-Level Data First

The initial assessment should focus on the proportion of teats affected, as this provides the clearest indication of whether a herd-level issue is present. However, patterns within the data may provide important diagnostic clues:

- A large proportion of cows may have the same teat affected (e.g., all right rear teats), suggesting a cluster alignment issue.
- A few cows may contribute disproportionately to the total number of abnormal teats if they have multiple quarters affected, indicating a cow-specific or udder conformation issue.

Recognising these patterns is critical for differentiating machine-related, management-related, and cow-related causes.

Table 8. Trigger levels for action for different teat abnormalities (from Reinemann *et al* 2001 and Reinemann 2007).

		Trigger levels for:	
Criteria	**Description**	**Quarter-level**	**Cow-level**
Teat Colour	**Red/blue** Light coloured teats are visibly reddened (congested) or tinged with blue (cyanotic).	8%	20%
Swelling	**'Ringing' at teat base** Marked swelling or palpable rings at or near the top of the teat.	8%	20%
Firmness	**Hard or wedged** Teat ends are classified as firm, hard, swollen, or noticeably wedged.	8%	20%
Openness	**Open** Teat ends classed as open after milking.	8%	20%
Teat end	**Hyperkeratosis** Teats are scored R or V R	8%	20%
	Teats are scored as VR	4%	10%
Vascular damage	**Haemorrhages** Light-coloured teats have Moderate or Severe petechiation	4%	10%
Teat skin	**Dryness, Roughness** Teat skin scored as rough, dry and scaly.	4%	10%
Lesions	**Chaps, cracks** Teats have open lesions, cracks or chaps.	2%	5%

Colour, swelling near the top of the teat, firmness near the teat end, openness of teat orifice and vascular damage are **short to medium-term effects** primarily associated with milking machine faults or poor milking management resulting in long periods of low flow below 1 litre/minute and/or over milking.

Teat skin condition and teat end hyperkeratosis are **medium to longer-term effects** primarily associated with poor environment, management or chemical irritation, or cow factors such as teat shape, yield and genetics. They are exacerbated by machine milking, especially if poor milking management results in over milking or prolonged milking at a low milk flow rate. Faults in milking equipment are unlikely to be primary causal factors if one or more of the short-term changes are not obvious.

Table 9. Lower bounds for the 'trigger for action' (i.e. the lower 95% confidence interval) for number of quarters (or cows) when 'true' prevalence of the abnormality is 8%, 4% or 2% for quarters, or 20%, 10%, 5% for cows, based on a binomial distribution.

	Number of abnormal quarters detected		
	Quarter prevalence		
No. quarters (cows) examined	8%	4%	2%
100 (25)	0	0	0
150 (38)	2	0	0
200 (50)	4	0	0
250 (63)	7	0	0
300 (75)	10	0	0
350 (88)	13	0	0
400 (100)	**15**	**4**	**0**
500 (125)	22	7	0
600 (150)	28	9	1

	Number of cows with at least one abnormal teat detected		
	Cow prevalence		
No. cows examined	20%	10%	5%
50	6	2	0
100	**13**	**5**	**1**
150	17	8	2
200	25	12	4
250	32	16	6
300	41	20	8
400	57	28	11
500	74	37	15
600	92	46	19

Note: If the number of abnormalities is greater than the number listed for that sample size, then the herd prevalence of that condition is not different from the trigger level, with 95% confidence.

Statistical interpretations:

Table 9 shows the lower 95% confidence interval for

- number of quarters with abnormalities that correspond to a likely true prevalence of teat lesions of 8%, 4% or 2% quarters, or
- number of cows having at least one teat with an abnormality that corresponds to a likely true prevalence of 20%, 10% or 5% of cows.

Note that a variance inflation factor of 1.5 has been applied to account for 'clustering', whereby quarters within a cow are not independent of each other (S. McDougall *pers. comm.*)

Note that:

- If 200 teats are examined and fewer than 4 abnormal teats are found, it is 95% likely that the true prevalence is not different to 8% (but 4% and 2% cannot be ruled out).
- To confidently rule out a quarter prevalence of 4%, then more than 400 quarters (100 cows) need to be examined.
- If 6 or more cows out of 50 have at least one abnormal quarter, it is 95% likely that the true cow prevalence is not different from 20%.
- However, if no abnormalities are found, the true prevalence of 5% of cows cannot be ruled out. To confidently rule out a prevalence of 5%, more than 200 cows should be examined.
- If 100 cows were examined with no teat abnormalities, it is 95% likely that the true cow-level prevalence is <5%.

③ Manage teat condition

Minimise the build-up of mud on teats.

Reduce teat condition and hygiene problems caused by mud by maintaining clean, dry trough areas, farm tracks, laneways, feed pads and stand-off areas, and entrances and exits to the farm dairy.

If wet and muddy conditions cannot be avoided for lactating cows, and the rate of new clinical cases starts to increase, teats will need to be washed and ideally dried before each milking.

➜ **Technote 1** discusses ways to fix areas that make udders muddy.

Minimise water on cows' udders

➜ **Technote 5.4** discusses udder cleanliness and pre-milking preparation.

Check teat spray mix, particularly emollient concentrations

➜ **Technote 7** discusses addition of emollients to teat sprays and servicing of the teat spray equipment.

Avoid the use of teat ointments, especially those from tubs or jars

Teat ointments intended to improve teat condition can increase mastitis risk by promoting teatcup crawl, increasing bacterial exposure at the teat end, and prolonging bacterial contact time. Lubricating the teat-liner interface was found to significantly increase residual milk or strippings at the end of milking (Mein *et al* 1973). In addition, ointments dispensed from shared jars are readily contaminated with environmental bacteria.

Avoiding teat ointments is preferable. If used, select non-greasy formulations (e.g. sorbylene- or glycerol-based), use dispensing systems that minimise contamination (e.g. single-dose pump containers), and apply only after milking.

④ Check important milking machine factors

Call in a NZMPTA-certified milking machine tester if concerned that the operation of the milking machine is contributing to teat damage.

➜ **Technote 6** describes how to monitor and maintain milking machine function, and outlines tests that can be carried out by certified milking machine testers.

⑤ Seek advice from your veterinarian if problems persist

Farmers are urged to seek advice from their veterinarian if problems are identified with teat condition.

Many farmers, especially those who have participated in training, use triggers to identify when their milking system is not operating properly – including assessment of teat condition.

Farmer assessment of teat condition covers the same range as described in this Technote, alerting them to changes in teat skin colour, swelling, hardness and teat ends. However, it is the adviser's role to investigate these alerts, including a thorough teat assessment, to better understand the situation.

➜ **Technote 13** and the **Mastitis Investigation Kit** provide a systematic approach to investigating problems.

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Technote 10

Detecting and managing clinical mastitis in lactation

In this technote:

If clinical cases are missed, they contribute millions of cells into the vat and can significantly increase Bulk Milk Somatic Cell Counts (BMSCC). Herds that have more than 5 clinical cases per 100 cows in the calving period, or 1 clinical case per 100 cows per month in subsequent months have a significant mastitis problem and help should be sought.

Rapid detection and treatment of cases means fewer chronic infections develop, and there is less chance of infection being passed to other cows. This requires milking staff to be aware of signs that indicate clinical cases and situations that increase the risk of mastitis spread.

Milk cultures are recommended to identify which bacteria are involved if a herd problem emerges. A sterile sample must be taken before treatment is started for each case.

Cows with heat, swelling or pain in the udder, or changes in their milk (wateriness or clots) that persist for more than three squirts, have clinical mastitis and require treatment.

➜ The DairyNZ **Mastitis Focus Report** can help to monitor the incidence of clinical mastitis in the herd.

① Monitor bulk milk SCC

Sharp rises or spikes in the BMSCC may indicate the presence of a new clinical case of mastitis in the herd.

➜ **Technote 11** provides more information on monitoring bulk milk SCC.

② Check for swollen and poorly milked out quarters

Swollen quarters and those that don't milk out as normal should be looked for before and after every milking, and strip-checked for clots or other clinical signs of mastitis.

➜ **Technote 4.3** describes techniques for checking udders.

③ Watch for clots on the milk filter

Milk filters ('socks'), located between the milk pump and bulk milk tank, remove gross contamination such as hair, dirt, and dung from milk that has not been removed before application of the teat cups, or was drawn in after accidental contact of teat cups with the floor or cow (Akam and Spencer 1992). Filters do not remove dirt particles less than 70 micrometres, somatic cells or bacteria.

The presence of clots on the filter sock is an indicator of poor mastitis detection (Blowey and Edmondson 1995). Filters should be inspected after every milking and before plant wash-down. If clots are detected, suspect cows should be examined at the next milking.

Not all clinical mastitis presents as clots on the filter sock (e.g., watery or discoloured milk). These cases may be indicated by a sharp rise in the BMSCC.

It is important that farm staff can distinguish between mastitis clots and clumps of internal teat sealant. Teat sealant clumps will smear or spread out when rubbed, whereas mastitis clots will not.

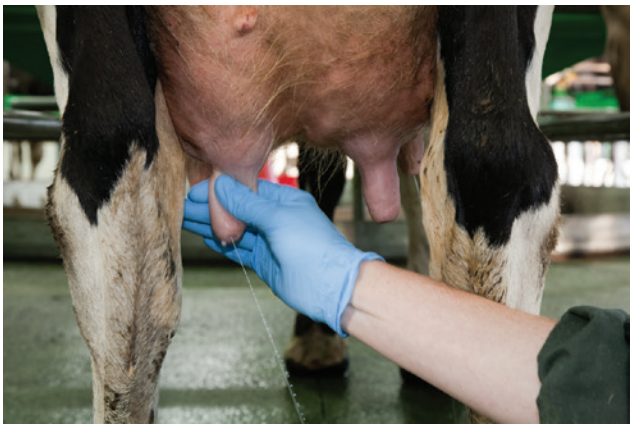
④ Foremilk strip for early detection

When clots are found on the filter or sharp rises in the BMSCC are observed, all cows should be foremilk stripped to check for clots.

'Suspect' cows should be marked for priority stripping. These include cows that:

- have calved recently;
- have had clinical mastitis within the past two months;
- have a high individual cow cell count (e.g., ICSCC above 500,000 cells/mL or a herd-specific threshold);
- have not milked out properly; or
- have teat damage or severe teat lesions.

Daily foremilk stripping of the whole herd is warranted during high-risk times, such as during outbreaks of clinical mastitis or the first 6-8 weeks of lactation.



This approach improves early detection of clinical cases, reduces missed infections, and helps limit rises in BMSCC.

➜ **Technote 5.3** describes advantages, techniques and routines for regular foremilk stripping.

⑤ Decide when to collect milk samples for culture

It is good practice to sample all new clinical cases to identify the causative pathogens, as pathogen profiles can change as lactation progresses. For cows with recurrent clinical cases, ensure at least 2-3 weeks has elapsed since the previous treatment before resampling, to minimise the risk of false-negative results due to residual antibiotic effects.

Identifying the predominant pathogens causing new infections provides valuable feedback on the effectiveness of current preventive measures and helps guide appropriate treatment selection.

Herd owners should be encouraged to use commercial diagnostic services, available through their vet or point-of-care diagnostic systems, to identify pathogens associated with new clinical cases. All diagnostic approaches depend on correct aseptic sampling technique to avoid contamination; therefore, staff responsible must be appropriately trained.

Aseptic milk samples, and where appropriate, diagnostic systems using herd test samples, can also be used to investigate high SCC cows as part of a targeted mastitis control plan.

➜ **Technote 4.4** discusses collection, storage and analysis of milk samples for culture and other bacteriological tests.

➜ The **Healthy Udder Guide** provides step-by-step instructions for sampling cows in an aseptic manner.

⑥ Record and treat clinical cases as recommended by your veterinarian

The animal health treatment plan provided by the herd veterinarian will set out relevant treatment approaches for dealing with clinical cases of mastitis. Generally, this will involve an antibiotic treatment and may include use of a NSAID (non-steroidal anti-inflammatory drug), to aid recovery.

MRS T provides a useful reminder of the steps to safely manage cows under treatment for clinical mastitis and avoid contaminating the bulk tank with antibiotic-treated milk.

➜ **Technote 4** provides more detail on mastitis treatments, including NSAIDs, as well as management of animals during treatment.

Acknowledgements

DairyNZ acknowledges the valuable input of veterinarians, milk quality advisers, and industry stakeholders who contributed to the development and review of these resources. Most are representatives of the National Milk-Quality Advisory Committee (NMAC) and have given generously of their time and expertise for the technical review.

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Technote 11

Monitoring bulk milk SCC

In this technote:

1 What is BMSCC and how is it measured?

Bulk milk somatic cell count (BMSCC) is the concentration of somatic cells (cells/mL) present in vat milk. It is used:

- On farm – to assess milk quality status and alert mastitis issues.
- By processors – for payment/penalty decisions, and quality assurance.
- Nationally – for benchmarking and marketing of milk quality.

BMSCC is measured in 'drip samples', collected during milk transfer from the vat to the tanker. Samples are analysed by an independent laboratory using machines such as Fossomatic counters that stain and count somatic cell nuclei. BMSCC measures inflammation, not number of bacteria present. Testing laboratories in New Zealand calibrate machines using internationally recognized reference standards.

Results may be reported as single test values, as arithmetic or geometric means, or as rolling means. The EU standard, implemented since January 1998, requires a rolling 3-month geometric mean of less than 400,000 cells/mL for farms supplying milk for human consumption (EU Directive 92/46/EEC). This threshold has been widely adopted by processors globally (Hubble 1997).

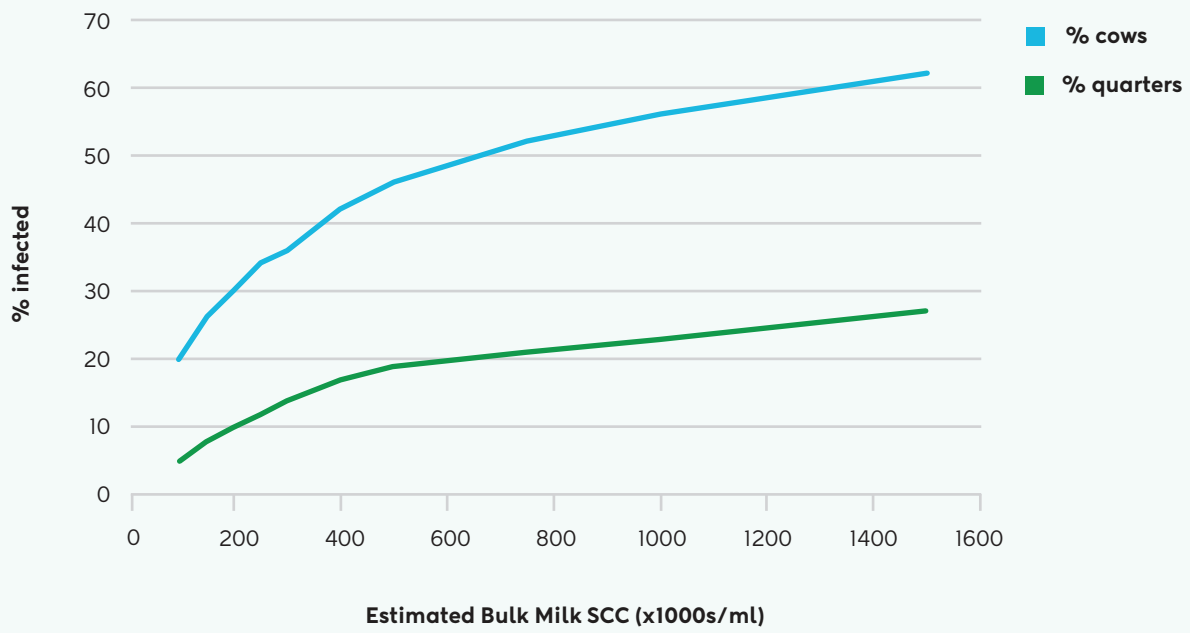
The geometric mean approach reduces the influence of extreme or seasonal variation and applies where herds are tested at least once a month. Recommendations for summarising and reporting national cell counts have been published (International Dairy Federation 1996) to improve consistency in reporting between different countries.

In New Zealand, the value of per-consignment (daily) testing was demonstrated in the mid-1990s when the New Zealand Dairy Group introduced daily BMSCC testing for their suppliers. Compared with 10-day testing, daily testing was associated with a decline in the company's average BMSCC by 18% in the first season (Lacy-Hulbert 1998).

Estimating the level of mastitis in a herd using BMSCC

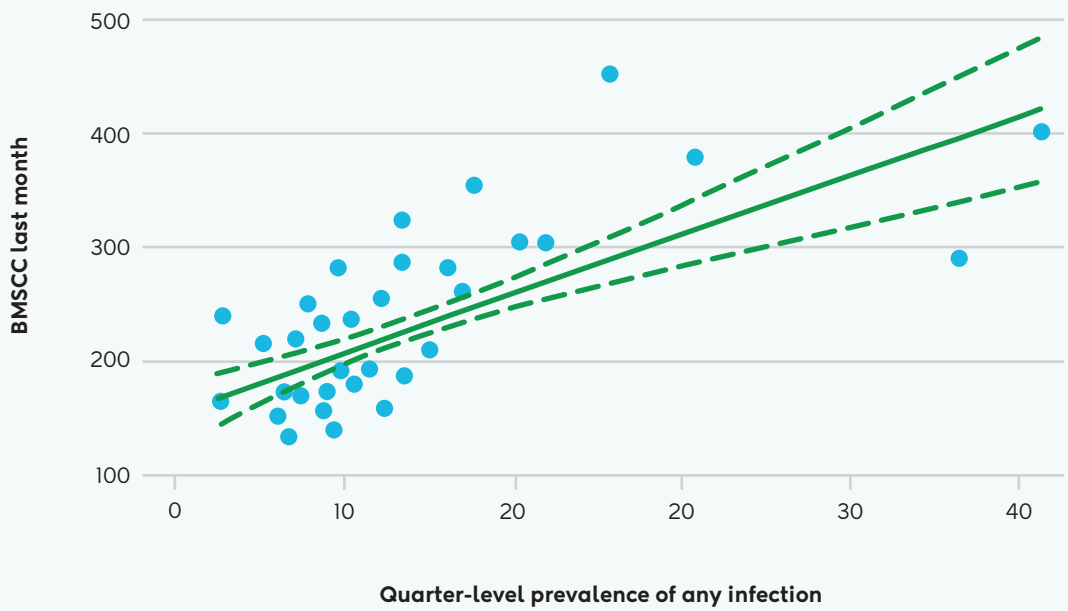
Estimates of BMSCC correlate with prevalence of mastitis in a herd (Figure 1; Holdaway *et al* 1996). Earlier studies demonstrated that for every 100,000 cells/mL increase, there was approximately 10% more cows infected with a major pathogen. With more recent lower BMSCC levels, this guide may be a poor estimate of prevalence, however, it does provide a useful starting point for discussions.

Figure 1. Percent of cows and quarters infected compared with the bulk milk SCC, from Holdaway (1996).



A study of 36 NZ herds near dry off reported a reasonable linear correlation between bulk milk SCC in the last month of lactation and the quarter prevalence of any pathogens (Figure 2) or *Strep. uberis*, but little correlation with quarter prevalence of *Staph. aureus*, as detected when cows were cultured for bacteria at dry off (McDougall *et al* 2021).

Figure 2. Prevalence of any pathogen isolated from glands of a representative sample of cows in each of 36 herds at dry off and bulk milk SCC in the last month of lactation (McDougall *et al* 2021).



The relationship between BMSCC and prevalence of intramammary infection depends on:

- sensitivity of detection and removal from supply of cows with clinical mastitis, since clinical cows contribute very high SCC and a single undetected case can elevate the BMSCC substantially, and
- the rate at which somatic cells are shed into the milk, which is affected by:
  - causative pathogens, for example *Strep. uberis* often produces higher SCC than other pathogens (Barkema *et al* 1998),
  - stage of lactation, body condition score and milk production (Berry *et al* 2007)
  - season (Berry et al 2006, Shock *et al* 2015) milking interval and timing, and
  - duration of infections.

Because of this variability, BMSCC should be regarded as a screening test for prevalence of intramammary infections. More precise estimation requires individual cow somatic cell counts (ICSCC) and/or bacteriological testing of a random proportion of cows in a herd.

Other bulk milk tests

Bacterial culture of bulk tank milk using selective media has been commercialised to provide tests that enable screening for the presence of specific pathogens. These include:

- Bulk milk culture for multiple mastitis pathogens (e.g., Snapshot).
- Bulk milk culture specifically for *Staph. aureus* and *Strep. uberis*, followed by testing of isolates for minimum inhibitory concentration for specific antimicrobials (Dairy Antibiogram, McDougall *et al* 2018).

Note that these are useful tools for detecting specific pathogens in the bulk tank but the number of bacteria detected are only poorly correlated with cow-level prevalence. Additionally, the diagnostic sensitivity to detect specific pathogens remains generally undefined.

② Check BMSCC regularly

In NZ, per-consignment testing of BMSCC is routine, with results available within 24 h of pickup, by internet, email or text. Tanker dockets are usually delivered at the next pick-up. This frequency makes BMSCC a valuable, real-time screen for prevalence and incidence of intramammary infection of a herd.

Herds with BMSCC <150,000 cells/mL have good mastitis control. A sudden rise of more than 30-50,000 cells/mL may signal an undetected clinical case or increase in incidence of subclinical infections (**see section 11.4**).

Plotting rolling averages of BMSCC over time is more informative than interpreting daily fluctuations, which can arise from new infections in individual cows or variation in cell shedding from chronically infected cows (Figure 3). Herds with greater BMSCC show greater daily variation (Schukken et al 2003), increasing the risk of supplying non-compliant milk.

When assessing a BMSCC series, look for:

- a rising trend over time,
- results exceeding warning or grading levels, and
- changes in the processor's ranking for the herd.

A grading event can incur 5-100% of the milk payment, depending on severity and timing. If high results continue and the rolling geometric mean exceeds 400,000 cells/mL, the processor may choose to discontinue supply.

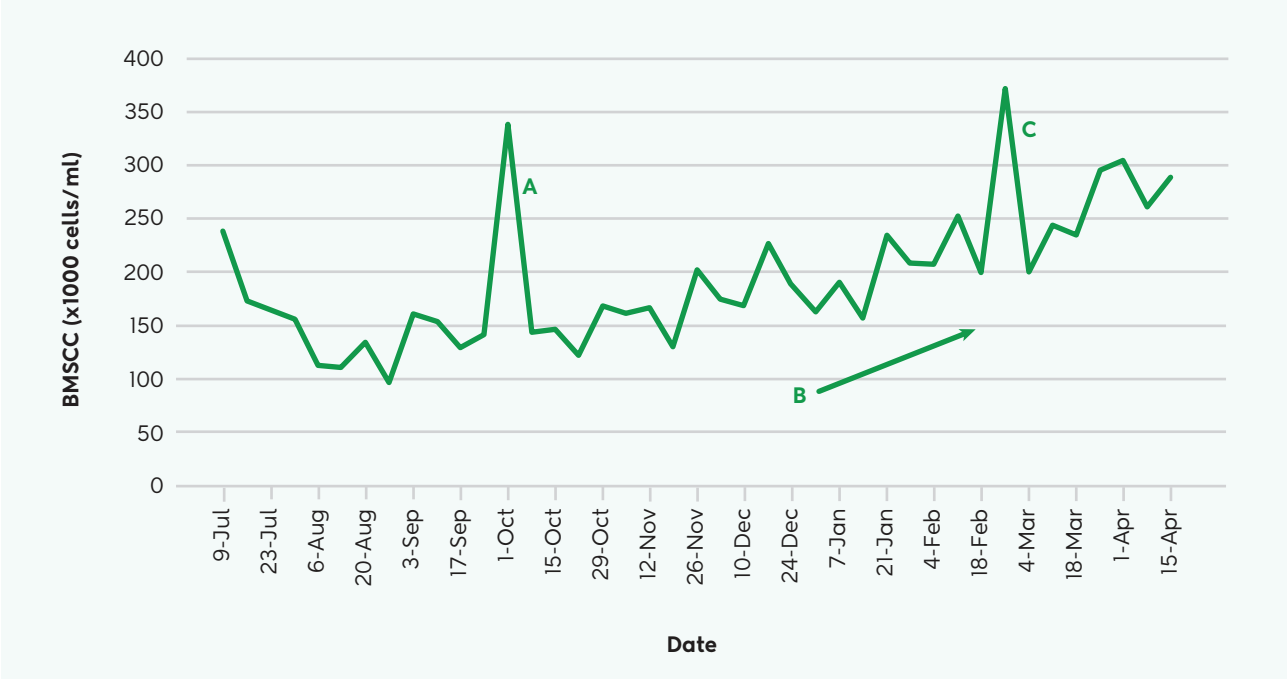
BMSCC patterns (Figure 3) can be interpreted as follows:

A. Single high spike in early in lactation (i.e. October).
   - **Action** – Check the herd for a missed clinical case.

B. Upward trend during the lactation (i.e. October to March).
   - **Action** – Seek technical or veterinary advice and implement more proactive mastitis control strategies

C. BMSCC approaching grading (>400,000 cells/mL) in lactation
   - **Action** – Remove high SCC cows from supply and seek technical or veterinary advice to improve mastitis management.

