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Reduce exposure to environmental mastitis bacteria

'Environmental mastitis' refers to intramammary infections caused by organisms that survive in the cow's surroundings – including in soil, manure, bedding, calving pads, water, or on body sites of the cow other than the mammary gland. Infection of the udder with these organisms is often opportunistic, taking advantage of circumstances that favour environmental contamination and changes in the mammary gland's susceptibility to infection. There are many bacteria in the environment and some have biological characteristics that enable them to multiply within the udder.

Most cases of environmental mastitis occur within a few weeks of calving, when the cows' natural defence mechanisms are low and their udders have been in contact with mud and manure during calving. However, exposure of teat ends to environmental bacteria can occur at any time: before heifers have their first calf, during calving, at milking time or in paddocks during the lactation or dry periods. During lactation, factors that predispose cows to infection with environmental bacteria include milking udders that are wet or dirty, or administering intramammary infusions if the teat orifice is not sterile. During the early and late dry periods, absence of the keratin plug in the teat canal may make cows highly susceptible to infection.

Bacteria that commonly cause environmental mastitis are *Streptococcus uberis* or *Escherichia coli*. Other environmental organisms causing mastitis include other coliform bacteria (*Klebsiella* species, *Enterobacter aerogenes*), *Pseudomonas aeruginosa*, *Bacillus cereus*, *Arcanobacterium* (formerly *Actinomyces* or *Corynebacterium*) *pyogenes*, *Serratia* species, *Nocardia* species, *Candida* (yeast) and *Prototheca* (algae). Characteristics of some of these bacteria are described in the following tables.

Strep uberis usually responds to treatment but some cases can be difficult to cure. Coliforms do much of their damage through toxins released after the bacteria die. *Pseudomonas* is virtually impossible to treat and cows that survive must be culled.

Streptococcus dysgalactiae has characteristics of environmental and cow-associated causes of mastitis and it is not easy to categorise. In Australia, *Strep dysgalactiae* is commonly seen in heifers before they start lactation. The bacteria can be isolated from the environment and from sites on the animal such as the mouth, udder and vagina. Infection can occur between milking from *Strep dysgalactiae* in the cow's environment or it may be spread between cows at milking. Flies can physically spread the bacteria.

Mastitis is divided into two types – cow-associated and environmental. The bacteria causing cow-associated mastitis usually reside in udder tissue and on teat skin and are most commonly spread at milking. The bacteria causing environmental mastitis survive in the cow's environment and, although milking may facilitate their entry through the teat canal, the environment is the primary source of infection.

[Technote 14.3 and 14.4 discuss *Strep uberis* and blanket Dry Cow Treatment.](#)

[Technote 5 describes characteristics of common cow-associated mastitis bacteria.](#)

Characteristics of the common environmental mastitis pathogens

Characteristic	Strep uberis	Escherichia coli*
Reservoir of infection	<p>The bacteria can be isolated from the environment, faeces and many sites on cows – especially the abdominal skin.</p> <p>Some cows pass large numbers in their faeces.</p> <p>The udders of chronic, subclinically infected cows are a potential reservoir and their milk may contaminate milking equipment.</p>	<p>The bacteria is widespread in the environment.</p> <p>In rare cases, udders of chronically infected cows are a reservoir of infection and their milk may contaminate milking equipment.</p>
Spread	<p>Contamination of teat surfaces occurs in the environment.</p> <p>Infection can occur at any time, including during milking.</p>	<p>Contamination of teat surfaces occurs in the environment.</p> <p>Infection can occur at any time, including during milking.</p>
Cow susceptibility	<p>Infection most frequently occurs in the first two weeks of the dry period, and during the calving period and early lactation, especially if there is teat end damage or oedema.</p> <p>In the early dry and calving periods, changes in udder secretions, the lack of flushing at milking, and the absence of the keratin plug in the teat canal make the cows highly susceptible to infection.</p> <p>Infection with <i>Corynebacterium bovis</i> may make quarters more susceptible to <i>Strep uberis</i> (Hogan et al 1988).</p>	<p>Clinical cases are common in heifers and cows before and during calving, and in high-producing cows in early lactation. Downer cows with milk fever paresis may be at higher risk.</p> <p>Susceptibility is increased in cows with selenium or Vitamin E deficiency especially in the two weeks either side of calving.</p>
Clinical signs	<p>About 50% of clinical cases have an enlarged, inflamed quarter and changes in the milk. In about 40% of cases changes are visible only in the milk. In about 10% of cases the cows develop a fever and go off their feed.</p> <p>Research indicates significant differences between the ability of various strains of the bacteria to infect the udder. Some strains are protected by bacterial capsules, some invade mammary tissue and may resist natural defence mechanisms and the action of antibiotics.</p>	<p>Most infections are mild and have watery milk with small flakes.</p> <p>The bacteria can cause a sudden and severe toxæmia where cows develop a high temperature and may become recumbent and die. Milk from these cases can be a yellow, watery secretion with white flakes that can turn bloody (brown) later.</p> <p>Coliforms do not usually invade udder tissue – toxins cause the damage. Quarters often return to part production in the same lactation and full production the following lactation.</p>
Bacterial shedding in milk		