Figure 3. BMSCC patterns requiring review and action.



Graphing of SCC data for consecutive years helps visualise SCC changes through time, and the impact of management changes and interventions to be assessed.

Some researchers have used more advanced graphing methods. Dohoo & Meek (1982) demonstrated a strong relationship between a 3-6 monthly rolling average BMSCC and the quarter-level infection prevalence. Using this method, they classified herds as having low (<10%), medium (10-25%) or high (>25%) quarter infection rates with an 80% accuracy.

Other researchers suggest use of statistical process control charts to improve sensitivity for associating BMSCC change with variation in prevalence and incidence of intramammary infections (Lukas et al 2005).

Increases in BMSCC should be further investigated by examining ICSCC data and assessing any other changes on farm.

3 Consult with a veterinarian or milk quality adviser if BMSCC is consistently high

A high or unstable BMSCC indicates a mastitis issue requiring further investigation. It is recommended to initiate a mastitis investigation when herds show any of the following:

- One or more BMSCCs above the penalty threshold
- Two or more BMSCC warnings
- Regular spikes in BMSCC over a farm-defined threshold
- An upward BMSCC trend steeper than expected e.g. more than 20% over a three-month period
- Monthly BMSCC averages are "off target" for the past 3 months

➜ **Technote 12.3** describes using ICSCC to detect the spread of infection in herds, while **Technote 13** describe how advisers may respond to warning levels.

4 Check for clinical cases or exclude cows from supply

In herds with a BMSCC below 200,000 cells/mL, a sudden rise of 30-50,000 cells/mL often indicates a missed clinical case. For example:

- 150 cows at 200,000 cells/mL, each producing 20 litres = vat BMSCC of 200,000 cells/mL
- 149 cows at 200,000 cells/ mL + 1 cow at 5,000,000 cells/mL, all at 20 litres = vat BMSCC of 232,000 cells/mL.

These changes are more easily detected in low SCC herds, because high SCC herds have much greater day-to-day variation due to many infected quarters contributing fluctuating cell outputs.

➜ **Technote 4.3** describes the physical examination of the udder to detect clinical mastitis, while **Technote 5.3** describes foremilk stripping to detect clinical mastitis. **Technote 12.2** shows how to estimate the impact of high cell count cows on the BMSCC.

Acknowledgements

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Technote 12

Using individual cow SCC for management decisions

In this technote:

1 Understanding individual cow SCC

Individual cow somatic cell counts (ICSCC) are the concentration of somatic cells (white blood cells and epithelial cells) in composite milk from all four quarters of a cow, and reported as cells/mL. During herd testing, samples are taken throughout a milking using an approved meter, providing a representative sample.

Individual cow SCC is considered a relatively accurate and cost-effective tool for detecting inflammation and therefore, intramammary infection (Holdaway *et al* 1996). A comparison of ICSCC with quarter-level bacteriology showed 77% agreement for estimating infection prevalence and incidence of new infections, with a higher agreement in mid-lactation (McDougall *et al* 2025).

Healthy cows shed small numbers of cells in milk, typically between 20,000 and 150,000 cells/mL in mid lactation. Around 98% of these are white blood cells (79% macrophages, 16% lymphocytes, and 3% neutrophils), and the remaining 2% being mammary epithelial cells (Lee *et al* 1980).

Somatic cell response to mastitis infection

When bacteria enter the udder past the teat canal, white blood cells are rapidly recruited from the circulation via chemotaxis. These cells engulf and destroy (phagocytose) bacteria, release enzymes and assist with tissue repair. The SCC can rise from 100,000 to 100,000,000 cells/mL within hours in peracute clinical cases (Blowey & Edmondson 1995). Neutrophils dominate the response, accounting for more than 90% of cells during an active infection.

The pattern and magnitude of SCC elevation for an individual cow depends on the number of quarters infected, and pathogen type. Infections by *Escherichia coli* are typically of short duration and associated with a rapid rise and fall in SCC over 2-3 weeks. *Staphylococcus* infections are more chronic, showing cyclical changes throughout lactation (Figures 1 and 2).

Figure 1. Example of SCC response in a quarter with clinical mastitis due to *Escherichia coli*.

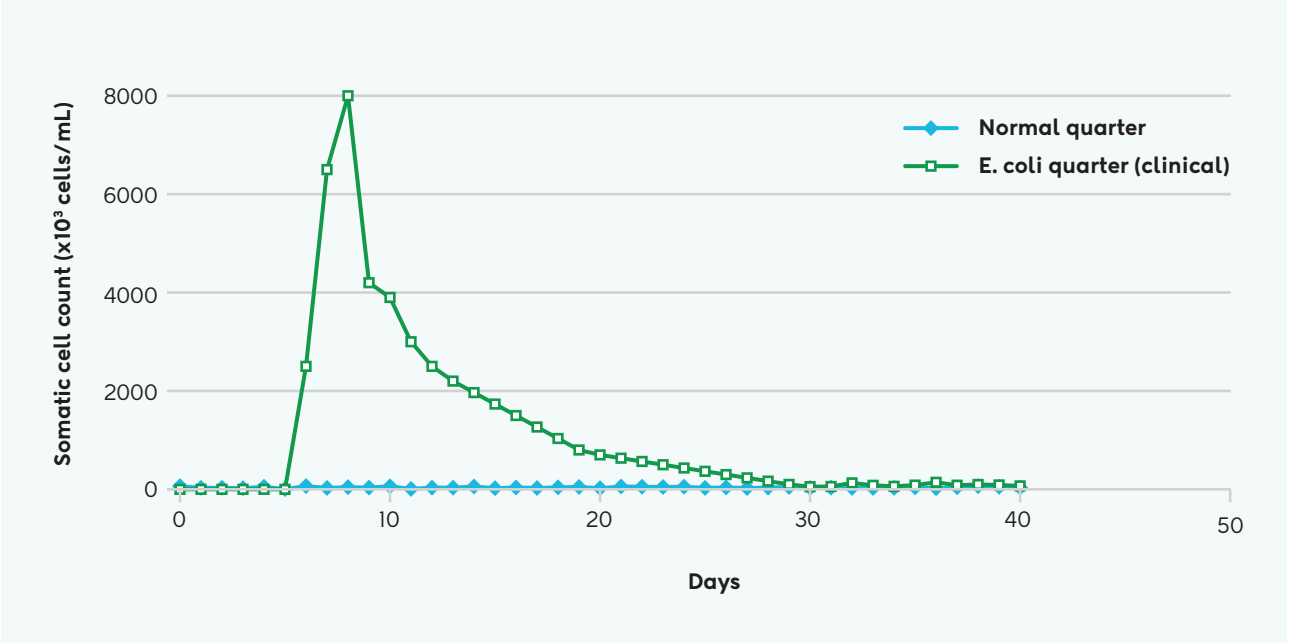
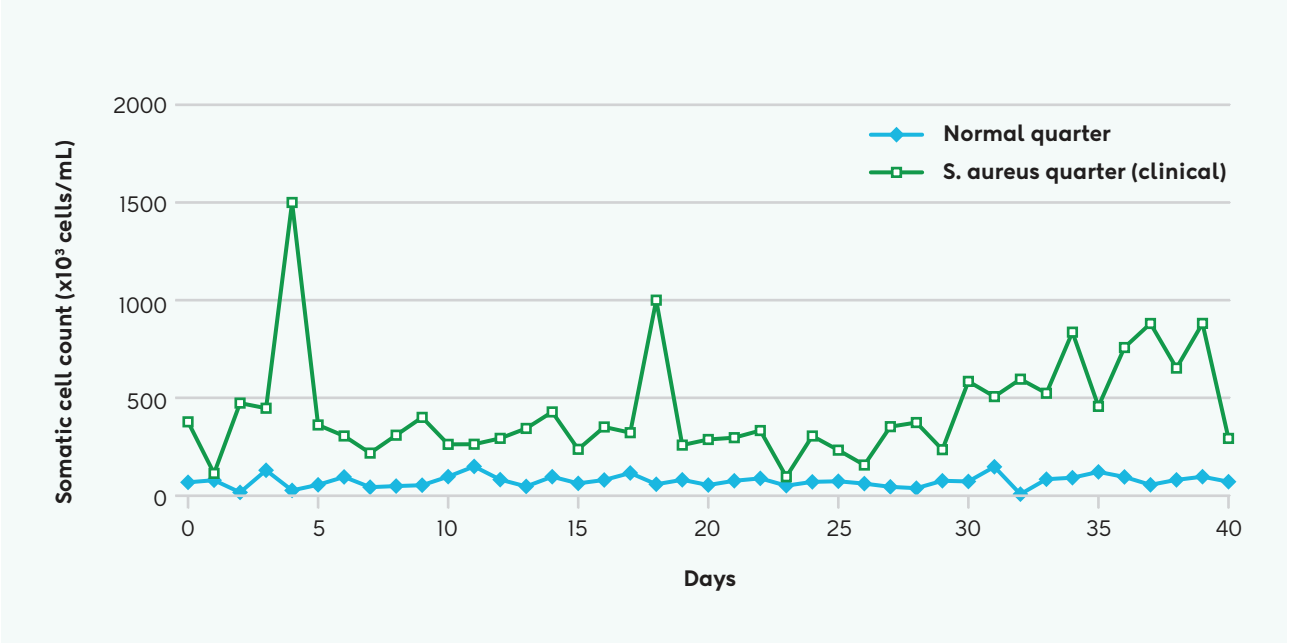


Figure 2. Example of SCC response in a quarter with subclinical mastitis due to *Staphylococcus aureus*.



Analysis of ICSCC reflect these patterns. Infections due to *E. coli* show rapid rises and declines between herd tests, while *Staph. aureus* shows persistent elevated patterns with chronic fluctuations (de Haas *et al* 2004). Infections by streptococci show less consistent patterns.

Weekly ICSCC profiles for *Strep. uberis* and *Staph. aureus* infected cows are illustrated in Figures 3 and 4 (Williamson JH, unpublished results).

Figure 3. Examples of individual cow SCC for cows with *Streptococcus uberis* infections, first detected at calving.

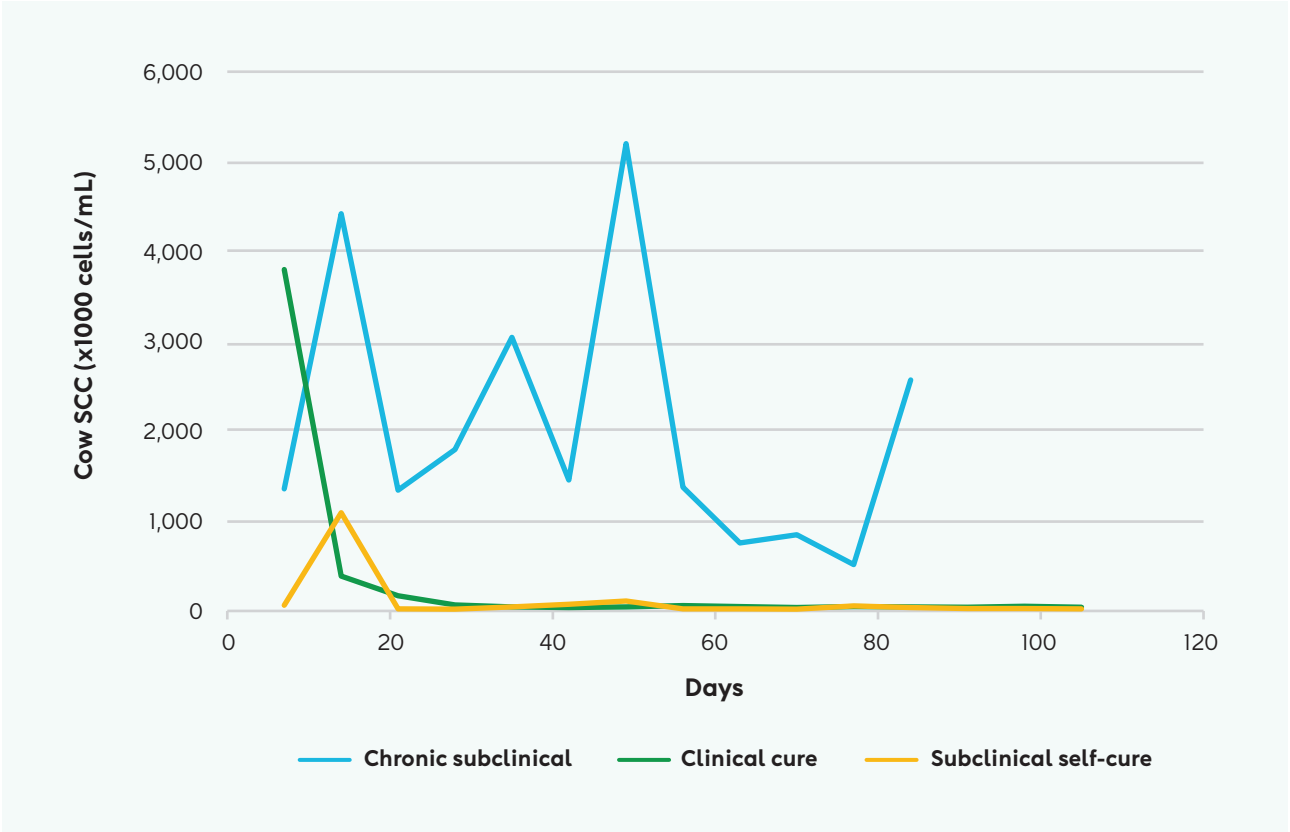
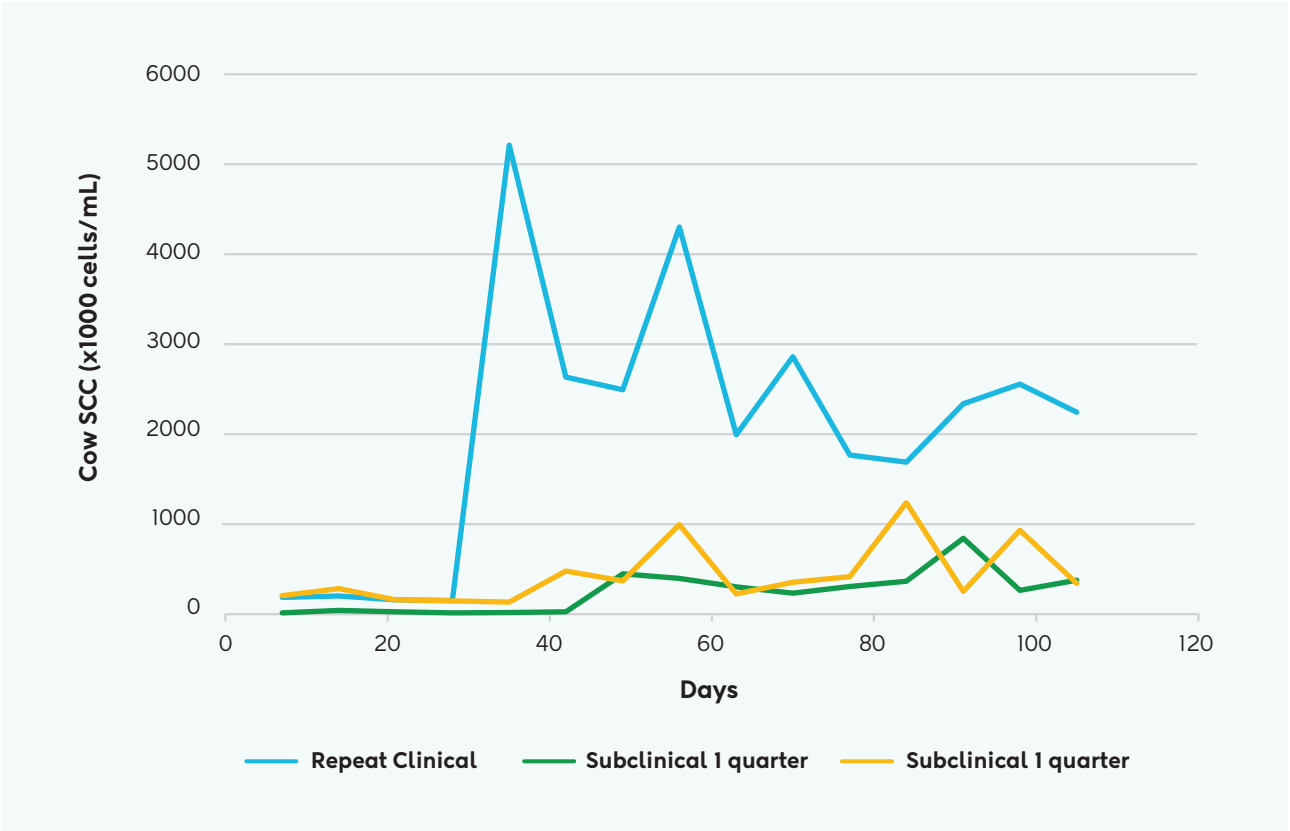


Figure 4. Examples of individual cow SCC for cows with *Staphylococcus aureus* infections, first detected in mid lactation.



Factors affecting somatic cell count

Intramammary infection is the primary determinant of SCC (Harmon 1994; Schepers *et al* 1997). Although other factors may influence ICSCC, these have limited biological effects. Harmon (1994) provides a comprehensive review of non-infectious influences and clarifies common misconceptions. Key factors are summarised below.

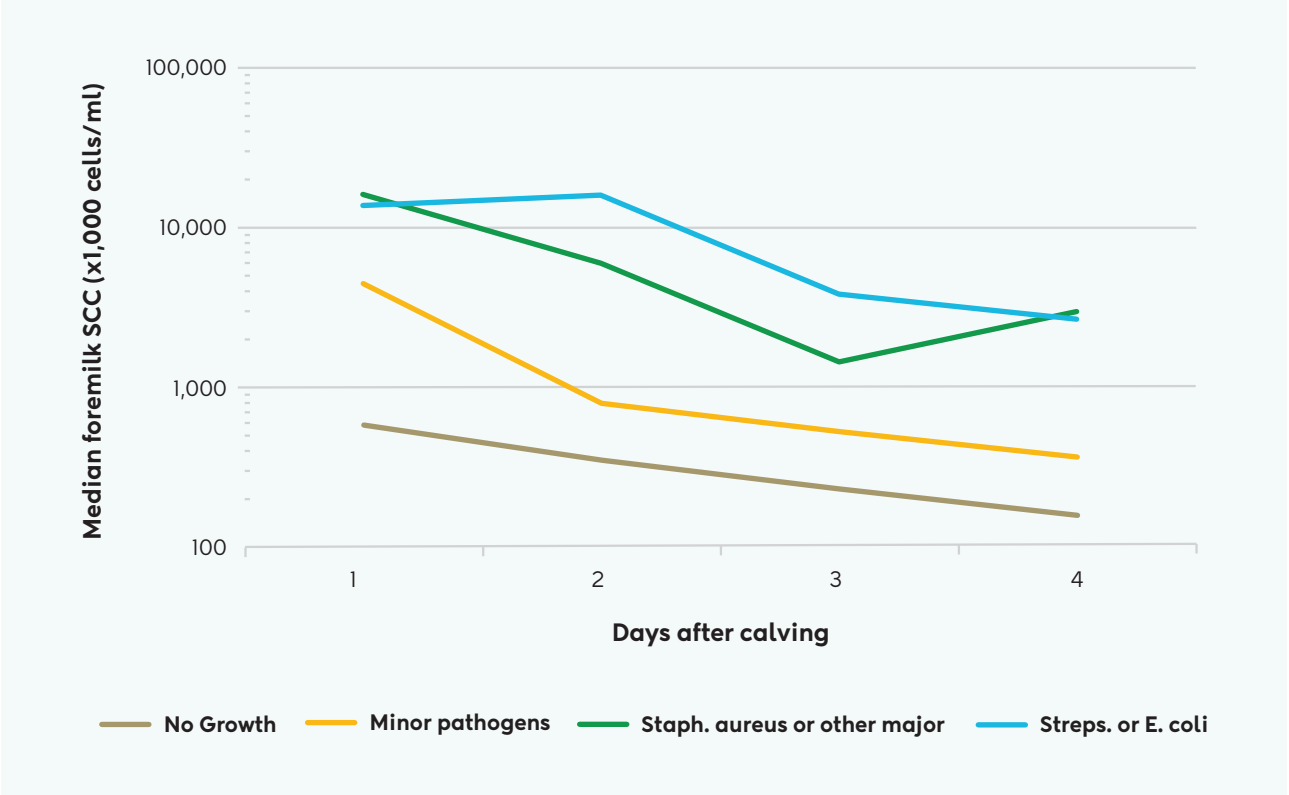
Calving

A cow's SCC is elevated after calving, regardless of infection status, due to the normal immune response as mammary tissue prepares for lactation. Counts decline rapidly after calving in uninfected quarters. Sheldrake *et al* (1983) showed that all quarters have elevated cell counts immediately postpartum, regardless of infection status but uninfected quarters, or those with minor pathogen infections, decline quickly.

The SCC for uninfected cows should fall to below 300,000 cells/mL by day 5 post-partum. By contrast, quarters infected with major pathogens maintain high SCC on day 4 after calving (Figure 5, McDougall, S. unpublished).

➜ **Technote 3** discusses factors that affect bulk milk SCC and cow SCC after calving.

Figure 5. Median foremilk SCC for quarters sampled between 0 and 4 days after calving, categorised by pathogens present: No Growth, n = 5577 samples; Minor pathogens (i.e. Coagulase negative *staphylococci* or *Corynebacterium spp.*), n = 235; *Staph. aureus* or other mixed major pathogens, n = 51; and *Strep. uberis*, *Strep. dysgalactiae* or *E. coli*, n = 158.



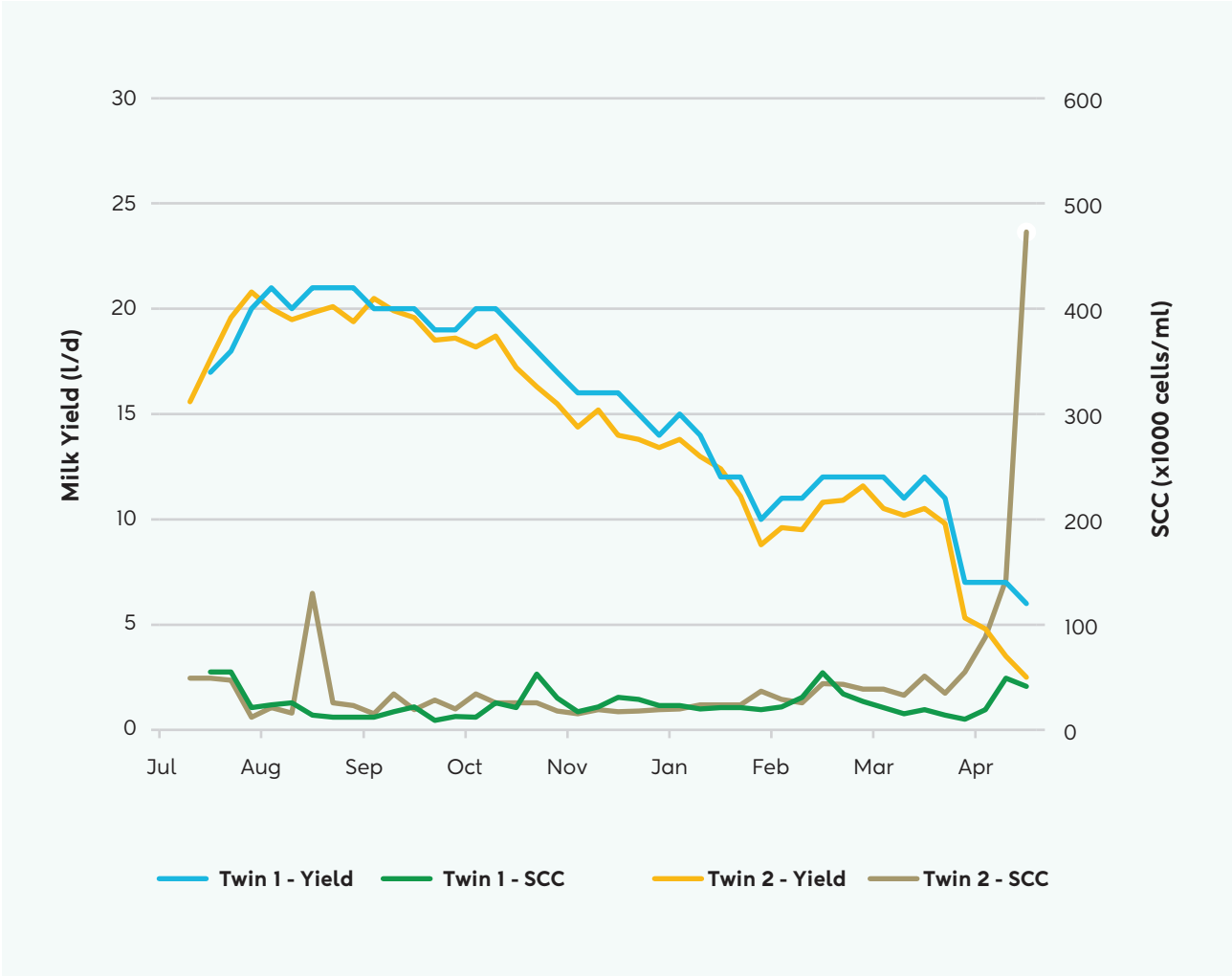
Age and stage of lactation

Cow SCC tends to increase with cow age and stage of lactation (McDougall *et al* 2025). However, when cows are grouped by infection status, uninfected cows show little change with age or stage of lactation (Eberhart *et al* 1979). The average ICSCC of older cows is generally higher than for younger cows, a reflection of a higher prevalence of infection.

In late lactation, SCC often rises for low producing cows because a relatively constant number of cells enters a declining milk volume. Involution of the mammary gland is associated with a decline in milk yield and a rapid increase in ICSCC, independent of infection. This is illustrated in Figure 6, where one twin, producing above 5 L/day (0.45 kg/d milksolids), maintained ICSCC below 100,000 cells/mL while her identical twin, producing below 5 l/day, showed a sharp ICSCC rise in the final month, despite both being uninfected at dry off. Despite this increase in ICSCC with involution, SCC remains associated with intramammary infection, even late in lactation.

➜ **Technote 16** discusses management of milk SCC before drying off.

Figure 6. Milk yield and ICSCC for an uninfected twinset where Twin 1 maintained production >5 L/d and ICSCC remained <100,000 cells/mL until dry off while Twin 2 dropped production <5 L/d and SCC rose sharply.



Frequency of milking

Cows milked once a day (OAD) throughout lactation have consistently higher SCC than those milked twice daily (Stelwagen *et al* 2013), but this is not necessarily associated with a higher prevalence of intramammary infection (Lacy-Hulbert *et al* 2005). In one study, Friesians milked OAD had a geometric mean SCC of 162,000 cells/mL. compared with 74,000 cells/mL for cows milked twice daily (Clark *et al* 2006).

Transitioning from twice daily to OAD milking is typically followed by a rapid, but temporary, increase (or doubling) of ICSCC, and bulk milk SCC (Stelwagen & Lacy-Hulbert 1996; Stelwagen *et al* 2013). Higher SCC cows will tend to show a greater elevation than cows with lower SCC following a switch to OAD milking (Stelwagen *et al* 2013).

Unexpected delays in milking, caused by equipment failure (Lakic *et al* 2011) or a weather-related crisis, for example, (Dalley & Davis, 2006) will lead to significant but short-lived spikes in cow SCC.

Milking cows at milking intervals of less than 24 h, such as 3 times in 2 days, appears to have minimal impact on mastitis or SCC (Edwards *et al* 2022). For cows milked in automated milking systems, where the milking interval can vary constantly, only weak correlations were detected between the preceding milking interval and ICSCC, with the variation in interval having a greater impact than milking interval *per se* (Mollenhorst *et al* 2011).

Other factors

Although various stressors have been suggested as causes of SCC elevations, controlled studies show minimal or no effect (Harmon 1994). There is no evidence that stray voltage, oestrus or other stressors directly increase SCC. Short-term increases are more likely due to temporary withholding of milk for 1-2 days.

Increases in systemic white blood cell counts from non-mammary diseases do not raise milk SCC. The ICSCC varies normally within a day, usually lower at the morning milking and higher at the evening milking. This diurnal variation is the main cause of fluctuations in SCC of uninfected cows.

Benefits of using ICSCCs

Regular collection of ICSCC allows identification of cows with subclinical mastitis (Holdaway *et al* 1996; McDougall *et al* 2025). This information enables advisers and farmers to:

- estimate mastitis prevalence in the herd,
- estimate new infection rates or spread of infection,
- select cows for antibiotic Dry Cow Treatment (DCT) and Internal Teat Sealants (ITS),
- identify persistent high SCC cows for culling,
- assess cow-level contributions to a high BMSCC,
- determine milking order, so that high ICSCC cows are milked last,
- assess the mastitis status of cows prior to purchase; and
- support outbreak investigations.

➜ The **DairyNZ Mastitis Focus Report** provides advisors and farmers with a tool to interpret, at herd level, ICSCC data and clinical records. **Technote 19** provides more on using ICSCC when purchasing cows.

Critical ICSCC thresholds

Individual cow SCC results represent composite milk samples collected from all four quarters. A result above 150,000 cells/mL indicates a cow likely infected in at least one quarter. This threshold has been widely used for over 30 years to provide a practical distinction between infected and uninfected cows in New Zealand, especially in mid-lactation (Holdaway *et al* 1996), with a lower threshold (120,000 cells/mL) recommended for first lactation heifers.

Quarter level SCC may have a higher sensitivity than a cow composite SCC. For example (Karzis *et al* 2017) reported a sensitivity of 70.8% (95% CI 69.5-72.0%) and specificity of 63.6% (95% CI 62.4-64.8%) for quarter milk samples at a cutpoint of 200,000 cells/mL. This compared with a sensitivity of 65.3% (95% CI 64.0-66.6%) and specificity of 66.8% (95% CI 65.7-67.9%) for cow composite (ICSCC) at a cutpoint of 150,000 cells/mL.

However, the additional cost and logistical complexities of quarter level sampling and testing outweigh this advantage. Note that hand-collected samples from individual quarters cannot be compared with herd test samples because cell counts vary across foremilk, mid-flow milk and strippings.

In NZ, where *Strep. uberis* and *Staph. aureus* predominate, cows are classified as infected if their highest ICSCC in a lactation exceeds the threshold of 150,000 cells/mL, or 120,000 cells/mL for first lactation heifers.

The Mastitis Focus report assumes that a cow remains infected until records show:

- 4 consecutive ICSCC results below the threshold
- 1 ICSCC below the threshold after a dry period.

Herd improvement organisations provide multiple reporting formats, with the facility to export data for further data manipulation or customise reporting through their web-based packages.

The chosen ICSCC cutpoint affects the sensitivity, specificity, positive and negative predictive value of ICSCC:

- At a 200,000 cells/mL threshold, sensitivity was 89% and specificity was 75% for detecting major pathogen infections, in a study of 12 New York herds (McDermott *et al* 1982).
- Using a 150,000 cells/mL cutpoint for the maximum ICSCC across lactation, sensitivity was 92% and specificity was 64% for predicting major pathogen infections at dry off across six New Zealand herds and 1,681 cows (McDougall, unpublished).
- A study across 36 herds (McDougall *et al* 2021) reaffirmed the utility of 150,000 cells/mL maximum ICSCC cutpoint for identifying cows likely infected with a major pathogen at dry off in NZ herds. Using a lower cutpoint increased sensitivity but lowered specificity, while increasing the cutpoint reduced sensitivity, and increased specificity (Table 1)

In practice, ICSCC thresholds guide decisions such as identifying infected cows for culling or selecting cows for DCT. Ideally, different thresholds would be chosen based on the economic consequences of diagnostic errors i.e. missing infected cows versus incorrectly categorising uninfected cows. However, applying herd-specific thresholds is impractical on most farms. For this reason, the universal thresholds of >150,000 cells/mL for cows and >120,000 cells/mL for first-lactation heifers remain a practical and effective standard across New Zealand.

➜ **Technote 14.6** provides more information on SCC thresholds for selecting cows for antibiotic DCT.

Table 1. Point estimates (±95% CI) for sensitivity (SE), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) of the maximum or last cow somatic cell count (SCC; x1,000 cells/mL) during lactation for predicting if a cow has one or more quarters infected with a major pathogen at dry off (from McDougall *et al* 2021).

Cut-off	Max SCC				Last SCC			
	SE	SP	PPV	NPV	SE	SP	PPV	NPV
>150	0.84 (0.78-0.89)	0.73 (0.71-0.75)	0.19 (0.17-0.22)	0.98 (0.98-0.99)	0.76 (0.69-0.82)	0.80 (0.78-0.82)	0.23 (0.19-0.26)	0.98 (0.97-0.98)
>200	0.77 (0.70-0.83)	0.80 (0.78-0.82)	0.23 (0.20-0.27)	0.98 (0.97-0.99)	0.66 (0.59-0.73)	0.86 (0.85-0.88)	0.27 (0.23-0.32)	0.97 (0.96-0.98)
>250	0.68 (0.60-0.75)	0.84 (0.83-0.86)	0.25 (0.21-0.29)	0.97 (0.96-0.98)	0.53 (0.45-0.61)	0.90 (0.89-0.92)	0.30 (0.25-0.36)	0.96 (0.95-0.97)

② Manage cows contributing high cell counts to the vat

To manage problems with a herd's BMSCC, the ICSCC and milk volumes can be used to calculate and rank cows by their contribution to the vat total somatic cells. Cows contributing the highest number of cells can then be diverted from the vat, resulting in rapid improvements in BMSCC.

Note that:

- BMSCC = volume weighted average of all cows contributing to the vat, which enables monitoring of milk quality, but not localisation of the problem.
- ICSCC (x1,000 cells/mL) x 1,000 mL per L x milk yield per cow (L) = a cow's contribution to the total somatic cells in the vat. Summing them all will approximate to the total cells in the vat.

It is possible to predict the BMSCC using the milk yield and ICSCC of individual cows. A BMSCC and average herd ICSCC taken on the same day do not always report the same value. Differences are usually explained by:

- Milk from some cows being withheld from the vat.
- Differences in sampling errors when comparing BMSCC measured on one vat sample compared to multiple tests collected across many cows.

Milk volume and SCC data for individual cows can be exported from herd test organisations. Customisable reports can be used to export SCC and milk yield into Excel (or similar) and the data manipulated to:

1. Calculate the total cells each cow is contributing to the vat
2. Rank cows in order of their contribution
3. Simulate removal of the worst 1, 2 or 5% of cows in terms of BMSCC and vat volume.

This is useful for herds where the BMSCC approaches or exceeds regulatory levels, or the farm is exploring ways to achieve and maintain premium payments. It is only profitable if the gain in payment for vat milk with a lower BMSCC exceeds the value of the withheld milk. However, it is not a long-term solution for mastitis problems.

As a general rule (see Figure 7):

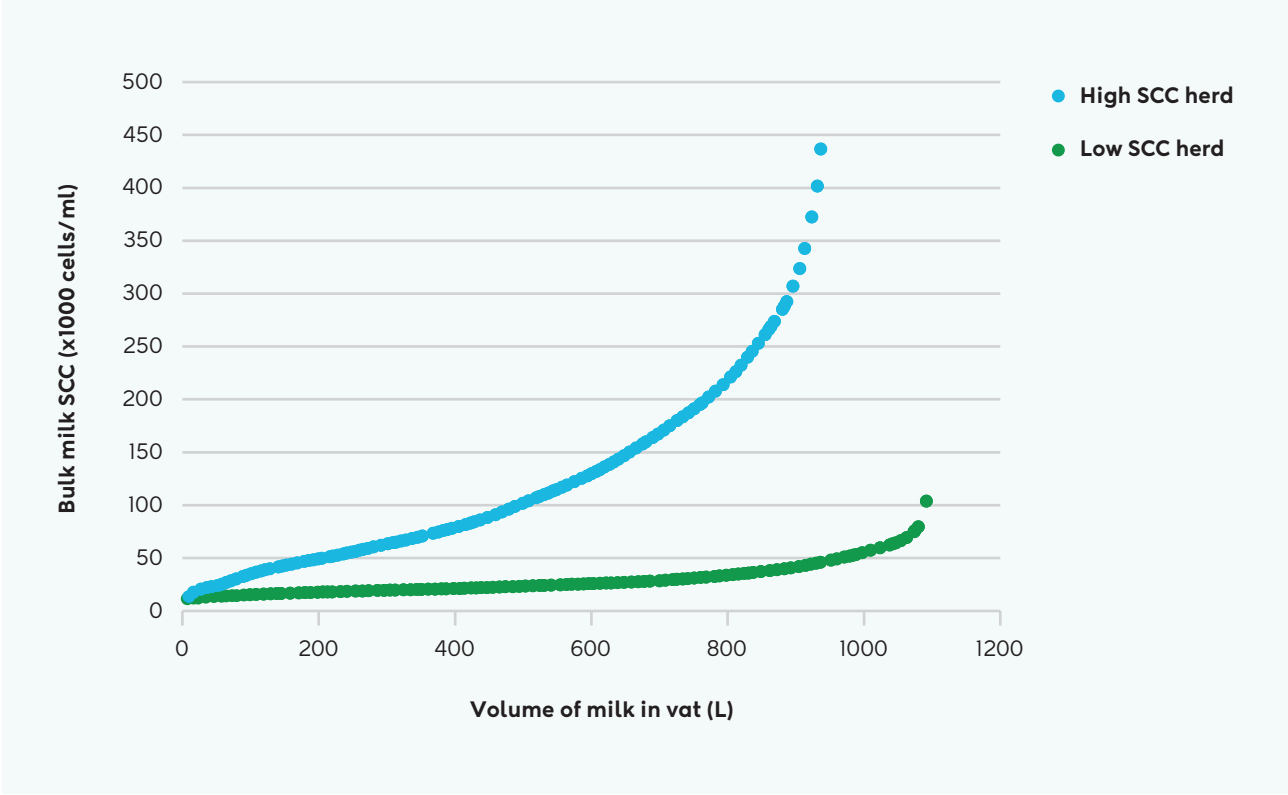
- removing between 5 and 10% of cows (the highest contributors of cells to the vat),
- can reduce the BMSCC by up to 50%, but
- only reduces vat milk volume by around 10%.

This rule is most applicable in mid-lactation but may have less impact later in lactation when a greater proportion of cows may have moderate-to-high ICSCC.

Options for maintaining a lower BMSCC include:

- Excluding cows from supply.
- Strategic drying off selected quarters or cows.
- Culling chronic high SCC cows.

Figure 7. The contribution of individual cows to bulk milk SCC and milk volume, when ranked from the lowest to the highest contributor of somatic cells. Each dot represents a cow; removing the cow contributing the most cells (highest dot) will reduce the bulk milk SCC and volume to those of the next dot, or cow, in the ranking. Removing the worst 3-5 cows significantly reduces the bulk milk SCC but has minimal impact on milk volume, for both low and high SCC herds.



Options for dealing with high cell count cows

There is no quick fix for managing high cell count cows (Shephard 1997). Treatment of such cows during lactation results in a drop in BMSCC while cows are out of supply during the milk withholding period, but BMSCC usually increases when cows are reintroduced to supply, as even with bacteriological cure, such cows have high ICSCC for some weeks or months. Long term control relies on reducing prevalence by preventing new infections during lactation, implementing an appropriate dry cow programme, using accurate diagnostics to identify the underlying cause, and maintaining an effective culling strategy. This is often frustrating for farmers and advisers, because milking high SCC cows reduces milk quality and increases the risk of mastitis spread, particularly when associated with contagious pathogens such as *Staph. aureus*.

Several short-term management options can be used once individual cows are identified as contributing high numbers of somatic cells to the vat. The best approach depends on:

- the number of cows with high ICSCC,
- whether mastitis is actively spreading through the herd,
- the production level and history of individual cows, and
- time of the year or stage of lactation.

1. Culling

Consider culling cows with high SCC across consecutive lactations, despite antibiotic Dry Cow Treatment (DCT). The Mastitis Focus criteria for culling are cows that still have ICSCC above 150,000 cells/mL despite the intervention of antibiotic DCT at the last 2 drying off periods.

Culling may be the best option for older cows with chronic high SCC and little prospect of improvement (for example those with *Staph. aureus* infection or with multiple quarters affected), particularly if small numbers of cows are involved.

➜ **Technote 15** describes issues to consider when culling cows.

2. Drying-off cows

Cows with high ICSCC (>150,000 cells/mL) can be dried off and treated with antibiotic DCT. Although they will not contribute milk for the remainder of the season, they may be cured and will be productive in future lactations. This may be the best option for heifers, and for cows nearing the end of their lactation that have had low SCC in previous lactations.

3. Drying-off individual quarters

The Rapid Mastitis Test (RMT), or quarter sampling and culture can be used to determine whether infection is only in one quarter.

Drying off an individual quarter may be a preferred option for cows likely to be culled at the end of the lactation and only infected in one quarter. Simply cease to milk the affected quarter, and it will slowly dry off and involute.

However, there are risks, such as accidentally milking the affected quarter into the vat, so identifying or marking the cow to prevent such mistakes is critical. The quarter also cannot be treated with antibiotic DCT at the end of lactation as it is already involuted.

Whether or not this strategy affects the BMSCC depends on the number of cells the affected quarter is contributing to the vat.

➜ **Technote 4.11** provides more on quarters that fail to respond to treatment.

4. Treating high SCC cows in lactation

Many studies have shown it is not economic to routinely treat high SCC cows with antibiotics during lactation.

Case selection is important. Factors that impact probability of cure (Davis *et al* 1975; Sandholm *et al* 1990; Hillerton & Semmens 1999; Sol *et al* 1997; van den Borne *et al* 2011) include:

- Cow's age
- Individual cow, and quarter, SCC
- Location of the quarter within the udder (front or back)
- Number of quarters affected within the cow
- Presence of any udder or teat end damage
- Pathogen type, strain and resistance to the antibiotic
- Duration or chronicity of the infection.

The basis of selecting quarters or cows that may benefit from treatment includes (1) an assessment at cow level (i.e. is the cow worth treating and have a reasonable chance of cure) and then (2) selection of the quarter.

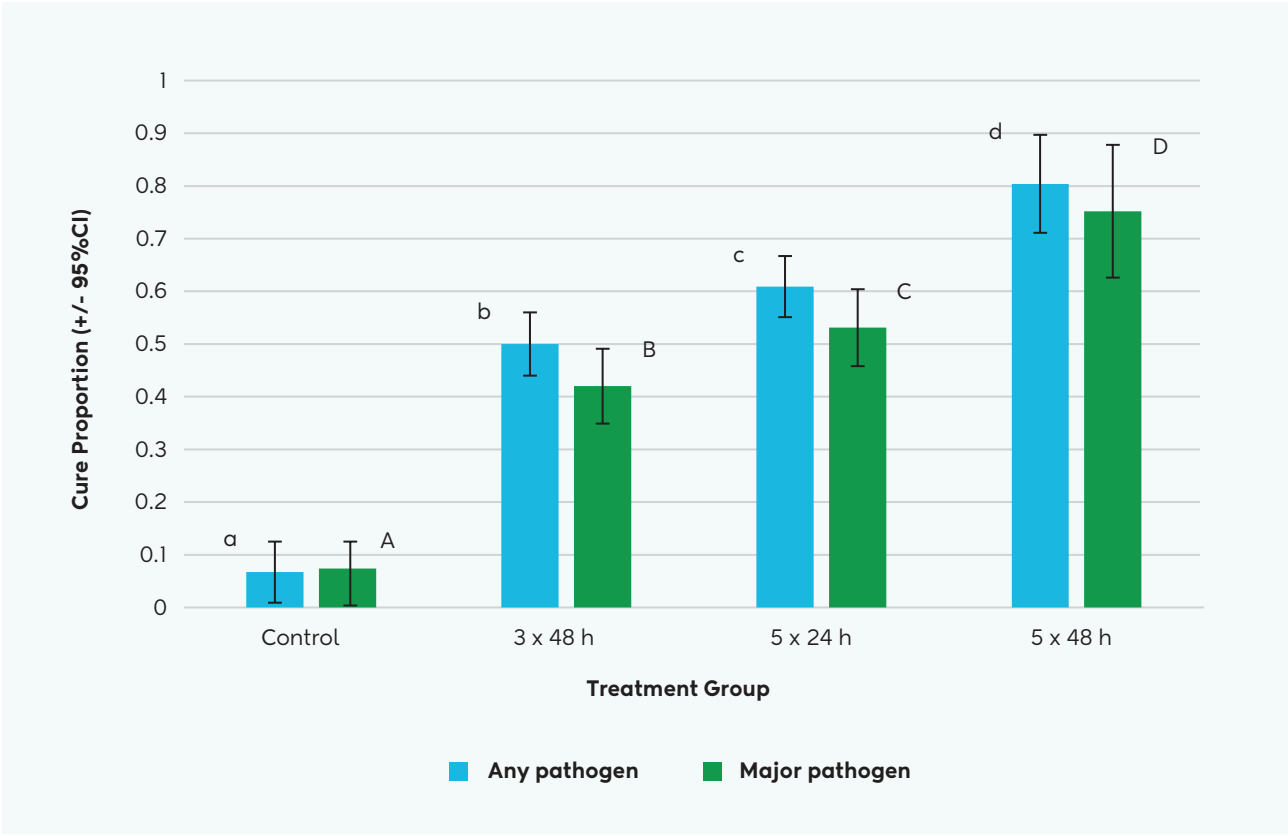
Combining an elevated ICSCC (e.g. >500,000 cells/mL) with identification of the affected quarter(s) with a positive RMT provides a practical approach. Bacteriological testing increases specificity and may identify the causative pathogen, and hence probability of cure, but with increased cost and a time delay.

Bacteriological cure rates can be increased by extending the duration of therapy:

- Intramammary treatment with ceftiofur for Nil, 2, 5 or 8 days led to bacteriological cure rates of 10%, 39%, 54% and 66%, for naturally acquired subclinical infections (Oliver *et al* 2004).
- Intramammary treatment with pirlimycin, a lincosamide, for 0, 2 or 8 days led to bacteriological cure rates of 6%, 56% and 86% for *Staph. aureus* infections (Deluyker *et al* 2005).

- Intramammary treatment with cefuroxime for 0, 3 or 6 days led to bacteriological cure rates of 13%, 24% and 53% for naturally acquired *Staph. aureus* infections, in a NZ study (Shelgren *et al* 2007).
- Parenteral treatment with penethamate for 0, 3 or 6 days led to bacteriological cure rates of 16%, 32% and 56% for naturally acquired infections (Steele *et al* 2010).
- Intramammary treatment with cloxacillin for longer, or more frequent doses, led to better bacteriological cure rates for naturally acquired infections (Figure 8; McDougall *et al* 2022).

Figure 8. Proportion of quarters (mean ± 95% confidence limits) with subclinical mastitis that cured for those left untreated (Control; n = 80 quarters) or for those treated with intramammary cloxacillin by either 3 tubes at 48 h intervals (n = 281 quarters); 5 tubes at 24 h intervals (n = 279 quarters); or 5 tubes at 48 h intervals (n = 72 quarters). Infections were by any pathogen or by major pathogens: *Staph. aureus*, *Strep. uberis*, *Strep. dysgalactiae*, *Strep. agalactiae*, *E. coli*, *Nocardia spp.* Bars within pathogen group with different superscripts differ (p <0.05). From McDougall *et al* 2022.



The costs of treating high SCC cows include:

- costs of purchasing antibiotics
- withholding milk
- diagnostic testing and misclassification errors (McDermott *et al* 1983).

Potential benefits may include:

- reduced risk of clinical mastitis
- reduced cow SCC and bulk milk SCC
- reduced milk production losses for cows with a high SCC
- reduced cow to cow transmission and fewer cases of mastitis (Swinkels *et al* 2005a).

Economic modelling generally shows little or no benefit:

- Treating cows with SCC >500,000 cell/mL in the first month of lactation with intramammary (cloxacillin) and systemic (erythromycin) antibiotics yielded no improvement in bacteriological cure, SCC or probability of culling (Shephard *et al* 2000).
- Treatment was considered uneconomic when misclassification errors led to uninfected cows being treated on the basis of elevated SCC, resulting in no improvement in SCC (Douglas *et al* 1997).