Characteristic	Strep uberis	Escherichia coli*
	Most infections are short-lived but a small percentage become chronic (Hogan and Smith 1997).	Bacteria are shed in the first 6-12 hours of clinical signs, and are reduced thereafter. Most infections are of short duration – more than 50% last less than 10 days. Some (1-2%) continue for more than 100 days. Severe cases are nearly always culture positive. Other cases are often culture negative because the cows have already eliminated the bacteria.
Cell counts (ICCC)	Most infected cows have ICCC higher than 500,000 cells/mL.	ICCC rapidly increase following infection and persist for about two weeks, after which the bacteria are eliminated. In chronic cases ICCC tend to be high (about 500,000 cells/mL) although they can fluctuate.
Milk quality	Bacteria are not usually found in vat milk unless there is a high prevalence of infection in the herd. Most isolations from vats are likely to be from bacteria on teat surfaces rather than from udder infections. Strep uberis can multiply in vat milk refrigerated at 10°C.	Clinical and chronic coliform cases do not contribute significantly to vat milk contamination. Most isolations from vats are likely to be from bacteria on teat surfaces rather than from udder infections.
Management during outbreaks	Manage calving cows to minimise exposure to contamination. If possible, use sand rather than organic materials for calving pads. Begin milking and disinfecting teats of cows tight with milk prior to calving, especially those leaking milk. Improve pre-milking hygiene and consider pre-dipping teats before milking. Examine milking machine functions (especially pulsation, liner length and vacuum). Use blanket long-acting Dry Cow Treatment at the next dry period to prevent new infections.	Manage calving cows to minimise exposure to contamination. If possible, use sand rather than organic materials for calving pads. Begin milking and disinfecting teats of cows tight with milk prior to calving, especially those leaking milk. Improve pre-milking hygiene and consider pre-dipping teats before milking. Overseas, vaccination with J-5 vaccine in the dry and early lactational periods reduces the incidence and severity of many of the coliform infections. This vaccine is not registered for use in Australia.

*Escherichia coli infection is often called 'coliform mastitis', which can also be caused by the less common but related bacteria Klebsiella spp and Enterobacter aerogenes.

Characteristics of some less common environmental mastitis pathogens

Characteristic	<i>Pseudomonas aeruginosa</i>	<i>Arcanobacterium pyogenes</i>	<i>Bacillus cereus</i>	<i>Nocardia</i> species
Reservoir of infection	The bacteria is common in the environment – in places such as water sources and ponds. It can colonise water hose and hot water systems and is resistant to some sanitisers.	The bacteria is common in the environment.	The bacteria is common in the environment and forms heat- and chemical-resistant spores.	The bacteria is common in soil. It can also survive in chlorhexidine teat disinfectant.
Spread	Infection may be introduced into the udder with intramammary treatments if teat ends are not dried or prepared aseptically. Spread is from contaminated water – either in the environment or water used to wash udders.	Occasional individual cases may be associated with teat or udder injury. This bacteria is one of a mix of bacteria causing ‘summer mastitis’ described in Europe and possibly spread by biting flies.	Infection may be introduced into the udder with intramammary treatments if teat ends are not dried or prepared aseptically. Mastitis has been associated with feeding brewer’s grain containing spores.	Infection may be introduced into the udder with intramammary treatments if teat ends are not dried or prepared aseptically. Spread can be by contaminated water used to wash udders or in contaminated teat disinfectant. Spread from cow to cow at milking is possible.
Cow susceptibility	Cows are susceptible during milking and whenever udder infusion takes place.	Dry cows and heifers prior to first calving are susceptible to infection.	Susceptible during udder therapy.	Infection occurs sporadically.
Clinical signs	Cases range from mild to a severe acute form with septicemia and death. Secretion varies, but may be a brown serum. Affected cows do not respond to treatment registered for use in cattle. If infection occurs at Dry Cow Treatment, clinical signs may not be seen until the next calving.	Infection commonly causes a severe mastitis. Typically the cow is sick, the quarter is hard, the teat is often very swollen, and secretions consist of thick pus with a putrid smell. 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 at Dry Cow Treatment, 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. Secretions are grey and viscid with small (1 mm) white flecks. Lumps may rupture and discharge to the surface. Infected cows do not respond to treatment. WARNING: Take care when handling infected cows as <i>Nocardia</i> species can cause respiratory infections in people.
Bacterial shedding in milk	Generally low numbers of bacteria are shed, with intermittent shedding in chronic cases.	Cases are usually clinical and large numbers of bacteria are passed in the secretion.	Cases are usually clinical.	Bacteria in fresh milk may not survive refrigeration or freezing of sample.