Other studies suggest treatment may be cost-effective in certain situations:

- Treatment of *Staph. aureus* subclinical cases may be economic to treat as prolonged (8 day) therapy has been associated with higher rates of bacteriological cure (Swinkels *et al* 2005a).
- Treatment of *Streptococcus* spp. cases may be cost-effective following a 3-day treatment course (Swinkels *et al* 2005b).

Early lactation treatment of high value cows may be more favourable (Steeneveld *et al* 2007) than low value cows in late lactation, since economic models are sensitive to the rate of transmission of infection, cow value and stage of lactation. Modelling suggests optimal response occurs in herds with low to moderate rates of cow-to-cow transmission (Barlow *et al* 2009) or where the intervention occurs soon after a new infection is established, leading to higher cure rates and fewer secondary cases (van den Borne *et al* 2010).

The economics of treating subclinical mastitis in NZ remains uncertain due to limited data on:

- true rate of cow-to-cow transmission,
- retention versus culling pay-off,
- clinical mastitis risk where bacteriological cure fails.

Because the quarter-level and ICSCC remain elevated for some weeks post-treatment, treatment of subclinical cases to reduce BMSCC is unlikely to be successful.

5. Using milk from high cell count cows to feed calves

Feeding high cell count or mastitic milk to calves may seem like a practical solution, but it carries significant risks:

- Increased incidence of clinical mastitis in first lactation heifers was associated with feeding mastitic milk to calves, in a NZ epidemiological study where 40% of 250 herd owners reported using this practice (Parker *et al* 2007).
- Increased incidence of calf diarrhoea was reported for calves fed mastitis milk from cows with subclinical *Staph. aureus* infections, although the study was under-powered to detect any increased mastitis risk at first milking for these calves (Abb-Schwedler *et al* 2014).
- Greater proportion of antimicrobial-resistant *E. coli* from calves when fed whole milk, pasteurised or unpasteurised, from mastitis cows (Aust *et al* 2012) and transfer or induction of antibiotic resistance in the intestinal flora of calves (Langford *et al* 2003).
- Greater potential for violative antibiotic residues in calf tissue (Musser *et al* 2001), especially for calves slaughtered within 24 hours after feeding.
- Transfer of other pathogens such as *Mycobacterium avium* subspecies *paratuberculosis* (Johne's disease) may occur (Ridge *et al* 2005).

For these reasons, feeding mastitic milk to calves is not recommended.

6. Milk chronically infected cows last

Segregation or separate milking of infected cows reduced the prevalence of *Staph. aureus* infection from 29.5% to 16.3% and the BMSCC from 600,000 to 345,000/ml over a 6-to-24-month period (Wilson *et al* 1995).

➜ **Technote 8.3** provides more on milking order and reducing spread of mastitis.

③ Monitor ICSCC trends for evidence of infection spread

Individual cow SCC are a powerful tool for monitoring mastitis control and investigating outbreaks (Ryan 1992). Analyses of ICSCC data can be used to:

- Monitor contagious spread of mastitis, particularly among heifers that were uninfected at calving.
- Assess infection dynamics among different age groups and the number of cows crossing the critical threshold (150,000 cells/mL) over time.
- Identify cows that should be sampled for bacteriological testing.
- Identify cows that could be milked last or run as a separate high-SCC group.

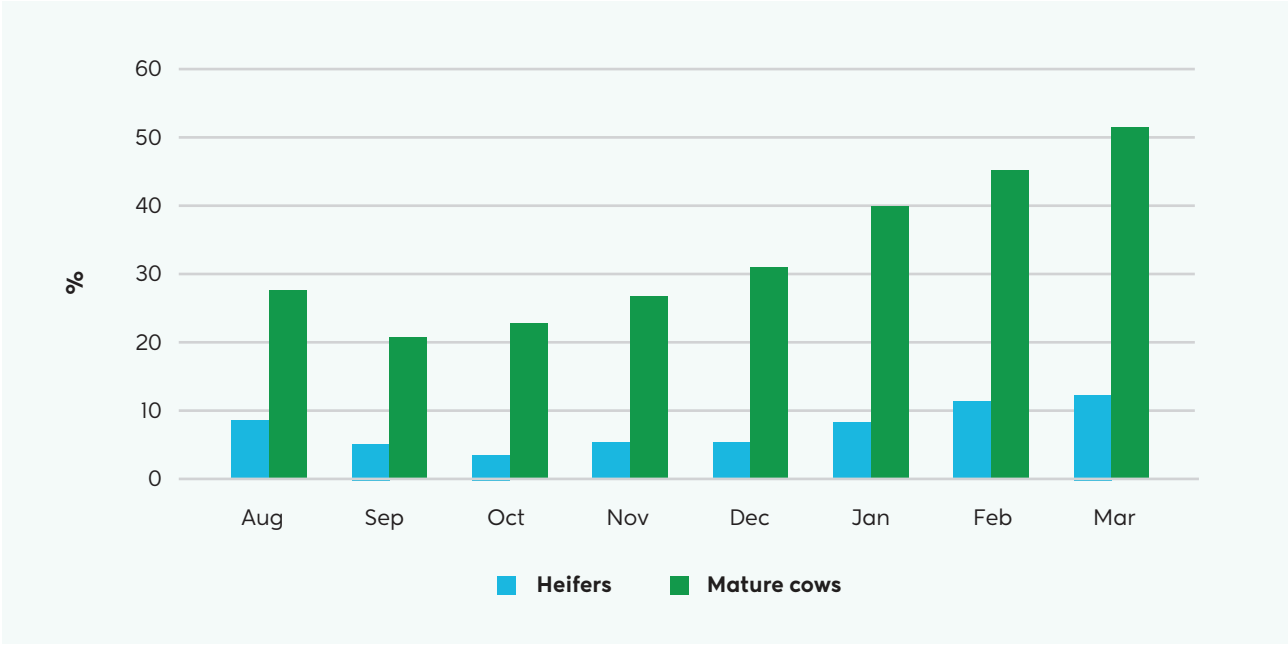
Repeated ICSCC measures help distinguish cows that do not have mastitis from chronically infected cows with consistently high, or fluctuating, SCC. Changes in ICSCC status can also indicate:

- New infections – in cows moving from below to above the threshold.
- Dry period cures – in cows previously above the threshold whose SCC drops below in the next lactation due to treatment or self-cure.

A high incidence of new high SCC in heifers indicates active spread of new mastitis infections in the herd. In contrast, a high proportion of high SCC in older cows but not heifers suggests that infection is not spreading (Figure 9).

As a guide, heifers are considered to have a high incidence of new infections if more than 20% are above the 120,000 cells/mL threshold.

Figure 9. A high mastitis rate in older cows but a low rate in heifers suggests the infection is not spreading.



➜ **Technote 5** describes management of outbreaks due to contagious spread during lactation.

➜ **Technote 1** covers outbreaks due to environmental pathogens, which can also spread cow-to-cow as lactation progresses.

Scattergraphs

Changes in ICSCC status can be effectively visualised using scatter graphs (Rapnicki 1997), where:

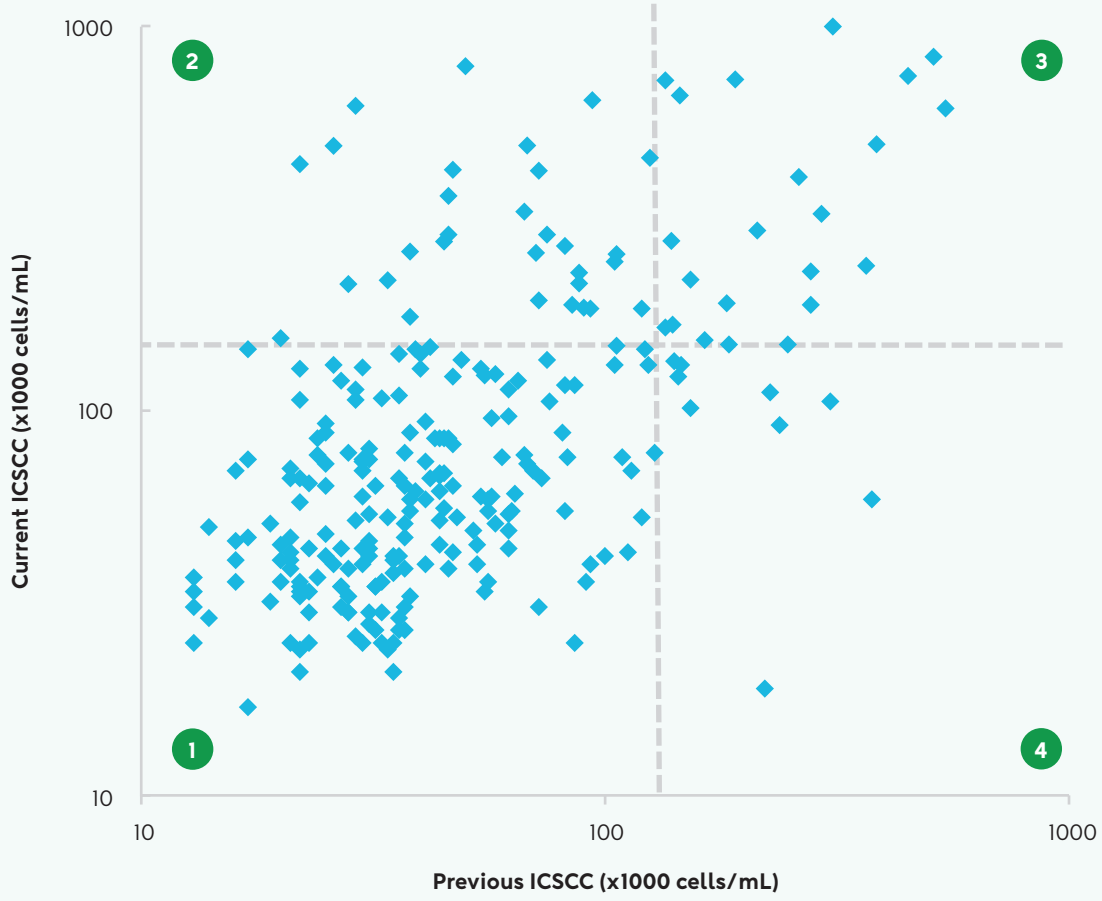
- the x-axis = previous period ICSCC,
- the y-axis = current period ICSCC,
- threshold-lines (e.g. 150,000 cells/mL) to divide the graph into four quadrants (Figure 10).

This allows rapid identification of cows that stayed uninfected, cows that remained infected, cows with new infections and those that have cured between herd tests.

Scattergraphs can be used to summarise the success of DCT strategies, by comparing ICSCC patterns between lactations, and can be stratified by parity or lactation stage to support more detailed mastitis investigations.

In cows with *Staph. aureus* infections, changes in mastitis status should be assessed between lactations because fluctuations in ICSCC are expected within a lactation.

Figure 10. Example of a scattergram comparing the ICSCC at 2 sequential herd tests, with the threshold of infection set at 150,000 cells/mL, shown by the dashed lines.



④ Annually review your herd testing approach

Herd testing provides essential data for benchmarking herd performance at farm, regional and national levels. New Zealand farmers can choose between CRV AmBreed and LIC as herd testing providers and can select the frequency and timing of tests to suit herd needs and budget.

Herd testing involves collecting individual milk samples from all lactating cows. A full herd test reports:

- milk volume, fat and protein yields
- individual cow somatic cell counts (ICSCC).

Typically, NZ herds are tested three to four times per lactation, and over 75% of herds, and 80% of all dairy cows, are herd tested annually (DairyNZ & LIC 2025).

Herd testing provides a comprehensive view of herd productivity and subclinical mastitis status, allowing identification of:

- cows with high ICSCC, for withholding milk from the vat, for drying off or culling,
- cows with low production, for drying off or culling,
- high producing cows, for breeding decisions.

If clinical mastitis data is entered, herd records also support long-term tracking of clinical mastitis cases and treatments.

National Milk-Quality Advisory Committee (NMAC) recommends a minimum of bi-monthly herd testing, which generally equates to 4 tests per seasonal lactation.

Regulatory framework

CRV AmBreed and LIC are certified herd testers. Under the Dairy Industry (Herd Testing and New Zealand Dairy Core Database) Regulations 2001, certified testers must submit herd testing data to the New Zealand Dairy Core Database.

Collection of milk volumes by a certified herd tester without the corresponding SCC is not permitted by the Regulations. All the ICSCC data are accessed for the purpose of producing New Zealand Dairy Statistics (DairyNZ & LIC 2025) and for producing the NZAEL Somatic Cell Breeding Values for dairy sires.

Data collection and reporting

Herd testing involves collection and analysis of milk samples from all lactating cows in the herd. Herd test results are supported by accurate herd records of cow ID and calving and dry off dates, with release of full reports prevented if records are not up to date.

Herd testing provides:

- Measures of milk, protein and fat yield for each cow for each test day and the whole lactation.
- Indexes for Production Worth (PW) and Breeding Worth (BW).
- Measures of ICSCC.

Standard reports are available from herd test providers, and web-based reporting systems allow farmers and advisors to customise herd reports for their requirements.

More herd tests per lactation increases the accuracy of cow-level production and udder health. Herds in NZ typically test fewer times per year than countries with monthly testing, but 3 to 4 tests per lactation provides adequate information for breed improvement purposes, and for herd and cow-level decision-making.

Herd recording

Herd records enhance the value of herd testing by providing evidence of a cow's genetic merit and productive performance, relative to other herds.

Herd records also provide information on the udder health status of the herd during a single lactation, and across consecutive lactations.

The overall level of mastitis in a herd can only be fully assessed if records of both clinical cases and subclinical cases (ICSCC) are available. Herd recording systems provide opportunities to record all clinical mastitis cases and treatment details electronically.

Mastitis Focus Report

Mastitis Focus brings together records of subclinical mastitis from herd test records (ICSCC), and clinical mastitis case records into one single report. The report helps to identify key mastitis management areas where improvements can be made.

A **Mastitis Focus Report** is more accurate and informative when:

- Herd testing occurs more frequently (i.e. 4 or more tests per lactation), and over consecutive seasons
- Data relating to clinical and dry cow treatment records are uploaded regularly to the herd test provider.

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Technote 13

Investigating a mastitis problem

In this technote:

1 A structured approach to mastitis investigations

A structured, consistent approach to mastitis and milk-quality investigations helps ensure the problem is clearly defined, relevant information is collated and any extra data needed to identify probable risk factors is collected. Following such an approach, as described in this Technote, increases the likelihood that an effective, farm-specific action plan can be developed and implemented.

Before recommending solutions, advisers must be confident that the mastitis problem is accurately defined. This requires a systematic investigation of the problem to identify:

- the nature of the problem - is it grading or high bulk milk SCC (BMSCC), high clinical case rate, or poor teat condition?
- the pattern - is it acute or chronic, when in lactation is it occurring?
- the causative pathogens - what bacteria are causing problem(s) for the herd?

Understanding herd-specific epidemiology and risk factors is essential. A practical way to gain an overview is to assess:

- People – quality of communication, clarity of responsibilities, recent staff changes, compliance with on-farm protocols, any on-farm pressures.
- Cows – herd age structure, culling patterns, fertility-related retention of older cows, recent introduction of cows with unknown mastitis status.
- Farm dairy – maintenance and servicing of plant and milking equipment.
- Environment – the feeding, grazing or housing conditions that may elevate mastitis risk.

Effective problem definition usually requires coordinated input from a multi-disciplinary team, including veterinarians, milking machine technicians, the farm consultant/adviser, and in some cases the accountant and banker (Figure 1). Developing strong local relationships with key providers of services and information will support quicker, more effective mastitis investigations.

Once the problem is clearly defined, advisers can work with the farm team to agree on 3-4 key factors that must be addressed for progress to be made, develop practical on-farm actions, and set up ongoing monitoring and review processes.

This Technote outlines the Mastitis Investigation Kit, which provides checklists and recording sheets for use during farm visits, and an Investigation Master Sheet to help organise and prioritise findings, so that a workable farm-specific plan can be developed.

➜ Download the **Mastitis Investigation Kit** here or find it on dairynz.co.nz.

Figure 1. Flow chart of the general approach for investigating a mastitis problem

STEP 1

Describe the presenting problem

- Describe the problem as the farmer sees it.
- Examine and interpret the available information and identify information gaps.
- Redefine the problem with available data.
- Plan how to start gathering the next set of critical information.
- Get the client to set goals for solving the problem i.e. to achieve x% incidence of CM; lowering the bulk milk cell count by xxx cells/mL.

STEP 2

Define the problem more specifically using milk culture results

- Collate available milk cultures results. If inadequate, the consultant or vet should plan a detailed milk sampling strategy and organise sampling and transportation to the lab.
- Interpret milk cultures to determine the bacteria causing the problem in the herd.
- Consider likely sources and modes of transmission of the bacteria in the herd.

In some circumstances STEPS 2 and 3 may be done in reverse order.

STEP 3

Activate the advisory team

- Identify who needs to be involved in this investigation.
- With the advisory team, plan relevant examinations using the Investigation Master Sheet.
- Do the tests and analyse the results.

STEP 4

Collate and assess findings with the advisory team

- With the advisory team, collate and assess results using the Investigation Master Sheet:
  - consider bouncing ideas off an experienced mentor,
  - identify any further examinations required, do them, and assess results,
  - agree to key factors critical to resolving the problem (check against presenting and re-defined problem).
- Report initial findings to the farm owner and discuss options for plan development.

STEP 5

Develop a farm plan with the farm team

- Organise a farm meeting and involve the whole team in planning practical ways to address key areas needed to resolve the problem.
- Summarise them in a report e.g. a farm mastitis action plan.
- Activate processes, agree to triggers for action and set a date for review.
- Re-emphasise farm goals (and/or establish them).

STEP 5

Review progress

- Measure progress in key areas and make a date to review overall progress.
- Set regular times for review even if done remotely via web-based systems.

② Review mastitis indicators regularly

Farmers are urged to seek professional advice whenever mastitis-related problems persist, such as:

- Bulk milk SCC is higher than normal
- Herd test SCC shows increasing number of cows with high SCC
- Clinical mastitis incidence is higher than industry benchmarks or above the farmer's own targets.

Warnings can take the form of an alert from a processor, triggered by critical events such as a bulk milk SCC warning or penalty grade (Table 1). Warnings can also appear as a performance trigger or 'trigger for action'. This involves regular monitoring of performance and prompt follow-up when a pre-set threshold is exceeded. A common example of a trigger might be '*any bulk milk cell count above 200,000 cells/mL*'. These triggers are often set at or below formal alert levels, depending on-farm goals (Table 2).

The mastitis **industry benchmarks** are based on large datasets from milk processors, herd test organisations and veterinary organisations. Benchmarks for the best performers (usually top 25%) of herds are provided, with warning levels provided in the **Mastitis Focus Report** that reflect:

- extensive field experience (e.g. teat condition),
- economic penalties (e.g. BMSCC) and likely economic impact of mastitis,
- understanding of mastitis epidemiology (e.g. the presence of less common environmental pathogens or *Staph. aureus*), and
- expert opinion (e.g. using individual cow somatic cell counts (ICSCC) to assess mastitis spread).

The Mastitis Focus Report provides a structured summary to help identify risk areas within a herd and monitor progress after management changes are implemented.

Generate a **Mastitis Focus Report** after each herd test, and after uploading mastitis treatment records.

➜ The **Mastitis Performance Calculator** can be used to identify the benefits of closing the gap between a herd's current performance and industry goals.

Table 1. Take immediate action and seek help when alert levels are reached.

Indicator	Alert levels	Reason for action
Bulk Milk SCC *See **Technote 11***	One or more SCC above grading (e.g. 400,000 cells/mL) or alert level (e.g. 300,000 cells/mL) from dairy company.	Grading for SCC is costly. Action is required to reduce the SCC to below penalty levels.

Table 2. Take action and seek help when trigger levels are exceeded, before problems escalate.

Indicator	Trigger levels	Reason for action
Bulk Milk SCC See ***Technote 11***	Regular spikes in SCC (i.e. increase of 30 - 50,000 cells/mL or more above previous tests) OR Upward trend in SCC is steeper than target curve OR Monthly average SCC above industry average, or a herd's self-selected target for past 3 months.	Herds with BMSCC above 200,000 cells/mL are at risk of grading before the end of the lactation.
Clinical cases *See **Technote 4*** *See **Mastitis Focus report***	More than **5** clinical cases per 100 cows of heifers calved for **monthly clinical case rate at calving**. OR More than **1** clinical case per 100 cows in milk for **monthly clinical case rate in lactation.**	These clinical case rates have been observed in herds with below average performance.
Individual Cow SCC *See **Technote 12*** *See **Mastitis Focus report***	More than **10** cases per 100 cows in milk per month for **new infection rate – subclinical and clinical** OR More than **20%** for **first calver new infection rate**	These estimates are indicators of the spread of infection in seasonally calving herds.
Cultures *See **Technote 4***	The presence of **increasingly common environmental pathogens** isolated in any clinical cases. OR The presence of ***Staph. aureus*** in the majority of culture samples. OR The presence of ***Strep. agalactiae*** in any culture samples.	Isolation of unusual environmental pathogens indicates unique risk factors for the herd. *Staph. aureus* can be contagious and may be hard to cure. *Strep. agalactiae* is highly infectious but has been eradicated from most herds.
Teat condition *See **Technote 9***	**5%** of cows (2% of teats) affected by gross lesions or cracks OR **10%** of cows (4% of teats) affected by dry or rough skin or haemorrhages or teats scored as VR (Very Rough) for hyperkeratosis OR **20%** of cows (8% of teats) affected by hyperkeratosis (VR or R), or redness/blueness, ringing, wedging or openness/ after milking.	Teat condition reflects the quality of milking management, the dairy system and the environment.

③ Seek professional advice if mastitis indicators are above warning levels

NMAC (National Milk Quality Advisory Committee) strongly recommends a team-based approach to mastitis investigations, as resolving complex cases and developing a robust control plan often requires multi-disciplinary expertise.

A designated lead adviser should activate and coordinate the advisory team (i.e. those involved in interpreting information and developing the control plan), manage information flow and keep all relevant parties updated on progress.

Early in the investigation, the advisory team should agree on:

- Appropriate diagnostic tests and on-farm observations
- Organisation of farm visits
- Timing and frequency of data review and team discussions
- Key interaction points with the farm owner/manager including confirming investigation goals, presenting preliminary findings, and discussing control options.

Establishing a realistic, structured timetable and following it improves team efficiency and engagement (refer to Flowchart in Figure 1).

An extended regional and national advisory network is available, and consulting an experienced mentor at critical stages can enhance decision-making, build confidence, and assist with resolving complex issues.

➜ A list of NMAC Accredited Mastitis vets from across New Zealand can be found here on the **DairyNZ website**.

The Mastitis Investigation Kit

The **Mastitis Investigation Kit** consists of:

- **Investigation Master Sheet (Sheet A)** for coordinating the investigation and developing a plan of action; and
- **12 recording sheets (Sheets B to M)** for collecting and interpreting key data.

This Technote outlines each element of the Kit and its use. Investigators should be familiar with the Kit before starting a farm investigation.

Early in the investigation, the advisory team should decide which diagnostic tests and assessments are needed to complement existing information and allocate these tasks accordingly. The Kit should be used to ensure all relevant risk factors are checked, and data is systematically collected and analysed.

This structured approach often uncovers additional issues not directly relevant to the current problem. They can be noted on the Investigation Master Sheet as 'different problem' and addressed separately.

➜ See **page 15** for tips on how to collect data most efficiently at a milking-time visit.

General approach to investigating a mastitis problem

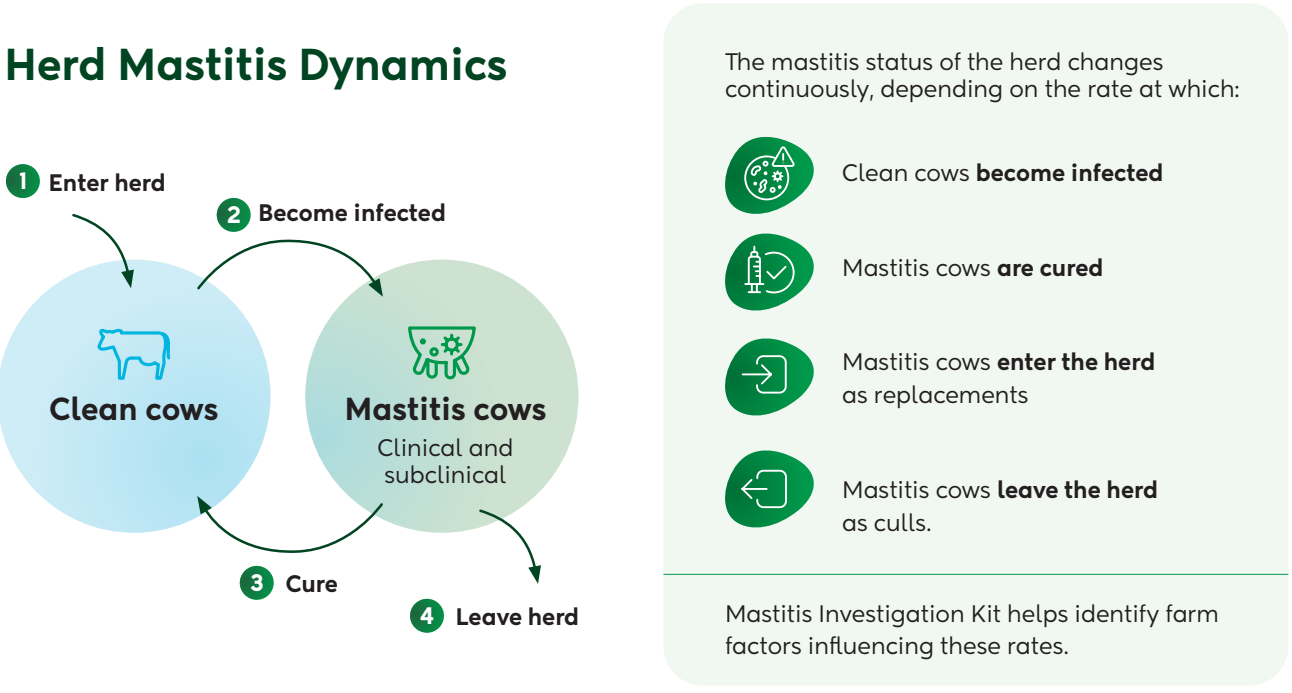
A. Investigation Master Sheet

The Investigation Master Sheet (A1-A7) provides a structured process for identifying the key factors that will shape the mastitis action plan. It is the central tool of the investigation because it is used:

- **By the advisory team** to construct a clear, concise problem definition and allocate tasks
- **By individual team members** to summarise their findings and highlight practices that deviate from industry guidelines
- **As the decision-making hub** for assessing whether these practices are contributing significantly to the problem and identifying the main underlying risk factors.

The Herd Mastitis Dynamics Chart (Sheet A7) supports advisers in creating a visual summary of how herd management influences mastitis in the herd (Figure 2). This helps the team maintain an overall perspective on mastitis control while addressing seasonal or high priority issues. It also serves as an effective communication tool for discussions with herd owners and staff.

Figure 2. A model to describe the ever-changing infection status of cows in a herd.



To improve the likelihood of identifying an effective solution:

1. **Focus on the factors rated as 3 or 4** in importance in the right-hand column of the **Investigation Master Sheet**.
2. **Transfer these** onto the **Herd Mastitis Dynamics Chart** (Sheet A7) according to their area of influence.
3. **Interpret the chart** in the context of the **epidemiology of the major pathogen(s)** present in the herd.
4. **Prioritise the factors** most likely to deliver meaningful improvement.
5. **List these priority factors** on **Sheet A1** (box on front page of Investigation Master Sheet) and include them in your report to the farmer.

B. Farm profile

The **Farm Profile** is a 5-page questionnaire used to:

- summarise the presenting problem (Box 1, Figure 1),
- identify information already available for team assessment, and
- highlight potential leads for further investigation.

The first page provides a broad overview of the client and herd. It contains factual, non-technical information and can be completed by any competent team member.

Farm Profile **Sheets B2-B5** assess farm management practices that influence mastitis and should be completed by an advisory professional, typically a veterinarian. The questionnaire is intentionally concise to maintain focus and ensure that high quality, relevant information is collected.

NMAC recommends advisers gather this information through a personal interview (phone or in person) and complete the pages themselves. This ensures context-appropriate responses, improves data accuracy, and allows follow-up questioning when needed.

Vet technicians can efficiently compile BMSCC, herd test and treatment records, saving veterinary time. Prearranged access to milkquality data enables faster assessment and earlier intervention when problems arise.

The Farm Profile is the only sheet in the Kit that captures information on:

- BMSCC trends,
- numbers of clinical cases,
- drying off strategy and
- the impacts of mastitis on the herd culling policy.

Use the left-hand side of the Farm Profile Sheet B1 to organise the collection of information that is already available. This can be done before a farm visit to make the process of information gathering efficient.

C. Milk cultures

A critical step in mastitis investigations is to determine which bacteria are involved (Box 2, Figure 1). This requires an adequate number of milk cultures, and insufficient sampling is a common error that often stems from perceived cost concerns. However, without identifying pathogens, targeted and cost-effective control is unlikely. The veterinarian is typically responsible for organising sampling, interpreting results, and clearly communicating their importance to the farmer.

The goal is to define which bacterial pathogens are causing the problem. To do this, investigators should obtain at least 20 valid culture results, meaning samples must be collected from at least 25 cows to allow for contaminated or unusable samples.

Sampling strategy depends on the presenting problem:

- **Clinical Mastitis** – collect samples from all cases, prior to treatment. Samples can be frozen and submitted in batches, if required. Include any existing samples or results.
- **High Cell Counts** – collect samples from cows, based on mastitis history or recent ICSCC. Cow selection should be made by the veterinarian to test specific epidemiological hypotheses about mastitis in the herd, and could include:
  - a range of age groups, including heifers,
  - cows with recent SCC rises
  - cows with persistently high SCC across tests or lactations (e.g. maximum SCC from 150,000 to > 1,000,000 cells/mL).

Once cows are selected, sample the quarters most likely to be infected. Use a quarter-level screening test (e.g. Rapid Mastitis Test) and collect from quarters indicating subclinical mastitis.

Cow composite samples (i.e. a roughly equal volume of milk from each quarter into a single sample jar for each cow) may be used to save cost, but they:

- increase the risk of contamination
- have slightly lower sensitivity to detect pathogens than quarter-level samples and
- do not identify which quarters are affected.

Milk Cultures Sheet C can be pre-populated with the selected cows. A separate Sheet C should be used for each batch to track sampling and results.

When sampling a number of cows, avoid collecting samples at milking time. Preferably draft out cows at a morning milking and then sample them immediately before the afternoon milking. This allows sampling to be done in a clean environment.

➜ See **Technote 4.4** for a detailed description of the collection, storage and analysis of milk samples for bacterial culture.

D. Individual cow somatic cell count analysis

Individual Cow Somatic Cell Count (ICSCC) analysis provides valuable herd-level insights of apparent mastitis prevalence across different cow groups (i.e., age, lactation stage, management groups) and helps estimate the new infection rates.

Most ICSCC data are available electronically, and herd improvement organisations provide web-based analysis tools. However, advisers commonly perform simple, targeted analyses, such as those summarised on Sheet D:

1. Comparison of mastitis prevalence across cow groups

Assess the proportion of cows in each age groups with a maximum SCC above 150,000 cells/mL (or 120,000 cells/mL for first calvers). This gives an indication of infection prevalence by age, or stage of lactation, although interpretation may be limited in small groups of cows.

2. Estimate of new infection rate

Evaluate the proportion of first-lactation animals with an ICSCC >120,000 cells/mL during lactation. More than 20% of heifers with a maximum ICSCC >120,000 cells/mL by the end of their first lactation suggests unacceptably high contagious spread of mastitis in the herd.

The Mastitis Focus report flags more than 10 newly infected cows per 100 cows in milk per calendar month as concerning for spread of infection, where the numerator is the number of newly infected cows between herd tests, and the denominator is the uninfected cows at the preceding herd test (i.e. not the whole herd).

3. Number of persistent infections

Determine the proportion of cows with persistent infections (i.e., ICSCC > 50,000 cells/mL in current and previous lactations) at each herd test. This indicates the chronicity of the problem and effectiveness of the last dry period in curing infections.

The Mastitis Focus report identifies persistent infections in two ways, by identifying the number of cows eligible for culling, and by assessing the proportion of clinical cases that have been retreated.

4. Number of cured infections

Calculate the proportion of cows likely cured (i.e. number of cows that are now uninfected at the current herd test, divided by the number that were previously infected (>150,000 cells/mL) at the preceding herd test). Where the interval includes the dry period, this also indicates dry-period cure effectiveness.

Analyses of ICSCCs should be based on regular herd testing data, not on single 'spot' tests. It is recommended to have at least four ICSCCs to determine the status of a cow during lactation.

A cow is classified as infected or uninfected based on:

- her highest (or maximum) cell count taken during the lactation
- an ICSCC exceeding 150,000 cells/mL (or 120,000 cells/mL for first calvers), in NZ herds where *Staph. aureus* and *Strep. uberis* are the main pathogens
- for Mastitis Focus purposes, cows remain infected until they have four or more subsequent tests below these values, or a dry period with antibiotic DCT and one ICSCC below 150,000 cells/mL.

➜ The **Mastitis Focus Report** provides a herd-level analysis of the infection status of the herd from the ICSCC data.

➜ **Technote 12** describes methods of analysing and interpreting ICSCCs.

E. Milking machine dry test (NZMPTA test or equivalent dry test)

NMAC recommends using technicians who are certified by the New Zealand Milking and Pumping Trade Association (NZMPTA) to perform the Dry Test to ensure high-quality testing, standardised reporting, and interpretation based on NZMPTA specifications. This test aligns with the International Standard ISO 6690:2007 (ISO 2007).

A Dry Test assesses:

- **Cluster component compatibility** – to ensure appropriate fit of liners to shells, claw nipples are suitable for average teat size, that cluster balance and weight are appropriate, and cluster air admission meets guidelines.
- **Vacuum regulation effectiveness** – to ensure that the vacuum is appropriate for the milkline height, that the vacuum regulator is functioning, that vacuum reserve is sufficient (unit fall-off test), and vacuum undershoot and overshoot is minimal.

When evaluating the possible contribution of the milking machine to mastitis (Boxes 3 and 4, Figure 1), the advisory team should review the key findings of the milking machine Dry Test report.

Machine technicians may also perform a Wet Test, which evaluates machine performance when air and water, or artificial milk, is pumped through the system. A Wet Test is often used to commission a new installation or a major plant upgrade and may help pinpoint a vacuum regulation problem.

➜ **Technote 6.5** describes different tests that can be carried out by a certified milking machine technician.

F. Performance tests of milking machines

Milking-time performance tests assess how well the milking machine setup matches the herd and measures its function under normal operating conditions. These tests typically include:

- **Cluster compatibility** with average udder and teat size.
- **Vacuum stability** in the milkline and receiver.
- **Measurement of claw vacuum** range during milking.

When evaluating the possible contribution of the milking machine to mastitis (Boxes 3 and 4, Figure 1), use the guidelines for performance tests given in Technote 6 and in the Mastitis Investigation Kit.

These performance tests build on Dry Test findings, and often help to pinpoint the underlying causes of:

- **frequent liner slips** (Sheet G),
- **poor teat condition** (Sheet I),
- **poor cow behaviour** or **slow milking** (Sheet J), or
- **incomplete milking** (Sheet K).

Some veterinarians use their own milking-machine testing meters during milking time investigation as a screening tool to detect gross machine faults. However, these meters may offer less precision than more specialised milking-machine assessment equipment, used by registered NZMPTA technicians.

➜ **Technote 6.2** provides guidelines for interpreting milking routine observations, including milking times and completeness of milking.

G. Milking routines and cup slips

Milking routines

The **milking routines checklist** (Sheet G) is intended for advisers to complete based on direct observations in the dairy at milking – not for milkers to fill out. Some lists allow multiple tick boxes to be selected.

Careful assessment of milking routines often reveals factors contributing to the presenting problem (Boxes 3 and 4, Figure 1). When developing a farm plan (Box 5), improving routines and communication with the on-farm team members is low-cost, motivating and beneficial for mastitis control.

Cup slips

Cup slips or falls occur unpredictably, so experienced observers usually listen and watch for slips while recording other aspects of the routine. The rate of slips or falls per 100 cows milked can be estimated from:

- the average number of cows per milked per hour and
- the time of the first and last recorded slip or fall.

➜ **Technote 6.2** lists the common causes of cup slips and falls.

H. Clinical cases

Clinical case management can be evaluated by reviewing the quality of the **clinical case records** (Farm Profile Sheet B3) and using **Clinical Cases** Sheet H to observe milking-time practices, discuss case-handling with milkers and assess treatment techniques for cases.

➜ **Technotes 4** and **10** describe recommended methods of detecting and treating clinical cases.

I. Teat condition

Formal teat-condition assessment helps identify milking machine, management or environmental factors, or infectious agents, contributing to teat and udder health (Boxes 3 and 4, Figure 1).

- Teat skin condition may be examined before milking but is often easier after milking.
- All other parameters on Sheet I should be evaluated immediately after milking.

➜ **Technote 9.2** provides more on assessing and interpreting teat condition in commercial herds.

J. Cow behaviour and milking time per cow

Cow behaviour

Cow behaviour provides insight into cow comfort, or discomfort, with the milking environment, routine or machine. Behaviour can be scored using systems such as KiSt (Kick, Step; Technote 6).

Observations should be made at different stages during milking:

- whilst cows wait in the stall or bail to be milked
- during teat preparation and cluster attachment
- in the first two minutes of milking
- in the last two minutes of milking.

In herringbone dairies, cow behaviour and milking-time measurements can be recorded concurrently for each cow (working across the sheet). In rotaries, observing different groups of cows is more efficient. See data collection tips at the end of this section.

➜ **Technote 6.2** describes the types of problems that may be occurring for cows showing discomfort at different stages of milking and outlines the KiST scoring system.

Udder and teat hygiene

Dirtiness of the udder and legs provides an indication of the environmental contamination pressure on teats. Cleanliness of udder and/or rear legs can be assessed before or after milking and scored on a 4-point scale, where:

- 1 = clean, free from dirt, up to
- 4 = > 30% of surface area is caked in dirt.

Teat spray coverage should be evaluated after spraying and can be scored visually, as adequate or poor for the front and rear teats. A more detailed assessment can be performed on selected cows using the paper-towel wrapping test, as described in **Healthy Udder** and **Technote 7**.

Milking time per cow

Three key metrics can be derived from careful measurements of a representative sample of cows:

1. **Proportion of cows showing delayed milk let-down**
   - Minimal: fewer than 10% of cows, or
   - Moderate: 10-20% of cows.
2. **Average milk-flow time per cow**
   - See guidelines in **Technote 6**
3. **Average over-milking time per cow**
   - Minimal: mean over milking time <1 minute/cow
   - Moderate: mean is between 1-2 minutes/cow.

This data provides a strong basis for milking management recommendations and helps explain underlying causes of:

- **new mastitis infections,**
- **frequent liner slips** (Sheet G),
- **poor teat condition** (Sheet I),
- **poor cow behaviour** (Sheet J) or
- **incomplete milking** (Sheet K).

Warning bells should ring if, for example, over milking occurs in conjunction with pulsation failure (Sheet E).

➜ **Technote 6** gives the expected milking time for herds producing between 10 and 20 litres per cow per milking and situations that will increase the average cups on time per cow.

K. Completeness of milking and cluster alignment

Completeness of milking

Although there is little recent evidence that under milking increases the risk of mastitis, assessing completeness of milking can still provide useful information about milking machine performance and milking team efficiency (Boxes 3 and 4, Figure 1).

- If incomplete milk-out is suspected, assess by hand stripping at least 25 cows or 100 quarters at the end of milking (Technote 6)
- In herds using efficient milking routines, Max T, or automatic cup removers with 400-800 mL/min cut offs, residual milk measurements are of limited value.

Recent research suggests that there is no long-term loss of production associated with some residual milk, so completeness assessments are rarely undertaken.

➜ **Technote 6** gives a guide to assessing incomplete milking.

Cluster alignment

Poor cluster alignment can reduce milking efficiency. This can be demonstrated visually by manually re-aligning the cluster when milk flow from a cow has nearly ceased.

- Hold the cluster squarely under the udder by manipulating the long milk tube, without applying extra downward pressure.
- Milk flow often resumes when clusters are poorly aligned.

Patterns such as higher residual strip yields from rear versus front quarters, or from left-side versus right-side quarters typically indicate problems with cluster positioning or uneven weight distribution across the four teat cups.

Teat size

Visual or measured assessment of teat size and shape is useful when reviewing liner selection, ensuring liners match herd teat conformation.

➜ **Technote 6** provides more on liner selection.

L. Teat disinfectant

Sheet L is used to assess issues related to teat disinfectant use prior to application (Boxes 3 and 4, Figure 1). This includes product selection, mixing accuracy, storage, and suitability of the stock solution.

- Coverage and application quality are evaluated separately in the milking routine assessment (Sheet G).
- The mixing section of Sheet L is not required on farms using ready-to-use disinfectant products.

➜ Use **Technote 7** to interpret the information and identify any leads to follow up about post-milking teat disinfection.

M. The environment

The environmental checklist supports evaluation of a herd's exposure to environmental mastitis risk, with emphasis on calving areas and practices, and the immediate post-milking environment.

- It is advisable to physically inspect key risk areas at the appropriate time of year, for example the calving areas at calving time, or feedpad areas when in use.
- Udder contamination prior to milking is recorded on Sheet G.

Tips for efficient data collection during milking-time tests and observations

Getting the numbers right

A frequent weakness in mastitis investigations is sample sizes that are too small. When too few cows are observed, the conclusions lack precision, and the time and effort invested yield little value.

NMAC recommends assessing a minimum of 25 cows, ideally, up to 100 cows, for milking-time observations, such as cow behaviour and milk flow times per cow (Sheet J) and completeness of milking (Sheet K).

Technote 9 provides guidelines on the number of teats and cows required to evaluate teat condition:

- Assess all teats of 100 cows to investigate system faults and causes of teat damage.
- Assess smaller numbers of cows (e.g. 50) to identify if a problem warrants further investigation.

Table 8 (**Technote 9**) provides the minimum number of teat abnormalities required to detect different prevalence thresholds, or triggers for action.

Efficient teamwork for data collection

Milking time investigations can be time-consuming and may require multiple people over more than one milking visit. Experienced advisers often need two milking visits to complete most observations. To improve efficiency and cost-effectiveness:

- Prioritise key risk areas from examining available pre-visit data (e.g., herd test results, microbiology).
- Use trained technicians to collect and record data where appropriate.
- Adopt electronic data-capture tools (e.g., phones, tablets) to streamline collection and preliminary analysis.

Options that reduce the need for extensive testing time on farm include:

- Conduct a quick vacuum regulator test for undershoot or overshoot before milking. This is a partial substitute for monitoring receiver vacuum during milking.
- Measure mean claw vacuum before milking, in 3-5 clusters using a flow simulator set at a controlled liquid flow rate of 3 kg per minute (or 5 kg per minute for very high producing cows).
  - This wet test is an acceptable substitute for measuring the mean claw vacuum on 6-10 real cows during milking.
  - In fact, it is a better measurement because the simulator flow rate is known and highly repeatable.

If these strategies are used, **milkline vacuum stability** becomes the only milking-time machine test that needs to be done *during* milking.

- Conduct this in the first 15 minutes of milking when milk flow is likely to be highest.
- On a rotary, use an empty stall for one rotation.
- In a herringbone, record at a convenient milking unit during removal and re-attachment of the first complete set of clusters.

In dairies where milkline size and slope meet current guidelines, **milkline stability testing** may be optional. However, it does provide a neutral 'activity' for a visiting technician while milking staff settle into their routine, before observations are made on milking routines, cow behaviour, etc. It can also reveal practical 'real world' performance issues and allow correlation of events, such as operator actions with measurements.

If a flow simulator is not available, mean claw vacuum can be measured by:

- Pre-installing 3-5 T-pieces between the claw outlet and long milk tube. These are capped when not in use.
- Connecting the vacuum recorder to record mean vacuum at 30 s and 90 s of milking for one cow, then move immediately to the next unit without waiting for the first cow to finish milking.
- Collect from one group of 3-5 cows after milkline vacuum stability testing, then repeat with another group later in the milking.

④ Plan and conduct the milking-time visit

Planning the visit – Before the visit, the advisory team should agree on which on-farm measurements will be taken and allocate tasks. With good organisation, **two people can collect most data in a single milking**, with a follow-up visit by one person if needed. Tasks can be organised as follows:

<table>
<tr><th></th><th>Adviser One</th><th colspan="2">Adviser Two</th></tr>
<tr><td rowspan="2">Before milking</td><td>Assesses environmental factors
Assesses case treatment procedures and recording</td><td colspan="2">• Assesses liner condition checks pulsators
• Checks claw air vents (either hole size or individual claw air admission)</td></tr>
<tr><td>Identifies teat spray active, mixing procedures, storage procedures and usage</td><td colspan="2">• Measures working vacuum and regulator undershoot and overshoot
• Measures mean claw vacuum with flow simulator, and/or pre-installed T-pieces
Where a vacuum meter (e.g., VaDIA) is available, install into one of the claws.</td></tr>
<tr><td rowspan="5">During milking</td><td>Evaluates cup on and off procedures, and milking routine,</td><td colspan="2">• Records milkline vacuum stability (15 minutes) and receiver vacuum (if necessary).
• Records mean claw vacuum on the first group of 3-5 cows (if required).
• Record all audible cup slips and falls.
• Record mean claw vacuum on a second group of 3-5 cows (if required).</td></tr>
<tr><td>Assesses teat condition and teat spray coverage on groups of cows throughout milking</td><td colspan="2">Observes cow behaviour and milking times per cow:
• Behaviour in yard and entry into bails
• Interactions with milkers</td></tr>
<tr><td></td><td>In herringbones:
Observe groups of 3-4 cows, for a whole side</td><td>In rotaries:
• Observe cow behaviour for 25 (or more) cows near cow entry position, note approximate stall position when milk starts flowing strongly into most claw bowls.
• Move to near cups off area and observe another group of 25 (or more) cows for:
  • the average stall position at which milk flow slows or stops for majority of cows,
  • the average stall position at which most clusters are detached,
  • cow behaviour during last 2 minutes of cups on.</td></tr>
<tr><td></td><td colspan="2">• Calculate total cups on time and average milk flow time per cow.
• Measure usual rotation time of the platform to help calculations, while ignoring unusual events or stoppages.</td></tr>
<tr><td colspan="3">Measure completeness of milking:
• Hand-strip all quarters of 25 cows preferably
• Dictate results into a tape recorder or work with an assistant.
• Stop once a quarter clearly exceeds 100 millilitres and record as ‘High’.</td></tr>
<tr><td>Follow up</td><td colspan="3">If two milking-time visits are planned, include one morning and one afternoon milking, as production levels and staffing can differ between milkings.</td></tr>
</table>

5 Record problems and actions taken

The aim is to develop a workable, farm-specific plan. This requires:

- forming a plan with the on-farm team,
- producing a clear, concise written report,
- ensuring actionable steps are listed on a wall chart or visible checklist, and
- scheduling appropriate follow-up.

Adoption of recommendations is more likely when farmers see changes as relevant, achievable and offering tangible rewards, preferably financial (Gardner 1990). Plans developed collaboratively, with adviser guidance, are generally more successful.

Providing a clear written report

The **Investigation Master Sheet** is used to collate findings, prioritise issues, and refine problem definitions until practical solutions can be recommended. Written reports for the owner/manager, and meetings of the farm team and adviser(s) are then used to convert these findings into implementable actions for the situation.

Reports should provide a permanent record and should include:

- Objectives of the original visit
- Key findings from the investigation
- Clear list of agreed actions, including what, by when, and who is responsible
- Follow-up arrangements.

Reports should be brief, ideally one page, with detailed material (e.g., cull cow lists, culture results, herd test analysis) included as appendices. A custom report template improves efficiency and consistency.

Encourage the farmer and team to record relevant information as they implement the plan. Where possible, integrate this into the quality assurance systems or electronic farm records to avoid duplicate record-keeping

It is increasingly incumbent on professionals to document their work carefully. Most advisory services document recommendations and actions taken during client interactions as standard practice. Written records are invaluable to help resolve problems and disputes.

Follow-up

The report should specify:

- which areas need attention to maintain progress,
- the timeline for revisiting progress, and
- who should be involved in future discussions.

For veterinarians who are who are NMAC Accredited to provide mastitis investigations for Fonterra suppliers (or in training) the online database should be updated with all relevant documentation, including reports, Mastitis Investigation Kit outputs and supporting materials.