Characteristic	<i>Pseudomonas aeruginosa</i>	<i>Arcanobacterium pyogenes</i>	<i>Bacillus cereus</i>	<i>Nocardia</i> species
Cell counts	Cell counts are generally >500,000 cells/mL in chronic infections.	Cases are usually clinical with very high cell counts.	Cases are usually clinical.	Cases are often clinical.
Milk quality	Milk supply can be contaminated by water sources. This bacteria may cause milk spoilage.	Cases are usually clinical and their milk is excluded from the vat.	Cases are usually clinical.	Bacteria can be recovered from the bulk tank. This represents a potential milk quality hazard because the organism may not be killed by pasteurisation.
Management during outbreaks	<p>It is important to assess the intramammary technique being used and management of cows immediately after treatment.</p> <p>Affected cows do not respond to available antibiotics.</p> <p>Culture of water sources is often unrewarding, while changing water hose while changing water hose rubberware is often useful.</p> <p>Water supply for teat disinfectants should be heated to 70°C or above and cooled before use.</p> <p>Identification of infected quarters may require repeated culture.</p> <p>Positive cows should be culled.</p>	<p>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 (e.g. on the north coast of New South Wales).</p> <p>Consider blanket Dry Cow Treatment if this is a herd problem.</p> <p>Fly control is also very helpful.</p>	<p>It is important to assess the intramammary technique being used and management of cows immediately after treatment.</p>	<p>It is important to assess the intramammary technique being used and management of cows immediately after treatment.</p> <p>Affected cows do not respond to available antibiotics.</p> <p>Culture of water sources is often unrewarding.</p> <p>Assess the sterility of teat disinfectant.</p> <p>Infected cows should be culled.</p> <p>WARNING: Human infections are possible.</p>

Confidence – High

Local observations of the importance of hygiene in calving areas are consistent with overseas research and experience.

Research priority – Moderate

Further information on what constitutes a successful calving pad surface, including measurement of pathogen counts, could be useful.

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.

1.1 Calve on clean, dry pasture or a clean, dry calving pad.

The udder is very susceptible to infection at calving, and many infections detected in early lactation are established at calving (Hogan and Smith 1998).

The ideal place for cows to calve is a clean, sheltered, dry area. The ideal situation is a paddock with a good cover of grass, not irrigated or contaminated with milking shed or feed pad effluent, on an elevated site that is not wet, boggy or poorly-drained. Unfortunately, such areas are rare on most Australian dairy farms and most farm managers choose to use calving paddocks where the cows can easily be supervised or calving pads, especially in areas of high rainfall during the calving period.

Calving paddocks can work if they are large enough so that grass cover is maintained. However, it is common for small areas, which perhaps provide shelter, to be overused and become boggy. The only practical solution is to fence off such areas until they regenerate. If electric fences are shifted across a paddock at regular intervals, clean areas can be provided for new batches of calving cows. It is important to avoid 'back-grazing' (where cows have access to recently contaminated areas in addition to their new area). Some planning is needed to create access lanes and allow for access to drinking water in each strip-grazing area, for example by using mobile troughs. When cows are calving on grass it is also important to ensure that preventative measures for metabolic diseases have been taken.

Calving pads can be a successful alternative for wet conditions. Drainage is probably the most important factor and can be supplied by providing sufficient fall on the pad (of about 3-4%), or by installing underground slotted polyvinyl chloride (PVC) pipe drainage on flat sites (Davison and Andrews 1997).

Usually some bedding material is provided to make the cows more comfortable. Organic bedding materials (straw, rice hulls, shavings or sawdust) support higher bacterial populations than non-organic materials (washed sand or ground limestone). The particle size is also important. The surface area for bacterial growth and the chance of bacterial attachment and colonisation is increased in finely chopped or ground organic material. For this reason, long straw is generally better than finely chopped straw and shavings are better than sawdust (Hogan and Smith 1998).