Acknowledgements

DairyNZ acknowledges the valuable input of veterinarians, milk quality advisers, and industry stakeholders who contributed to the development and review of these resources. Most are representatives of the National Milk-Quality Advisory Committee (NMAC) and have given generously of their time and expertise for the technical review.

Key papers

Gardner I. Reporting disease outbreaks. In: *Post Graduate Foundation in Veterinary Science Proceedings* 144, Epidemiology at work, University of Sydney, 1990: 29-42.

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Drying off

Technotes 14–18

Technote 14

Deciding on dry cow management strategy

In this technote:

1 Why a dry cow strategy matters

At the end of lactation, dairy cows require a sufficiently long dry period to allow the udder tissue to repair and rejuvenate. During the early dry period, milk-secreting alveolar cells collapse, and the number of active cells declines to a minimum (Wilde *et al* 1997). New secretory tissue is laid down as cows approach calving, resulting in an overall increase in secretory capacity from one lactation to the next.

A minimum dry period of six weeks, and preferably eight weeks, is recommended to allow adequate udder regeneration. Dry periods shorter than 20 days have been associated with significant reductions in milk production (Kok *et al* 2017).

Another key physiological change following dry off is closure of the teat canal by formation of a keratin plug derived from sloughed epithelial cells (Williamson *et al* 1995; Dingwell *et al* 2004).This plug reduces the risk of new infections, although more than 20% of quarters may still lack an effective plug five weeks after dry off (Williamson *et al* 1995).

Delayed teat canal closure after dry off has been associated with teat end damage, higher milk yield before dry off (Dingwell *et al* 2004) or higher milk flow rates before dry off (Summers *et al* 2004). By contrast, use of antibiotic dry cow treatment (DCT) has been associated with faster closure

compared with no treatment (Williamson *et al* 1995). Additional protection may be provided by an internal teat sealant (ITS), which can provide a barrier when a keratin plug is absent at the beginning or end of the dry period (Woolford *et al* 1998; Kabera *et al* 2018).

Antimicrobial resistance

Increasing antimicrobial resistance (AMR) is a shared concern for human and animal health. The New Zealand dairy sector supports prudent and responsible antibiotic use to maintain future efficacy and meet animal welfare and market expectations.

Antimicrobial stewardship is a core objective of the New Zealand AMR action plan. In support of this, the New Zealand Veterinary Association (NZVA) advocates a shift toward selective use of antibiotic DCT on dairy farms.

The specific antibiotic DCT product used does not alter resistance risk. All DCT products available in NZ contain ß-lactam antibiotics, which inhibit bacterial cell wall synthesis. Use of any antibiotic DCT, regardless of active ingredient or duration of activity, has the potential to select for antibiotic resistance.

Evidence increasingly links on-farm antimicrobial use with the presence of resistant bacteria:

- The proportion of herds isolating penicillin-resistant *Staphylococcus aureus* and *Streptococcus uberis* increases as the proportion of cows treated with antibiotic DCT increases (McDougall *et al* 2022a).
- Organic herds generally show lower MICs for multiple antimicrobials compared with herds using whole herd cloxacillin or cephalonium DCT for more than three years (McDougall *et al* 2021a).
- Increased risk of penicillin-resistant *Staph. aureus* is associated with use of penicillin-novobiocin DCT, and ampicillin-resistant *Escherichia coli* with cloxacillin, penicillin-novobiocin, or cephapirin DCT (Saini *et al* 2012; Saini *et al* 2013).
- Use of cefquinome or framycetin DCT is associated with increased risk of ampicillin-resistant *E. coli* (Schubert *et al* 2021).
- Changes in MIC resistance profiles have been reported for NAS (Non-Aureus Staphylococci) bacteria isolated at calving compared to dry off, for cows that received different classes of antibiotic at dry off, and for cows that did not receive antibiotic DCT at dry off (Okello *et al* 2023).
- Reduced sensitivity of faecal coliforms to cephalothin and streptomycin has been reported for herds following cephalosporin DCT use (Mollenkopf *et al* 2010).

Accordingly, antibiotic DCT should be targeted to cows most likely to be infected, as a key component of antimicrobial stewardship and mastitis control, aligned with One Health.

② Calculate dry off dates to ensure an adequate dry period

Dry off dates should be calculated to ensure all cows receive at least six weeks, and preferably eight weeks, between dry-off and calving. Accurate expected calving dates are best obtained from a combination of artificial breeding and/or natural submission information and early-aged pregnancy testing (cows tested at 5-16 weeks pregnant). This provides the most reliable basis for determining optimal drying-off dates.

The optimal dry period length of 6 to 8 weeks allows cure of existing intramammary infections (IMI) and regeneration of mammary secretory tissue. Observational studies from North America (Kuhn *et al* 2006) and Europe (Kok *et al* 2017) report that milk production is maximised with dry periods of approximately 40 to 60 days.

A systematic review by van Knegsel *et al* (2013) reported that shorter dry periods were associated with a 4.5% reduction in subsequent milk yield, an improved postpartum energy balance and body condition score, no consistent effect on mastitis or major periparturient diseases, and variable effects on subsequent reproductive performance.

In split-calving herds, tracking individual dry periods can be challenging so care is required to ensure all cows experience a dry period of at least 6 to 8 weeks.

In New Zealand, many cows will have dry periods longer than 8 weeks. For cows treated with antibiotic DCT alone, observational studies have reported an increased risk of new IMI with increasing dry period length (McDougall 2010; Bryan *et al* 2011). Use of an ITS may provide extended protection during prolonged dry periods (Berry & Hillerton 2007; Laven *et al* 2014).

Cows likely to experience extended dry periods include young or low BCS cows dried off early to maintain body condition, high somatic cell count (SCC) cows dried off early to manage bulk milk quality, cows dried off early to manage feed supply constraints (e.g., drought) or cows not pregnant and 'carried over'.

Knowledge of the expected dry period length is also essential to guide selection of appropriate antibiotic DCT, to minimise the risk of antibiotic residues in milk in the subsequent lactation.

③ Dry off high SCC cows early to help lower bulk milk SCC

➜ **Technote 12** describes how to use individual cow SCC for management decisions.

➜ **Technote 16** describes how to manage milk volumes in the lead up to drying off.

④ Collect data to assess herd mastitis status

A milk quality consultation prior to drying off provides an opportunity to:

- assess current milk quality performance against goals and national key performance indicators,
- identify opportunities to improve mastitis control, and
- make herd- and cow-level decisions on culling and dry off treatments.

➜ See **Technote 15** for more on which cows should be considered for culling at dry off.

Information used to assess management practices, mastitis prevalence and incidence, and support selection of cows for antibiotic DCT and ITS, may include:

- questionnaires and/or milking management visit reports,
- bulk milk SCC,
- individual cow somatic cell count (ICSCC) records and/or RMT results,
- clinical mastitis treatment records and/or product sales,
- bacteriological test results (e.g. microbiological or PCR testing) from clinical or subclinical mastitis cases.

Analysis of ICSCC, with or without clinical case information from the preceding lactation, has consistently been shown to be effective for estimating mastitis prevalence and incidence, and selecting cows for selective antibiotic DCT. Collection of appropriate cow-composite or quarter milk samples for bacteriological testing further improves understanding of herd epidemiology and helps prioritise mastitis control measures.

Decisions for individual cows (e.g., antibiotic treatment, dry cow product use or culling) should be based on all available cow-level information, including age, clinical mastitis history, herd test SCC and diagnostic results.

Bacteriological results should not be used in isolation but can complement ICSCC data when making DCT and ITS decisions.

When ICSCC data are available, tools such as the DairyNZ **Mastitis Focus Report** or spreadsheets can be used to benchmark mastitis prevalence and incidence against industry best-practice trigger levels.

⑤ Plan appropriate treatment and prevention for all cows in the herd

NMAC (National Milk-Quality Advisory Committee) recommends that all cows receive protection during the dry period.

For most herds, this involves use of antibiotic DCT in selected cows, and internal teat sealants (ITS) for all cows. Selective DCT requires identification of cows most likely to be infected, while ITS is used to reduce the risk of new infections during the non-lactating period.

Selective use of antibiotic DCT at dry off has been comprehensively reviewed by McCubbin *et al* (2022) and involves two complimentary objectives:

1. Cure existing intramammary infections

Antibiotic DCT maintains antibiotic concentrations above the minimum inhibitory concentration of common mastitis bacteria for several weeks, maximising the chance of cure.

Antibiotic DCT results in higher bacteriological cure rates than no treatment (Halasa *et al* 2009; McMullen *et al* 2021). Under New Zealand conditions cure rates are typically reported between 80 to 90% (McDougall 2010; Bryan *et al* 2011), although cure rates for quarters infected with *Staph. aureus* may be lower (~60 to 70%; (McDougall 2010).

2. Prevent new infections during the dry period

Internal teat sealants contain an inert material (commonly bismuth subnitrate) that is intended to remain in the teat canal and teat sinus during the dry period to prevent new IMI.

In low-risk cows, ITS alone reduces mastitis prevalence at calving, clinical mastitis incidence and ICSCC in the subsequent lactation (Woolford *et al* 1998; Berry & Hillerton 2002). Meta-analysis shows ITS alone reduced the risk of a new IMI by 73%, compared with no treatment, and 25%, compared with antibiotic DCT alone (Rabiee & Lean 2013).

For cows eligible for antibiotic DCT, combining ITS with DCT extends protection beyond that provided by antibiotic DCT alone. This approach reduced new IMI in high SCC cows (Berry & Hillerton, 2007; Bradley *et al* 2010), lowers clinical mastitis incidence, and reduces herd test SCC in the following lactation (Runciman *et al* 2010; Bradley *et al* 2011). A New Zealand study reported an approximately 40% reduction in clinical mastitis risk when ITS was used alongside DCT in high SCC cows, compared with DCT alone (Bates *et al* 2016).

⑥ Selection of cows for antibiotic DCT

Antibiotic DCT should be reserved for cows with evidence of mastitis. This could include:

1. Cows with a history of clinical mastitis

Cows treated for clinical mastitis in the lactation preceding dry off, and/or the previous dry period, should be considered eligible for antibiotic DCT.

Cows with clinical mastitis in one lactation have a 1.8-fold higher risk of IMI at dry off and a 1.7-fold higher risk of clinical mastitis in the first 60 days of the subsequent lactation (Pinedo *et al* 2012). Affected quarters also have a 4.2-fold increased risk of clinical mastitis in early lactation (Pantoja *et al* 2009).

In the absence of clinical records, most cows with prior clinical mastitis will have elevated ICSCC and therefore be identified for DCT. However, inclusion of clinical records in addition to herd test data does not materially improve accuracy of cow selection for selective DCT (McDougall *et al* 2021b).

Chronically infected cows are less likely to respond to DCT than more recently infected cows. Where ICSCC are available, cows that:

a. had high SCCs in the previous lactation,

b. were treated with an appropriate DCT at dry off, and

c. continue to have a high SCC the following lactation,

could be considered as chronically infected and culled. See **Technote 15** for more on culling criteria.

2. Cows with 1 or more high ICSCC

Individual cow SCC provides a robust basis for antibiotic DCT decisions, as elevated ICSCC indicates an inflammatory response, most commonly due to bacterial infection. Common questions include:

Which herd test?

Individual cow SCC from 4 or more herd tests provides the most complete information. However, a single herd test SCC within 80 days of dry off is as predictive as up to four tests across lactation for identifying cows infected with major pathogens at dry off (McDougall *et al* 2021b).

In a study of 36 New Zealand herds, 8.6% of quarters cultured bacteria at dry off, but only 2.4% of quarters (7.2% of cows) were infected with major pathogens (i.e., *Staph. aureus*, *Streptococcus* species or *E. coli* (McDougall *et al* 2021b).

How many high tests?

Any cow with one or more elevated ICSCC during lactation may be considered eligible for antibiotic DCT.

However, cows with multiple high ICSCC results across two or more lactations are likely to have a low probability of cure and should be considered for culling.

What threshold is appropriate?

Increasing the threshold ICSCC alters sensitivity (Se; the proportion of truly infected quarters detected) and specificity (Sp; the proportion of quarters defined as uninfected that truly were uninfected) for detecting quarters with major pathogen infections (Table 1). The relative performance of Se and Sp remains consistent across herds with differing BMSCC and prevalence of *Staph. aureus* (McDougall *et al* 2021b).

Historically, thresholds of 150,000 cells/mL have been used. In herds with good mastitis control, thresholds may be increased to 200,000 to 250,000 cells/mL, with only a small risk of increasing SCC and clinical mastitis incidence in the subsequent lactation.

What about in-line sensors for SCC?

The SCC results from an in-line SCC system were reported as having similar Se and Sp values to the last herd test, and maximum herd test SCC result, during a lactation (McDougall *et al* 2024).

Table 1. Classification of cows using different thresholds or cut-points for maximum cow somatic cell count (SCC x1,000 cells/mL) to define cows as likely infected with a major pathogen compared with quarter-level culture results, where a cow was defined as infected if one or more glands was culture-positive for a major pathogen. This table models a 7.5% cow-level prevalence of a major pathogen infection in one or more glands at dry off in a group of 500 cows.

Cut-point	Max SCC	N cows infected	N cows uninfected or minor pathogen	Se[1]	Sp[2]	PPV[3]	NPV[4]	N tubes DCT[5]
100	Above	34	186	0.91	0.60	0.15	0.99	**880**
	At or below	3	276					
150	Above	31	128	0.85	0.72	0.19	0.98	**636**
	At or below	6	333					
200	Above	29	**94**	0.78	0.79	0.23	0.98	**492**
	At or below	**8**	367					
250	Above	25	74	0.68	0.84	0.25	0.97	**396**
	At or below	12	388					

[1] *Sensitivity*

[2] *Specificity*

[3] *Positive predictive value*

[4] *Negative predictive value*

[5] *Assuming that only cows with one or more SCC above the SCC cut-point would be treated with antibiotic DCT (1 tube/gland).*

When using a maximum cow SCC of >200,000 cells/mL as the cut-point for the last herd test within 80 days before drying off, the Se and Sp were 0.78 and 0.79, respectively (Table 1). This means that, for a herd of 500 cows being dried off, with a 7.5% cow-level prevalence of major pathogens, then:

- **8** cows with a major pathogen infection would be **false negatives**, i.e. defined as uninfected due to a SCC ≤200,000 cells/mL, and would receive treatment with ITS,
- **94** cows with no major pathogen infection would be **false positive**, i.e. defined as infected due to a SCC >200,000 cells/mL, and would receive antibiotic DCT.

This is assuming all cows with a maximum SCC above 200,000 cells/mL would be treated with antibiotics and those below 200,000 cells/mL would be infused with a non-antibiotic ITS.

3. Cows with a positive RMT result

In herds without routine herd testing, the rapid (Californian) mastitis test (RMT) provides a practical, low-cost alternative for assessing SCC close to dry off. It has the added benefit of flexibility in that it can be carried out close to dry off and requires no laboratory or third-party coordination.

Other indicators, such as electrical conductivity are less predictive than RMT, and combining conductivity with RMT adds little additional value (Gohary & McDougall 2018).

Using an RMT cut-point of Trace or greater for presence of a major pathogen, it was reported that:

- At cow level, where one or more quarters was at or over cut-point, the Se and Sp values were 0.80 and 0.50 respectively, and positive predictive value (PPV) and negative predictive value (NPV) 0.11 and 0.97 respectively (Gohary & McDougall 2018).
- At quarter level, the Se and Sp values were 0.93 and 0.58 respectively, and PPV and NPV 0.05 and 0.99 respectively (McDougall *et al* 2022c). Use of ICSCC at a cut-point of >200,000 cells/mL had a lesser sensitivity but greater specificity.

Thus, in the absence of any herd test data, RMT score, particularly at quarter level, provides a reasonable alternative to SCC, reducing antimicrobial usage compared with applying the cut-point at cow level (Table 2). Although antimicrobial usage remained higher than ICSCC-based selection, it was reported that RMT-based selection at the quarter level was associated with reduced new infections during the dry period, lower prevalence of infection at calving, and lower ICSCC in early lactation (Swinkels *et al* 2021; McDougall *et al* 2022c).

Table 2. Number of cows or quarters classified as rapid mastitis test (RMT) positive (Trace or above) and the presence or absence of a major pathogen infection at dry off. This table assumes a cow-level prevalence of 7.5% for a major pathogen infection in one or more glands at dry off, for 500 cows.

Prevalence	RMT result	Major pathogen infection		Total number of tubes of antibiotics used
		Yes	No	
Cow-level	RMT+	29	230	(29+230) x 4 = **1036**
	RMT-	7	233	
Quarter-level	RMT+	31	613	31 + 613 = **644**
	RMT-	13	1341	

To better understand the difference between applying the RMT cut-point at the cow or quarter level (Table 2), consider the example of a 500 cow herd with a true cow-level prevalence of major pathogen infection of 7.5% (or 2.5% at quarter level). In this example:

- **1,036** tubes of DCT would be used, as 259 cows would be categorised as infected, if a cow-level cut-point of RMT Trace or above for one or more quarters within a cow was applied, or
- **644** tubes of DCT would be used if the cut-point of RMT score of Trace or above was applied at the quarter-level.

Compared to a whole herd approach involving 2,000 tubes, these approaches would reduce antimicrobial use by 49% (cow-level) or by 68% (quarter-level).

4. Other factors influencing selection for antibiotic DCT

Decision-making for selective antibiotic DCT may be informed by additional risk factors, in addition to ICSCC.

A. Other diagnostic test results

Bacteriological tests can assist dairy farmers by:

- identifying bacteria in clinical mastitis cases to support case-specific treatment,
- identifying bacteria in cows with high ICSCC to inform management decisions, and
- improving understanding of herd-level mastitis epidemiology to refine prevention strategies.

When interpreting these tests, the following should be considered:

a. Whether bacteria are likely to be present and detectable at time of sampling (recognising intermittent shedding),
b. Sample collection, handling and storage quality,
c. Test accuracy for the target pathogens,
d. Clinical relevance of the organism identified,
e. Availability of supporting information (e.g. ICSCC, clinical history), and
f. How the combined information can be used to focus prevention efforts.

Common pathogens isolated from clinical cases include *Staph. aureus*, *Strep. uberis* and *Escherichia coli.* Cows with such infections are generally appropriate candidates for antibiotic DCT at dry off. Isolates from subclinical cases are more commonly *Corynebacterium* spp., or non-aureus staphylococci (NAS), previously known as Coagulase Negative Staphylococci (CNS).

Culture-based selection have not demonstrated any additional benefits, over and above SCC-based algorithms (Rowe *et al* 2020; Cuttance *et al* 2025).

The additional value of whole herd culture systems beyond ICSCC alone, remains uncertain. Situations such as high ICSCC cows with only minor pathogens isolated, or low ICSCC cows with major pathogens isolated, present examples where optimal treatment strategies are unclear.

Current evidence from multiple studies supports ICSCC-based selection as an effective approach for selective antibiotic DCT.

Bacteriological results should be used in conjunction with ICSCC, and not in isolation, to support individual cow decisions regarding antibiotic DCT and ITS.

➜ **Technote 1** provides more on pathogens such as *Strep. uberis* and *E. coli.*

➜ **Technote 5** provides more on pathogens such as *Staph. aureus*, NAS and *Corynebacterium.*

B. Other risk factors

Cows producing >15 L of milk at the final herd test of lactation and cows older than 4 years have an approximate 2-fold increased risk of clinical and subclinical mastitis during the dry period or early in the subsequent lactation than younger or lower producing cows (McDougall & Castle 2021; McDougall *et al* 2022b). These cows may be considered for antibiotic DCT, even when their maximum ICSCC is below 200,000 cells/mL.

Cows with teat end damage (e.g., very rough teat ends, or teat lesions) should also be considered higher risk and warrant antibiotic DCT, due to increased susceptibility tote new infections.

➜ **Technote 6** provides more information on milking machine function to minimise teat damage.

⑦ When might whole herd antibiotic DCT be considered?

NMAC recommends selective antibiotic DCT as the default approach for most herds.

International experience and emerging New Zealand evidence (McDougall *et al* 2025) indicates that only a small proportion of herds derive a meaningful additional benefit from whole herd DCT compared with selective DCT.

Whole herd antibiotic DCT may be justified only in herds with strong evidence of widespread, and increasing, prevalence of infection late in lactation (Table 3).

Table 3. Herds where whole herd antibiotic dry cow treatment may be justified.

Measure of infection	Criteria
1. Bulk milk SCC	Arithmetic mean bulk milk SCC until end of 7th month of lactation ≥200,000 cells/mL OR Whole season bulk milk SCC above 250,000 cells/mL.
AND	
2. Indication of significant change in prevalence of infection during late lactation	Arithmetic mean monthly bulk milk SCC has increased by >40,000 cells/mL between the 6th and 7th month of lactation OR Arithmetic mean monthly bulk milk SCC increases across last 3 months of lactation by ≥50,000 cells/mL.

Following the ban on whole herd antibiotic DCT in the Netherlands in 2012, national adoption of selective DCT resulted in no increase in new infection rates or reduction in cure rates (Vanhoudt *et al* 2018), alongside reduced BMSCC and no change in clinical mastitis incidence (Santman-Berends *et al* 2021). This demonstrates that effective mastitis control can be achieved with selective DCT within a comprehensive mastitis management plan.

New Zealand data similarly indicates that the overall benefit of whole herd DCT compared with selective DCT is small. A retrospective analysis (McDougall *et al* 2025) of approximately 1,100 herd-years showed that whole herd DCT was associated with an average reduction in subsequent lactation BMSCC of only ~16,000 cells/mL, with outcomes strongly influenced by:

- the BMSCC in the preceding lactation, and
- the change in BMSCC during the final months of lactation.

A substantial benefit of whole herd DCT (approximately 40,000 cells/mL reduction in BMSCC) was observed in herds where both of the following applied:

1. Average bulk milk SCC above 250,000 cells/mL over the entire preceding lactation, and
2. A more than 50,000 cells/mL increase in average BMSCC between the 3rd last and last month of lactation (Figure 1).

Herds using selective DCT for multiple years achieved similar outcomes to herds that recently transitioned from whole herd to selective DCT, indicating that milk quality can be effectively managed over successive lactations using selective approaches.

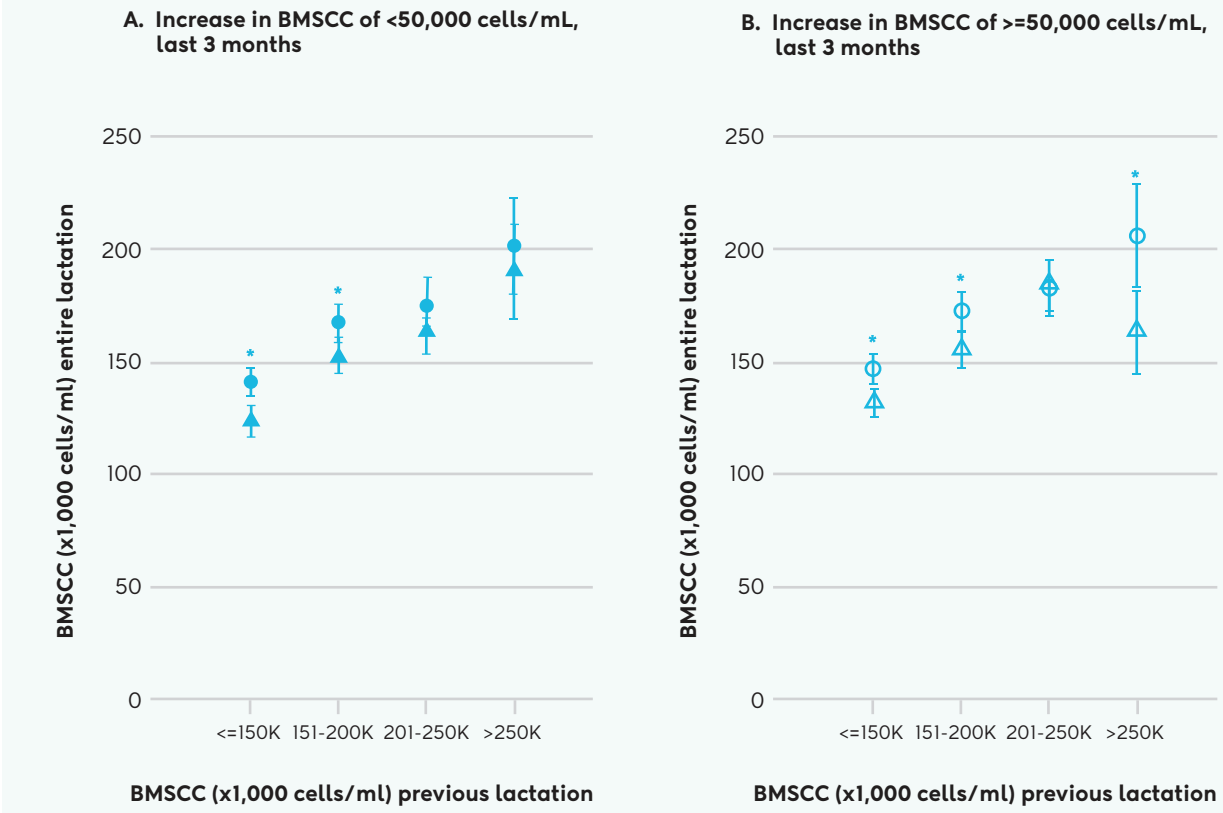
Use of ITS was associated with lower BMSCC in the subsequent lactation, irrespective of DCT strategy. Herds using ITS in some or all cows had 7,000 to 10,000 cells/mL lower BMSCC, and herds using ITS in heifers had ~8,000 cells/mL lower BMSCC compared with herds not using ITS in heifers.