Sawdust and other wood products tend to harbour the coliform bacteria and straw may contain large numbers of environmental streptococci, such as *Strep uberis* (Bramley 1982, Smith and Hogan 1997). Sawdust may have high pathogen (*Klebsiella* species) counts even when fresh (Hogan et al 1989). Kiln-dried sawdust is less of a problem. Sawdust can be used satisfactorily provided it is stored dry and managed correctly (Blowey and Edmonson 1995). Pathogen counts are much lower when contaminated sawdust is removed and replaced with fresh sawdust daily rather than weekly (Bramley 1992). Sawdust should not be used as bedding if it cannot be kept dry.

All bedding materials (organic and inorganic) will support high pathogen counts after becoming contaminated with manure (Blowey and Edmonson 1995). The area must be kept well drained and contaminated material removed and replaced on a regular basis. Pathogen counts will be high before the bedding looks soiled, and chemical disinfection (agricultural or hydrated lime, formalin, etc) of contaminated bedding is not effective (Hogan and Smith 1998).

The recommendations that no more than two pats of manure are present per square metre and no water is visible in foot prints are crude estimates designed to focus farmers' attention at least on gross contamination, given the lack of other more sophisticated monitoring techniques. Checking for fresh liquid manure, rather than dried pats, gives an indication of recent faecal contamination.

Practical and economic factors influence the surfaces available for calving cows and must be individually assessed for each farm.

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

- clean, grassed paddock with no surface water;
- well-drained inorganic material, such as sand;
- well-drained organic material; or
- poorly drained calving paddock (a last resort).

Confidence – Moderate

This recommendation assumes that most heifers enter springer mobs with a low prevalence of infection.

Research priority – Low

Analysis of the timing of clinical cases of mastitis, as part of the milk recording statistics, would provide better benchmark information on new infection rates.

1.2 Be alert to the number of cases of mastitis occurring, especially in freshly calved heifers. This is an indicator of the state of the paddock.

Mastitis in freshly calved heifers (first calvers) may result from infection that has occurred during their development since puberty or in the few weeks immediately before calving.

Heifers may be particularly susceptible to infection during the calving period. This is because they tend to spend longer calving, especially on the ground, and they often suffer from some degree of udder oedema that may reduce the ability of the teat and udder tissues to resist bacterial challenge (Slettbakk et al 1995). Field observations indicate a greater tendency of animals with oedematous teats to develop *Strep uberis* infections.

Clinical mastitis was observed at calving in 8% of first-calf heifers in a study of 11 herds in New Zealand (Pankey et al 1996). Environmental streptococci were isolated from 68% of these clinical cases.

The warning index of three or more cases in the last 50 calvings is an estimate based on the average incidence of clinical cases observed in the first month of lactation. Data on the incidence during the calving period (two weeks before and two weeks after calving) would allow this index to be refined, but it serves as a reasonable guide. It is probably of more relevance in seasonal herds where relatively large numbers of calvings occur over a short period (and 50 calvings may occur in as little as 1-2 days).

If this index is exceeded a reassessment of the calving environment and management should be made. It is often useful to have an independent adviser help with this to obtain the benefit of a 'fresh pair of eyes'. It is also worth noting that sometimes a high incidence of mastitis occurs at calving, even though the environment appears clean and dry. These may be infections that occurred at an earlier time (for example at drying-off) and then became clinical at calving.

1.3 Bring cows into the shed as soon as possible to milk out and check – certainly within 24 hours of calving.

In 1996 Pankey et al noted that many 'over-conditioned' heifers leaked milk prior to calving and had a higher prevalence of mastitis. They believed preferential treatment of heifers during the calving period may reduce the incidence of new infections and suggested several factors to aid mastitis control in heifers including:

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

In the past, preventive management of milk fever (a sudden reduction in the calcium level in the blood) sometimes involved leaving milk in the udder of fresh cows. This practice is now discredited because it predisposes to mastitis (O'Shea 1987). Rather than treating milk fever by incomplete milking, it should be controlled by managing the diet before and at calving to manipulate calcium availability in this period.

Technote 5.2 describes how to check milk from all quarters of freshly calved cows.

Confidence – High

Field experience in Australia shows that induced cows are more susceptible to *Escherichia coli* infection.