Importantly, antimicrobial sales for treatment of mastitis during lactation did not differ between herds using selective or whole herd DCT, nor were they associated with BMSCC in the preceding lactation or trends in the last months of lactation.

In summary, whole-herd antibiotic DCT should be reserved for **exceptional** herd level situations with persistently high and worsening infection pressure late in lactation. For most herds, selective DCT combined with ITS achieves comparable mastitis and milk quality outcomes while supporting antimicrobial stewardship and One Health objectives.

➜ Steps to reduce spread of infection when cows are lactating are an important tool for reducing mastitis and managing milk quality. See **Technote 5** for more on milking routines and mastitis prevention in lactation.

Figure 1. Average BMSCC (x 1,000 cells/mL) across the entire subsequent lactation (y axis) plotted against the average BMSCC (x 1,000 cells/mL) in the preceding lactation, stratified by 50,000 cells per/mL categories (x axis) and by change in BMSCC over the last 3 months of lactation. Panel A (closed symbols) represents herds with less than 50,000 cell/mL increase in late lactation BMSCC and Panel B (open symbols), herds with ≥50,000 cells/mL increase. Triangles denote herds using whole herd antibiotic DCT and circles, selective antibiotic DCT. Asterisks indicate significant differences between DCT strategies within preceding lactation BMSCC categories.



⑧ Important reminders on use of dry cow products

1. **The dry cow strategy is only one part of a mastitis management plan.**

Selection of a dry cow strategy must be integrated within a whole lactation mastitis management plan. Outcomes depend as much on lactational measures, such as effective teat disinfection, milking machine function, staff training and strategic culling, as on decisions made at dry off.

➜ **Technote 7** provides more on effective teat disinfection.

2. **Strong evidence supports ITS-alone for low ICSCC cows.**

The efficacy of ITS for protecting low ICSCC cows during the dry period is well established. A meta-analysis shows ITS-alone to be more effective than antibiotic DCT-alone in preventing new IMI in the dry period for low ICSCC cows (Rabiee & Lean 2013). A more recent meta-analysis reported a 74% reduction in relative risk (RR) for new IMI at calving (RR =0.36, 95% CI: 0.25-0.72), and 57% reduction in risk of early lactation clinical mastitis (RR =0.43, 95% CI: 0.17-1.10 in the first 30 days of lactation), for ITS-treated low ICSCC cows compared with non-treated controls, with no additional benefit from combining antimicrobial DCT with ITS (Winder *et al* 2019).

Under New Zealand conditions, ITS-alone compared with no treatment reduces new IMI at calving in both cows (Woolford *et al* 1998) and heifers (Compton *et al* 2014) and lowers early lactation incidence of clinical mastitis and ICSCC (Laven & Lawrence 2008; Compton *et al* 2014; Bates & Saldias 2018).

3. **Many infections cure spontaneously when ITS is used.**

Although ITS was once assumed to provide no therapeutic benefit in infected quarters (Berry *et al* 2004), subsequent evidence shows substantial spontaneous cure. A retrospective analysis of 4,655 quarters from ICSCC cows infused with ITS-alone found that, although ~1.5% were infected with major pathogens at dry off, 92% cured over the dry period and only 3% of these quarters were diagnosed with clinical mastitis (McDougall & Compton 2015). Other studies report cure rates of 72% (LacyHulbert *et al* 2016) or 85% (McDougall *et al* 2022c) for previously infected quarters treated with ITS alone, compared with ~95-100% for infected quarters that received antibiotic DCT.

Thus, while cure rates with ITS-alone are lower than with antibiotic DCT, the absolute difference (less than 25%) is small. Treating all low SCC cows with antibiotic DCT would therefore produce minimal herd-level benefit while markedly increasing antimicrobial use.

4. **When ITS-alone is prescribed, support for herd owners and staff is required to ensure hygienic application of product.**

Use of ITS-alone increases reliance on aseptic technique at dry off. Poor outcomes are strongly associated with inadequate staff training and non-compliance with recommended drying off procedures (McDougall *et al* 2019; McDougall & Castle 2021).

Early dry-period mastitis following ITS use may involve Gram-negative and Gram-positive bacteria, originating from pre-existing infections, iatrogenic introduction (i.e. introduction at infusion), or new infections post dry-off.

Formal training, monitoring of technique, and, where appropriate, use of trained technicians is recommended when introducing ITS-alone to a farm. Collection and culture of milk samples, following aseptic preparation of the teat end, can be used to audit hygiene practices and identify training needs. Note that, poor hygiene can result in severe infections following either ITS or antibiotic DCT infusion.

Other factors such as pre-dry off milking frequency and nutrition, handling facilities, number of animals to be dried off, training and skill level (and patience) of the farm team, feeding and paddock selection before and after dry off, management of cows immediately post dry off (e.g., trucking,

running to new pasture breaks) should also be considered.

➜ Hygienic preparation of the teat is critical before infusing intramammary treatments, especially ITS. See the DairyNZ **Healthy Udder Guide** for practical guidance.

5. Teat sealant residues after calving.

Residues of ITS may be present in colostrum and milk for several days post-calving. Careful stripping during the colostrum period is required to minimise bulk tank milk contamination.

Studies in Canada, New Zealand and Europe report ITS present in ~50 to 80% of quarters at the first milking (Bates *et al* 2022; Kabera *et al* 2018; Mehrtens *et al* 2023; Swinkels *et al* 2024), but no association with increased risk of mastitis in the dry period (Kabera *et al* 2018), risk of clinical mastitis in early lactation (Bates *et al* 2022) or subsequent subclinical mastitis (Swinkels *et al* 2024). Internal teat sealants may persist in the mammary gland for weeks post calving (Berry & Hillerton 2002; Kabera *et al* 2018; Swinkels *et al* 2024).

It is recommended that approximately 10-12 strips are used to remove teat sealant residues before the first milking. See **Technote 3** for more on managing residues after calving.

Key considerations when selecting a dry-cow strategy

When selecting an appropriate strategy for an individual herd, consider:

1. Recent history of DCT and/or ITS use
2. Clinical mastitis incidence in previous dry period and at calving
3. Clinical mastitis incidence in the current lactation
4. Average bulk milk SCC
5. Individual cow SCC, including frequency and timing of tests.

When selecting an antibiotic DCT product, veterinarians should consider:

- Predicted dry period length and withholding period of the product.
- Likely pathogens and antimicrobial sensitivity.
- Risk of new infections in the dry period and at calving.
- Management of residue risk for meat and milk.

When considering ITS-alone, also consider:

- Capability of farm team for aseptic infusion of products.
- Availability of trained technicians to support ITS infusions.
- Ability of milking team to strip teat sealant after calving.

9 Consult with your veterinarian when selecting antibiotic DCT

Selection of an appropriate antibiotic DCT for a herd must be undertaken in consultation with the herd veterinarian and consider such factors as:

- antimicrobial spectrum and likely pathogens present,
- expected bacteriological cure rates,
- predominant mastitis pathogens in the herd,
- duration of protection provided by the product, and
- predicted length of the dry period for cows to be treated.

Bacteriological cure rates following antibiotic DCT depend on pathogen type, duration of infection, cow age and herd. Cure rates are generally higher for *Strep.* spp. and lower and more variable for *Staph. aureus*.

A meta-analysis reported that antibiotic DCT improved the relative risk (RR) of bacteriological cure, compared with no treatment, to 1.78, (95% CI 1.51-2.10) for all pathogens, 1.65 (95% CI 1.38-1.96) for *Staphylococcus* spp. and 1.86 (95% CI 1.48-2.35) for *Strep.* spp. (Halasa *et al* 2009), with no difference between cloxacillin and non-cloxacillin products (RR = 1.00 (95% CI = 0.96-1.06). Under New Zealand conditions, cure rates of 79% for *Staph. aureus*, 78% for *Strep. uberis* and 88% of minor pathogens were reported (Williamson *et al* 1995). In studies using cephalonium products (McDougall 2010; Bryan *et al* 2011), cure rates ranged from 78% to 90% for all pathogens but were lower and more varied across herds (60-75%) for *Staph. aureus* infections.

Cure rates tend to decline with increasing cow age (from 95% to 85% for cows less than 4 years to over 8 years old) and with increasing dry period length (approximately 0.6% per week) (McDougall *et al* 2010). Evidence comparing shorter versus longer acting products is limited, and cure rates do not appear to differ between formulations with different withholding periods (Halasa 2009; McMullen *et al* 2021).

Broad-spectrum products such as cefquinome (a 4th generation cephalosporin) were hypothesised to offer superior protection against new infections (Bradley *et al* 2010); however, when used in combination with a teat sealant, a narrow spectrum, cloxacillin product provided similar protection (Newton *et al* 2008). Later work showed comparable cure rates across products, with better protection against new infections by *Strep. uberis* and other environmental bacteria in cows receiving a broad-spectrum product, or a combination of cloxacillin DCT and ITS, compared with cows receiving cloxacillin DCT only (Bradley *et al* 2011).

The benefit of antibiotic DCT should be weighed against documented self-cure rates. High bacteriological cure rates during the dry period have been reported for quarters infected with major pathogens (i.e. *Strep.* species or *Staph. aureus*) and infused with ITS alone, such as 92% (McDougall & Compton 2015) or 83% (McDougall *et al* 2022c) compared with quarters that received antibiotic-DCT and ITS, albeit in low SCC cows (McDougall *et al* 2022c). A German study reported higher cure rates for *Strep.* spp. with antibiotic DCT compared with ITS-alone, but no advantage for *Staph. aureus*, NAS or Gram-negative pathogens (Müller *et al* 2023).

⑩ Purchase and store the antibiotic DCT and ITS you will need at dry off

Farmers planning to administer DCT and ITS should obtain all required supplies well in advance of dry off, including intramammary tubes and materials for teat end sanitising. Advisers should emphasise the importance of correct storage of antibiotics, in accordance with label instructions, to maintain product efficacy and safety.

Antibiotic DCT must be stored separately from tubes of lactating-cow antibiotics to avoid accidental use in lactating cows, which can result in serious residue violations and costly milk losses.

Only new, previously unopened teat wipes should be used for teat end preparation, as opened containers dry out within days and alcohol-based wipes lose effectiveness through evaporation. Some veterinary practices prefer cotton wool balls soaked in 70% ethanol or methanol as an effective alternative.

Failure to adequately sanitise the teat ends before intramammary infusions can result in severe or fatal cases of clinical mastitis, due to iatrogenic introduction of pathogens from the teat skin or contaminated materials.

In cold conditions, intramammary products may be gently warmed to reduce viscosity. This should be done using a 'water-bath' method with products kept in their sealed plastic packaging, or by indirect warming (e.g. hot water cupboard or place a hot water bottle in the midst of the tubes).

Tubes must never be placed directly in water as moisture contamination can lead to catastrophic mastitis outbreaks within days of treatment. If teat sealant or DCT tubes become dirty before use, this will also greatly increase the risk of highly pathogenic bacteria being inserted into the udder.

➜ **Technote 4.9** describes typical antibiotic residue violations associated with DCT products.

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Technote 15

Culling persistently infected cows

In this technote:

1 Culling as a mastitis control strategy

Culling infected cows is an important mastitis control strategy as it is the only guaranteed way to eliminate some intramammary infections. Antibiotic Dry Cow Therapy (DCT) does not cure all infections, and the likelihood of cure declines with:

- increasing chronicity and severity of infection
- increasing cow age
- presence of *Staph. aureus* (Buddle *et al* 1987, Sol *et al* 1994).

In a New Zealand comparison of two dry cow antibiotic (DCT) formulations (McDougall, 2010), bacteriological cure rates for cows with *Staph. aureus* infections were only 62% or 75%, whereas cure rates for minor pathogens or *Strep. uberis* infections exceeded 89%. Cure rates were also lower for older cows (≥8 years; 89%) than for younger cows (≤4 years; 94%).

Culling due to udder health issues is common. A NZ study of herds with high-quality records (Xu & Burton 2003), found 10.4% of culls were due to mastitis or udder-related problems, the third most common reason after infertility and low production. Later work (Kerslake *et al* 2018) similarly identified udder health, mastitis and SCC problems as the 3rd most costly culling category. Internationally, 5-8% of cows are culled annually for mastitis or SCC-related reasons, with little change in incidence rate between the 1980s and 2000s (Compton *et al* 2017).

Although culling is effective, it is expensive, and bulk milk SCC problems will only be resolved if new infections are prevented concurrently. Halassa *et al* (2009) reported that culling was the largest contributor to total costs of mastitis, particularly for *Staph. aureus* mastitis.

➜ The **Mastitis Performance Calculator** allows a herd's culling performance for mastitis to be compared with industry targets.

② Culling cows with recurrent clinical mastitis

Treatment success can decline sharply in cows with recurrent clinical mastitis. NZ data from the 1990s reports cure rates of 75% for first cases, 45% for second cases and only 12% for cows being treated for the third time (NMAC 2000).

Bactereiological cure rates can vary by pathogen and cow factors. NZ studies (McDougall *et al* 2007a; 2007b) report:

- 70 to 90% cure rates for *Strep. uberis* cases
- 30% to 40% cure rates for *Staph. aureus* cases
- 88% cure for 2 year old cows versus 71% for cows ≥7 years
- 84% cure for cases treated on day of calving versus 68% cure for cases occurring >7 days postpartum.

Overseas findings are similar: cure rates for *Staph. aureus* cases decrease with increasing cow age, rising SCC, chronic infection duration, higher bacterial load in the milk, multiple quarters affected, rear quarter infections and presence of beta-lactamase producing genes (Barkema *et al* 2006; Sol *et al* 1994).

There is broad industry agreement that retaining cows with recurrent clinical mastitis is uneconomic. When three clinical episodes occur in a single quarter, a practical interim solution is to dry off the affected quarter for the rest of the lactation and plan to cull the cow.

Consider culling any cow when you find her third clinical case in a lactation.

➜ **Technote 4.6** summarises treatment approaches and expected cure rates by pathogen and **Technote 4.11** discusses the options for drying off chronically infected quarters.

③ Culling cows with persistently high cell counts

High cell counts in two consecutive lactations, despite antibiotic DCT in the intervening dry period, indicate likely refractory infections. **These cows have a low probability of cure and should be considered for culling when economically justifiable.** Bacterial tests can help validate the decision.

Whether culling is economic depends on:

- the cow's contribution to the bulk milk SCC and impact on payment;
- the risk of mastitis spread to other cows
- the cost of suitable replacements.

Before culling, review each cow's history. Cows with a single high SCC in lactation may still respond to antibiotic DCT and should not be automatically culled. Likewise, cows with a single culture result for *Staph. aureus* should be given the benefit of antibiotic DCT, and are NOT candidates for immediate culling.

The DairyNZ **Mastitis Focus Report** identifies cows with a SCC >150,000 cells/mL for three consecutive lactations, despite antibiotic DCT. These cows have had multiple opportunities to cure and are therefore high priority culls.

➜ See the **'Managing Staph. aureus Mastitis' factsheet** for more on managing these cases, and **Technote 8.3** for guidance on segregation of infected cows.

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Technote 16

Drying off abruptly, taking steps to reduce yield

In this technote:

The dry off strategy used can significantly influence the risk of new udder infections establishing during the dry period. Higher milk yield at dry off (Newman *et al* 2010) and milk leakage following dry off (De Prado-Taranilla *et al* 2020) have both been associated with an increased risk of infections detected at calving.

The primary objectives at dry off are to rapidly suppress milk secretion and achieve timely teat canal closure, which typically takes around 2-4 weeks. Most new infections occur in quarters where the teat canal has not yet sealed.

➜ **Technote 14** describes closure of the teat canal during the dry period.

① Dry off cows producing less than 5 L/day

Cows producing less than 5 L/day, or 0.4 kg MS/day, should be dried off because:

- They can significantly increase bulk milk SCC even without mastitis, as somatic cells become more concentrated in the reduced milk volume
- Udder involution accelerates as production falls, increasing SCC even in uninfected quarters.

A study of 94 uninfected identical twin cows approaching dry off found that over 60% showed a rapid SCC rise (>50,000 cells/mL per week) in the final month of lactation, and the majority (>60%) were producing less than 5 L/day (Lacy-Hulbert *et al* 1995).

NMAC (National Milk Quality Advisory Committee) therefore recommends drying off cows when their milk yield falls below 5 L/day (0.4 kg MS/day), to protect milk quality for processing.

② Reduce milk production during dry off

Advisers should stress the need for advance planning so that farmers can:

1. Implement management changes for high producing cows at least one week before dry off, and
2. Organise grazing so that cows go to clean paddocks immediately after dry off.

Cows producing 5 to 10 L/d (0.4 to 0.9 kg MS/d) usually tolerate abrupt drying off, provided management changes after the last milking encourage involution.

Cows producing more than 10 L/d require more active management of milk production, with nutrition restriction more effective than switching to less frequent milking (Holmes *et al* 1996, Lacy-Hulbert *et al* 1999, Tucker *et al* 2009) under NZ conditions.

Reducing feed allowance can rapidly suppress milk yields, by up to 30%, but may compromise cow welfare if not managed carefully. In a behavioural study, reducing dry matter intakes (DMI) to 8 kg DM/d for the final week of lactation and first 14 d of the dry period reduced milk yield from 9.3 L/d to 4-6 L/d by dry off, compared with cows eating 16 kg DM/d (Tucker *et al* 2009). This reduction was associated with less udder firmness, reduced udder leakage, and lower mastitis risk after dry off. But cows on low DMI showed clear behavioural signs of hunger, with 2-3 times more vocalisations than higher fed cows before and after dry off.

More moderate restrictions in DMI (e.g. 10-12 kg DM/d) may reduce hunger but it is unclear if this approach achieves the same rate of udder involution, and less mastitis risk. In this study, cows received no antibiotic DCT; provision of internal teat sealants (ITS) would be expected to reduce mastitis risk.

NMAC recommends that the DMI for high-producing cows (>1.0 kg MS/day) be reduced by 30-50% during the last 1-2 weeks before dry off, and after dry off, to assist the drying off process. This aligns with NMC guidelines (National Mastitis Council 2006) which advise cessation of concentrate feeding two weeks before dry off.

Rations must still meet the energy demands of a cow that is 6-8 months pregnant. As a guide, a 500 kg cow requires about 59 MJ/day of metabolisable energy for maintenance, excluding the energy demands of pregnancy and activity. Table 1 provides a guide to energy requirements and dry matter intakes (DMI) for transitioning cows from lactating to dry, based on **Facts and Figures** (DairyNZ 2021).

To comply with animal welfare codes, water must not be restricted at any stage.

Table 1 Daily metabolisable energy requirements and recommended daily dry matter intakes for a 500 kg cow transitioning from lactating to dry, for an 8-week dry period. Values derived from DairyNZ Facts and Figures (DairyNZ 2021).

Days before / after dry off:	-7 to -14	-1 to -6	Dry off	1 to 7	8 to 14
Weeks before PSC:	**10**	**9**		**8**	**7**
Energy Requirements for:	**Metabolisable energy requirements (MJ/cow/day)**				
Maintenance	59	59		59	59
Walking on flat (3 km x 2 MJ ME/km)	6	6		1	1
Pregnancy (35 kg calf birth weight)	21	23		27.5	32
Milk (0.9 kg MS/day)	72	-		-	-
Milk (0.4 kg MS/day)	-	32		-	-
Gaining condition[1]	6	-		-	39
Total Requirements (MJ/day) =	**186**	**120**		**88**	**131**
Dry matter intake for different feeds after dry off:	**Dry matter intake 'down the throat' (kg DM/day)**				
A. Autumn Pasture & Silage (e.g. 11 MJ ME/kg DM)	14.9	10.9		8.0	11.9
B. Pasture + low ME crop (e.g. 10.5 MJ ME/kg DM)[2]	-	-		8.6	12.8
C. Pasture + Hay (e.g. 9.5 MJ ME/kg DM)[2]	-	-		10.0	14.8

[1] *BCS gain estimated at 0.1 score per 30d in lactation, and 0.5 score per 30 d when dry. Note that 1 score equals 33 kg or 1.1 kg Lwt/day, and a milking cow requires 50 MJME/kg Lwt gain and a dry cow, 72 MJEM/kg Lwt gain. No gain planned for 1 week before and 1 week after dry off.*

[2] *Energy requirements increased by 2.5% or 7.5% to accommodate the lower DM, as per DairyNZ Facts and Figures (@ 5% per 1 MJ ME/kg DM different from 11)*

Note that the dry matter intakes make no allowance for wastage. If cows were grazing pasture, with a utilisation of 90%, they would need to be offered approximately an extra kg DM each day.

3 Dry off abruptly without reducing milking frequency

Dry off should be abrupt, with no reduction in milking frequency prior to the final milking. Maintaining the same milking schedule prevents unnecessary rises in BMSCC. Reducing milking frequency, particularly for cows with a higher SCC, will increase the bulk milk SCC (Holmes *et al* 1996).

Intermittent milking (i.e. milking every second day) should be avoided as this significantly increases the risk of mastitis (Zecconi *et al* 1995; Lacy-Hulbert & Woolford, 1999).

4 Put cows in clean areas after giving DCT or ITS

After administering antibiotic dry cow treatment (DCT) or internal teat seal (ITS), it is essential to minimise teat contamination with bacteria by:

- Thoroughly spraying teats manually after treatment, and
- Not allowing cows to lie down for at least 2 hours after treatment, avoiding bare soil, mud and manure-soiled areas.

Cows should be moved to clean, dry paddocks for 7-14 days after dry off (low manure load, no exposure to dairy effluent). High environmental levels of coliform and streptococcal bacteria markedly increase new infection risk. Severe outbreaks of *Pseudomonas* mastitis have occurred where cows lay in wet conditions in the first few days after dry off. These bacteria are usually associated with contaminated water supplies; infections can be severe, often fatal, and virtually impossible to treat.

Although formation of the keratin plug makes the teat canal more resistant to penetration in the dry period (as measured by water pressure needed to open the canal), O'Brien (1989) reported that the canal was not well closed until four days after dry off and that cows are particularly susceptible to infection during this time.

Full closure of teat canals, measured using a manual stripping technique, can take up to 40 days after dry off (Williamson *et al* 1995), despite administration of antibiotic DCT at dry off. Rapid closure of the teat canal helps prevent new infections (Capuco *et al* 1992, Williamson *et al* 1995).

Keeping cows in a clean paddock well away from the milking herd reduces the chance of triggering milk let-down, which supports plug formation. It also prevents accidental re-attachment of milking cups to dry cows.

5 Feed a maintenance diet for 7-14 days after dry off

Restricting feed intake after dry off helps accelerate udder involution by reducing milk secretion:

- Most cows in moderate body condition (i.e. greater than body condition score 4.5) can tolerate 7 days on maintenance before gross involution starts to occur, after which feed intakes can be increased (see Table 1).
- Cows producing more than 10 L/day at dry off may require up to 14 days on maintenance before udder swelling subsides, and involution becomes evident (i.e. reduction in udder swelling and firmness).

For cows treated with antibiotic DCT and/or ITS, the requirement to restrict feed to maintenance levels may be less critical than for cows receiving no protection, as these treatments provide protection against new intramammary infections.

During the transition, increasing the proportion of non-digestible fibre while reducing the dietary metabolizable energy content is likely to support rumination, satiety and cow comfort as cows adapt to dry off (Jensen *et al* 2022).

Greater use of rumination sensors has increased the focus on maintaining rumination rates during this period. But the rumination rates expected for typical NZ drying off approaches, involving different feed types, has yet to be determined.

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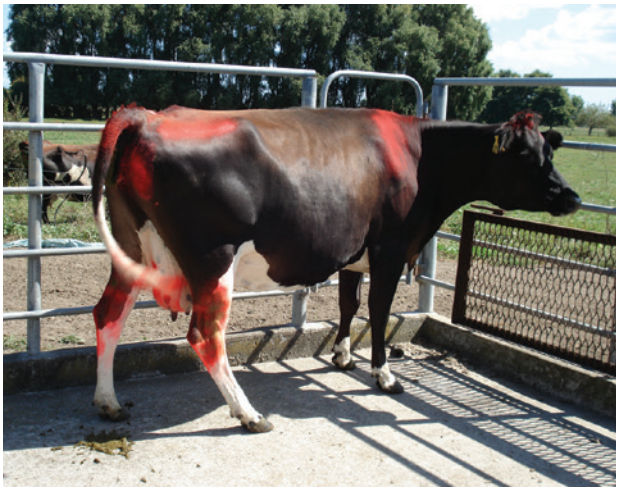
Technote 17

Administering dry cow treatments as recommended

In this technote:

Poor hygiene during administration of antibiotic Dry Cow Treatment (DCT) or Internal Teat Sealant (ITS) can introduce bacteria into the teat canal, resulting in severe, dry period mastitis.

A survey of 28 veterinary practices reported a higher incidence of herd morbidity and mortality following ITS-alone administration at dry off for herds receiving less than 1 hour of training in hygienic techniques (McDougall *et al* 2019). Effective treatment at dry off relies on meticulous preparation, correct technique, and appropriate cow selection.



① Plan for the time, effort and staffing required to treat cows

Administration of antibiotic DCT and ITS is a critical task for mastitis prevention and must be planned accordingly. Operators should be properly trained, competent and supervised.

NMAC (National Milk-Quality Advisory Committee) recommends allowing for one person to treat between 12 and 20 cows per hour, equating to approximately 3-5 minutes per cow, to adequately complete the following tasks:

- Safely restrain the cow;
- Mark the cow and check and/or record treatment details;
- Thoroughly disinfect all four teat ends;
- Treat all four quarters as required
- Thoroughly teat spray each teat; and
- Move the cow to an appropriate location.

Advisers should recommend having more than one operator, particularly to assist with restraint and cow handling. This reduces occupational health and safety risks and helps prevent rushed or compromised hygiene.

Fatigue and last-minute use of untrained staff can markedly increase the risk of errors. In larger herds some advisers may assist or supervise administration to ensure standards are met.

Advisers are encouraged to use the DairyNZ **Healthy Udder Guide** to teach clients correct aseptic technique for administering intramammary infusions. A physical demonstration to staff prior to dry off is often worthwhile.

② Select treatments in consultation with your veterinarian

Treatment selection should be undertaken in collaboration with the herd veterinarian.

- Antibiotic DCT should be reserved for cows with evidence of prior or existing infection.
- Internal teat sealants may be administered to all cows, either immediately after DCT, or alone, in cows with:
  - No clinical mastitis during the preceding lactation, and
  - No SCC results above a chosen herd-specific threshold (typically between 150,000 and 250,000 cells/mL).

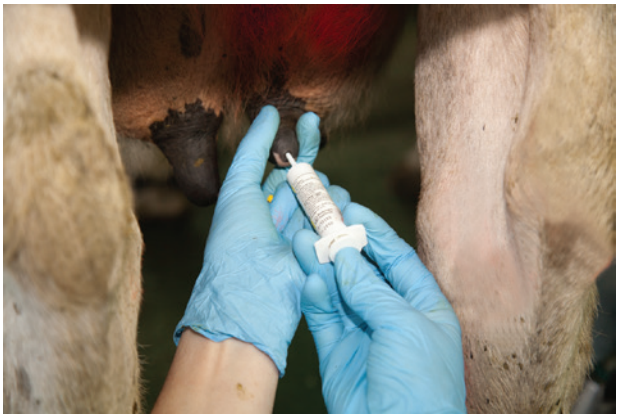
➜ **Technote 14** describes options and circumstances in which different dry cow strategies should be used.

③ Do not use antibiotic DCT on cows that are to be culled

Antibiotic DCT should not be administered to cows expected to be culled within the next 2-3 months. If cows treated with antibiotic DCT are subsequently culled, the meat withholding period of the product must be strictly adhered to.

④ Use antibiotic DCT only at the cow's last milking for the current lactation

Antibiotic DCT must be given only after the final milking of the lactation and should not be administered more than 24 hours after the last milking. Treating beyond this timeframe greatly increases the risk of inhibitory substance grades in milk at calving (Hill & Small 1985).



⑤ Clearly mark treated cows

Cows dried off early and treated with antibiotic DCT while the rest of the herd remains in milk pose a significant risk for antibiotic contamination of the bulk tank if mistakenly milked.

Cows should therefore be visibly marked before treatment in such a way that all milkers can readily identify them.

Recommended marking methods include:

- Spray paint on udder, tail and legs
- Tail tape or other highly visible identifiers

➜ The DairyNZ **Healthy Udder Guide** gives examples of methods for marking cows to be treated.

⑥ Administer the treatments using aseptic technique and partial insertion

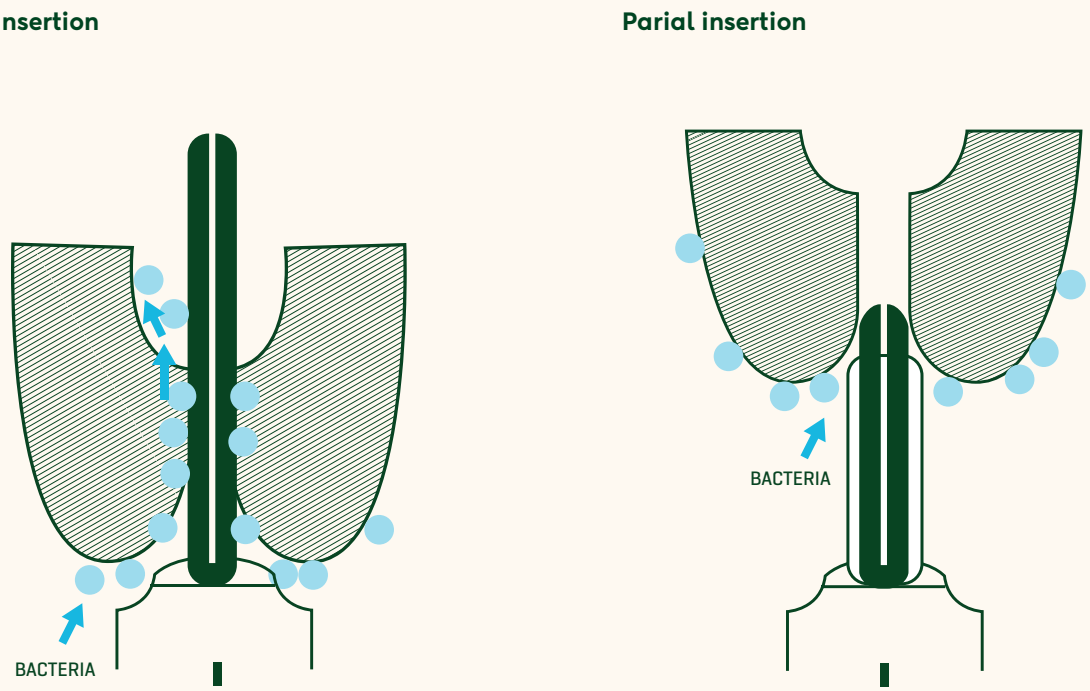
Teat ends must be thoroughly disinfected using aseptic technique immediately before treatment. Ideally, both antibiotic DCT and ITS should be given using partial insertion of the intramammary nozzle, inserting no more than 2-3 mm into the teat canal.

Partial insertion (Figure 1) minimises damaging the keratin lining of the teat canal and allows some product to remain in the teat canal, providing a temporary barrier to bacterial entry. In a controlled study, partial insertion reduced new infection rates by 50% compared with full insertion, across 86 cows (Boddie & Nickerson, 1986).

Short-nozzle products facilitate this approach but partial insertion is possible to achieve following appropriate training. While this technique may not be feasible in all herds, particularly where cows are not accustomed to teat handling, it should be used wherever practical.

➜ DairyNZ **Healthy Udder Guide** provides step-by-step instructions on aseptic technique for administering intramammary infusions.

Figure 1. If possible, use short nozzle tubes or the partial insertion technique to administer antibiotic DCT and ITS.



7 Treat all functional quarters appropriately

All functional quarters of cows selected for antibiotic DCT should be treated, except blind or fully involuted quarters.

Antibiotic DCT should not be administered to quarters that were dried off during lactation (i.e. cows milked as '3 titters') or to cows that have not been milked regularly. In such cases, antibiotic dispersion, absorption and clearance are unpredictable, and residues have been detected post-calving even after completion of the Minimum Dry Period and withholding period.

Cows producing very low milk volumes at dry off also carry an increased residue risk so shorter acting products, or ITS alone, may be more appropriate for these animals.

➜ **Technote 4** discusses quarters that have been dried off and **Technote 3** lists common reasons for antibiotic violations associated with antibiotic DCT.

8 Apply post-treatment teat disinfectant

Following treatment, all teats should be thoroughly sprayed with freshly prepared teat disinfectant to reduce bacterial contamination of the teat end.

➜ **Technote 7** discusses teat disinfection.

9 Maintain accurate treatment records

For every treated cow, record:

- Cow identification
- Date of treatment
- Product(s) used

Accurate records are essential for residue management, auditing, and treatment review.

10 Put cows in clean areas after treatment

Immediately after treatment, cows should not be left standing in laneways or yards. Where possible, ensure cows remain standing for the first 1-2 hours following antibiotic DCT or ITS administration.

Graze cows in dry, clean paddocks (not heavily soiled with manure, little bare ground, and no exposure to dairy effluent) for up to 14 days after treatment, or until udder involution is evident (i.e. udder swelling has subsided).

➜ **Technote 16** discusses the importance of a clean, dry environment at dry off.

➜ **Technote 18** describes the checks for clinical mastitis recommended for the first days and weeks of the dry period.

(11) Delay cow transport or movement for 10-14 days after dry off

To minimise milk leakage while the teat canal is closing, avoid long walking distances or transport during the first 2-10 days after dry off, when udder distension is greatest.

Clinical mastitis associated with poor treatment hygiene typically becomes apparent within the 2-4 days after treatment. If cows are moved short distances and can be closely monitored, movement within 12-24 hours after dry off may be possible.

Where monitoring is limited, transport should ideally be delayed until involution is established (approximately 10-14 days after dry off).

Acknowledgements

DairyNZ acknowledges the valuable input of veterinarians, milk quality advisers, and industry stakeholders who contributed to the development and review of these resources. Most are representatives of the National Milk-Quality Advisory Committee (NMAC) and have given generously of their time and expertise for the technical review.

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Technote 18

Checking udders regularly after dry off

In this technote:

Udder infections in dry cows are most likely to occur immediately after dry off and around calving. Cows are particularly susceptible to new infections in the first 2-4 weeks of the dry period before the teat canal has formed an effective seal (Thomas *et al* 1972, Williamson *et al* 1995).

Clinical mastitis that develops after dry off must be detected early and treated promptly to prevent persistence through to calving and adverse impacts on udder health in the subsequent lactation.

NMAC (National Milk-Quality Advisory Committee) recommends systematic monitoring of dry cows, with the intensity of checks being highest in the early dry period.

1 Observe cows daily for swollen quarters

For the first 1-2 weeks after dry off, cows should be visually inspected daily in the paddock for:

- Swollen, asymmetric or lopsided udders
- Signs of systemic illness (e.g. lethargy, lack of appetite, difficulty walking).

Any cow suspected of having clinical mastitis should be removed from the mob and examined more closely in farm dairy or yards.

➜ **Technote 4** describes how to check swollen quarters.

② Check swollen udders manually

Dry cow udders should be visually inspected during routine herd checks, with manual palpation reserved for cows with suspicious udders or clinical signs.

During the first 7-14 days, visual assessment of udder size and symmetry is usually sufficient, as milk secretion is still present and udders may be firm. However, suspect cases should be handled.

After dry off, normal dry cow secretions gradually become clear and viscous (honey-like) over 2 to 4 weeks. Secretions that remain watery, cloudy, or clotty are indicative of mastitis. Where there is uncertainty, the cow should be managed as a clinical case.

Particular vigilance is required in the first few days post dry off, as severe infections may arise following poor hygiene during administration of antibiotic DCT and/or internal teat sealants. These infections can be rapidly progressive and life-threatening, and early detection is critical.

③ Run all cows through the farm dairy for regular udder checks

NMAC advises that all dry cows undergo udder palpation at approximately 2, 4 and 6 weeks after dry off.

New clinical cases are most commonly detected between 14 and 28 days after dry off, before the keratin plug has fully formed. Where possible, cows should be run through the farm dairy or other facilities to allow effective palpation.

Teats should not be stripped unless heat, swelling or abnormal lumps are detected. If facilities are unavailable (e.g. cows at a run off), paddock checks can still be done, but these will only detect gross or acute cases.

Following any udder handling, all teats should be sprayed with teat disinfectant.

Teat spraying during the dry period has been shown to reduce bacterial contamination of teat ends. A New Zealand study reported lower teat bacterial counts and fewer *Streptococcus uberis* infections at calving for heifers sprayed 3 times weekly during the final 3 weeks of the dry period (Lopez-Benavides *et al* 2009). Similar benefits were observed in older cows treated with antibiotic DCT at dry off (Williamson & Lopez-Benavides, unpublished).

➜ **Technote 4** describes an udder palpation technique.

④ Treat clinical quarters by stripping out completely and using a lactation antibiotic

Clinical mastitis occurring over the dry period should be treated as for lactating cows, using:

- Complete stripping of the affected quarter, and
- A full course of lactating cow intramammary and/or injectable antibiotics, administered as recommended on the label.

These cows should NOT be re-treated with antibiotic DCT after completion of the treatment course, as this substantially increases the risk of Inhibitory substance grades.

During treatment, handling or stripping unaffected quarters should be avoided so that the teat seal or plug remains intact.

Acknowledgements

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Review and plan

Technotes 19–20

Technote 19

Taking care when selling cull cows and buying replacements

In this technote:

Both selling cull cows and introducing purchased cows as herd replacements pose important biosecurity and residue-management risks that require careful oversight.

1. Selling dairy cows for slaughter carries a strict obligation to ensure animals do not exceed Minimum Residue Limits (MRL) for meat. Errors can be costly and have the potential to jeopardise New Zealand's beef export trade.
2. Purchasing replacement cows also carries risk, particularly the introduction of mastitis and other infectious diseases. Cows bought through sale-yards, agents, clearing sales or herd dispersals require particular caution. Under these situations, 'buyer beware' (*caveat emptor)* applies, and animals offered are rarely the best cows in the herd.

① Check meat and milk withholding periods

To avoid errors, all cows treated with antibiotic (injectable or intramammary) must be clearly and permanently identified. While dairy farmers commonly use visible markings to manage milk withholding, these are insufficient for the longer meat withholding periods.

Accurate written and/or electronic records provide permanent identification of animals and are essential to confirm if meat withholding periods have elapsed before cows are consigned for slaughter.

② Prefer heifers over cows when sourcing replacements

Where possible, purchase heifers before first calving rather than mature cows.

Introducing replacement animals increases the risk of introducing various infectious diseases, such as Bovine Viral Diarrhoea or Johne's Disease (Mee *et al* 2012) as well as mastitis (Aggers *et al* 1974; Olde Riekerink *et al* 2010). The udder of purchased cows can be a major source of cow-associated or contagious, mastitis pathogens.

To reduce mastitis risk, three biosecurity principles apply:

1. Know the mastitis status of the farm of origin;
2. Know the mastitis status of the individual cows; and
3. Protect the home herd until introduced animals are 'cleared'.

Older cows carry a greater mastitis risk than younger cows because they:

- have had greater lifetime exposure to mastitis pathogens and milking equipment;
- are more likely to have had mastitis in previous lactations, which can increase subsequent risk of mastitis in the next lactation by 2-4 fold; and
- may have existing udder tissue damage (Buddle *et al* 1987).

Heifers that have not been milked in another farm dairy are more likely to be free of contagious mastitis bacteria. Where only a small number of replacements are required, heifers are preferred.

③ Do not buy cows without SCC and mastitis records

If cows must be introduced into a herd, farmers should be strongly encouraged to obtain mastitis information from the herd of origin, irrespective of the purchase pathway. Vendors unwilling or unable to provide this information should be avoided.

Relevant information includes:

- 6-12 months of bulk milk SCC (BMSCC) records;
- 6-12 months of clinical mastitis records and
- history of antibiotic dry cow treatment (DCT) use, particularly for dry cows;
- any relevant bacterial culture results.

As a general guide, persistently elevated BMSCC suggests the presence of subclinical infection with a major pathogen. Herds with BMSCC consistently below 200,000 cells/mL are more likely to have mastitis under control.

Cows should not be purchased without individual cow SCC (ICSCC) results. Avoid cows with average ICSCC above 150,000 cells/mL and be wary of older cows.

For cows treated with antibiotic DCT and/or internal teat sealants, the product name and treatment date must be obtained to manage residue risks, particularly if cows calve earlier than expected. This relies on good records from the herd of origin.

④ Check udders before purchase, and again before milking

Cows should be visually examined and palpated prior to purchase, including inspection of udders, teat ends, and foremilk (where appropriate).

A repeat examination should be conducted before cows are milked with the home herd, as udder abnormalities may become more evident after transport or calving.

➜ **Technote 4.3** describes how to examine and palpate udders.

⑤ Milk introduced cows last, until confirmed mastitis-free

Introduced cows should be regarded as suspect mastitis cases until their status is clearly established, via their:

- ICSCC history
- clinical mastitis records
- dry cow management
- physical examination of the udder, teat-ends and foremilk and
- bacteriological test results, where appropriate.

ICSCC is a valuable screening tool in New Zealand, given that over 70% of herds practice herd testing (DairyNZ & LIC 2025).

Cows with any ICSCC exceeding 250,000 cells/mL should not be purchased; with more conservative thresholds (e.g. below 150,000 cells/mL) further reducing risk. Because infections with *Staph. aureus* can be present in cows with mildly elevated ICSCC (>100,000 cells/mL), milk culture should be considered, even when SCC results appear acceptable.

Despite screening, no protocol guarantees freedom from disease. Newly introduced animals are simultaneously exposed to multiple stressors (dietary feed, transport, climate, social stress) which may increase susceptibility or reveal subclinical infections. Mastitis not detected at introduction may first become evident at calving.

Ideally introduced cows should be managed separately from the home herd for some months. Where this is not practical, the following precautions are recommended:

- Repeat full udder examination before each milking.
- Consider bacteriological testing even in clinically normal cows.
- Milk introduced cows last until they have a problem-free period.
- If there is any concern about antibiotic residues, exclude milk from the vat and consider residue testing.

➜ **Technote 4.4** discusses collection of milk samples for bacteriological testing.

⑥ Avoid sharing milking facilities with other herds

Sharing milking facilities with cows from other herds presents a high risk of mastitis transmission. This includes temporarily milking neighbour's cows or sending cows away to be milked elsewhere.

Maintaining a closed herd is the safest approach. Where emergency sharing of facilities is unavoidable, operate strict quarantine measures such as:

- Keep herds grazed and milked separately.
- Thoroughly wash the milking plant between herds.
- Segregate and milk last antibiotic-treated cows within each herd.

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Technote 20

Reviewing and planning mastitis control

In this technote:

Each year, time should be set aside to review, plan and implement the mastitis control programme, including milking routines, staff practices, milking equipment and use of animal health treatments. Regular monitoring and structured review are core components of quality management programmes and underpin production of high quality milk.

Every farm should operate a herd-specific mastitis strategy, aligned with its production goals and risk profile. Progress is best achieved through setting clear targets through an annual, farmer-led review that provides the basis for:

- assessing progress against the mastitis strategy,
- placing current performance in context,
- planning activities and targets for the coming year,
- supporting veterinarians and other advisers involved in herd investigations.

The annual review should include, or align with, a formal review of the Animal Health Treatment Plan, with particular attention to:

- appropriateness of antimicrobial use,
- opportunities to reduce antimicrobial use without compromising animal welfare, and
- alignment with antimicrobial resistance (AMR) stewardship principles (International Dairy Federation 2025) and One Health objectives (Pattis *et al* 2022).

While farmers should retain ownership of their mastitis strategy and review process, veterinarians and other advisers play an important facilitation role. Mastitis monitoring services can be delivered as part of the herd health services before dry off or calving, as adjuncts to milk recording or testing services, or as on-going follow up after a mastitis investigation. There are significant opportunities for veterinarians and other advisers to support planning, monitoring and review of mastitis control programmes.

① Schedule time to review progress and set goals

Effective mastitis programmes are herd-specific, goal-focused and evidence-based.

A mastitis control plan is the animal health equivalent of a farm budget and should be written annually, reviewed regularly, and designed so that interventions are timely, staff training requirements are recognised, and progress is monitored.

The plan should:

- summarise the current mastitis status of the herd,
- provide context, and identify opportunities for improvement,
- define broad and specific goals for the next 12 months,
- list key actions, responsibilities, and timelines; and
- integrate mastitis control with the Animal Health Treatment Plan.

The plan should be understood and endorsed, and ideally developed by the farm manager, in consultation with the whole farm team (which may include the farm owner) and advisers. It should be accessible to the milking team, kept concise and avoid unnecessary technical information.

The initial development of a mastitis control plan is often the most challenging step. Ideas may be drawn from advisers or peers, but the value of the plan ultimately depends on its relevance and ownership by the farm team.

The plan should be reviewed every 3-6 months to monitor progress and document unexpected events (e.g. weather, staffing changes). Without a planned programme and regular review, mastitis control on farm will be reactive rather than preventative.

② Involve all staff and family members

Everyone working on the farm influences udder health outcomes. Effective programmes require people to have clearly defined roles, understand their responsibilities, and know who is accountable for specific tasks.

Involving staff and family in planning and review improves engagement, cooperation, accountability, and long-term programme success.

Some farms extend the incentives in the milk payment systems to their employees.

③ Service and review milking system and equipment annually

Ensure the milking system is tested and serviced at least twice a year and upgraded as necessary by a qualified technician. Regular machine evaluation is an essential component of mastitis prevention and should be integrated into the mastitis control plan.

Ensure the teat spray equipment is serviced, maintained and upgraded as necessary. Ensure supplies of teat spray concentrate are on hand and stored appropriately. Check that volumes used in the past 6-12 months are consistent with use recommendations for the relevant equipment.

➜ **Technote 6** describes the test, service and upgrade of milking machines.

➜ **Technote 7** describes the use recommendations and considerations for different teat disinfectants.

④ Review the past 12 months and set new targets

A structured annual review should include:

- A brief description of the herd (cow numbers, age structure, number of replacements and culls, production).
- Key components of the mastitis control programme (e.g. milking routine, teat disinfection practices, dry cow products used, machine servicing, adviser inputs).
- Results of any investigations (e.g. milk cultures or test results, machine upgrades).
- Major events that disrupted the mastitis programme or diverted labour or resources.
- Review of mastitis indicators (e.g. clinical case rate, BMSCC distribution, proportion of milk supplied below the farm goal).
- Overview of farm staff, including skills and training completed.

For setting farm targets, ensure they are:

- realistic and achievable,
- exceed the minimum dairy company quality, and
- are more stringent than NMAC (National Milk Quality Advisory Committee) warning levels for mastitis indicators.

Annual targets may include:

- rate of clinical cases, from case treatment records,
- prevalence of subclinical mastitis in the herd, from herd testing information,
- proportion of milk eligible for premium payments (dairy processor records), and
- estimated number of cows lost/culled for mastitis-related reasons.

Some of the questions used in the mastitis and milk quality investigations in **Technote 13.1** can be adapted for review purposes. A comprehensive **Mastitis Focus Report** provides performance measures for key management areas including clinical mastitis, spread of new infection and dry off strategies.

➜ **Technote 11** discusses monitoring of bulk milk somatic cell counts.

➜ **Technote 12** discusses interpretation of individual cow cell count measures.

⑤ Seek advice when indicators exceed warning levels

If mastitis or antimicrobial use indicators exceed recommended thresholds, timely veterinary input is essential to identify causes and implement corrective action.

➜ **Technote 13** gives warning levels (critical and trigger alerts) for some mastitis indicators.

Acknowledgements

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