Research priority – Low

1.4 Take special care with induced cows.

Long-acting corticosteroids (such as dexamethasone) are widely used to induce parturition in dairy cattle in parts of Australia. They can impair secretion of proteins that are critical to normal cellular and humoral immune responses (Nonnecke et al 1997), an effect that is strongly linked with changes in the composition of the white blood cells. The ability of cows to respond to stressors may be reduced by the use of long-acting corticosteroids to induce premature calving.

Browning et al (1990) describe a collapse syndrome associated with the use of dexamethasone for inducing calving. It appeared to result from gram-negative endotoxaemia associated with subclinical infections as three of the seven cows in this study had peracute *Escherichia coli* mastitis confirmed at post-mortem examination.

Immune suppression resulting from the use of long-acting corticosteroids to induce parturition is still profound at the time of parturition. Steps must be taken to minimise exposure of induced cows to mastitis-causing pathogens at this time.

To minimise the risk of environmental mastitis in induced cows, practitioners recommend the following procedures:

- Maintain cows in clean, well-drained paddocks (the best calving area available on the farm) from the time they receive their first injection to induce parturition until after they have calved.
- Milk cows once the udder is tight with milk. Induced cows often bag-up tightly before calving and may drip milk. Machine milking is recommended once the udder gets tight with milk, even though the cow may not yet have calved. "If she's dripping milk, she should be milking."
- Watch udders carefully for signs of mastitis. Some cases can be rapid and severe with few initial changes or abnormalities in the milk (e.g. water milk, clots or flecks).
- Monitor induced cows very closely for signs of systemic illness. Cows may become acutely ill with an *Escherichia coli* mastitis endotoxaemia, even though visible changes in the udder may be limited and the secretion from the affected quarter is difficult to differentiate from colostrum.

1.5 Take care with pre-milking preparation of udders.

Technote 5 describes good milking technique and the importance of consistent routine.

Key papers

- Blowey R, Edmondson P. The environment and mastitis. In: Mastitis control in dairy herds, Chapter 8, Farming Press Books, Ipswich, United Kingdom, 1995:103-118.
- Bramley AJ. Bovine Medicine. Blackwell Science Publications, Oxford, United Kingdom, 1992.
- Bramley AJ. Sources of *Streptococcus uberis* in the dairy herd. I. Isolation from bovine faeces and from straw bedding of cattle. *J Dairy Res* 1982;49:369-373.
- Browning JW, Slee KJ, Malmo J, Brightling P. A collapse syndrome associated with gram-negative infection in cows treated with dexamethasone to induce parturition. *Aust Vet J* 1990;67:28-29.
- Davison TM, Andrews RJ. Feed pads down under. Department of Primary Industries, Mutdapilly Research Station, Queensland, 1997.
- Hogan JS, Smith KL, Hoblet KH et al. Bacterial counts in bedding materials used on nine commercial dairies. *J Dairy Sci* 1989;72:250-258.
- Hogan JS, Smith KL. Occurrence of clinical and subclinical environmental streptococcal mastitis. In: Proceedings of the symposium on udder health management for environmental streptococci, Ontario Veterinary College, Canada, 1997;36-41.
- Hogan JS, Smith KL. Risk factors associated with environmental mastitis. In: Proceedings of the 37th National Mastitis Council Annual Meeting, St Louis, Missouri, 1998:93-97.
- Hogan JS, Smith KL, Todhunter DA, Schoenberger PS. Rate of environmental mastitis in quarters infected with *Corynebacterium bovis* and *Staphylococcus* species. *J Dairy Sci* 1988;71:2520-2525.
- Nonnecke BJ, Burton JL, Kehrli ME. Associations between function and composition of blood mononuclear leukocyte populations from Holstein bulls treated with dexamethasone. *J Dairy Sci* 1997;80:2403-2410.
- O'Shea J. Machine milking factors affecting mastitis. In: Machine milking and mastitis, Bulletin of the International Dairy Federation No. 215, Brussels, Belgium, 1987:25-27.
- Pankey JW, Pankey PB, Barker RM, Williamson JH, Woolford MW. The prevalence of mastitis in primiparous heifers in eleven Waikato dairy herds. *NZ Vet J* 1996;44:41-44.
- Slettbakk T, Jorstad A, Farver TB, Holmes JC. Impact of milking characteristics and morphology of udder and teats on clinical mastitis in first- and second-lactation Norwegian cattle. *Prev Vet Med* 1995;24:235-244.
- Smith KL, Hogan JS. Risk factors for environmental streptococcal intramammary infections. In: Proceedings of the symposium on udder health management for environmental streptococci, Ontario Veterinary College, Canada, 1997;42-50.

