Summary

Rearing healthy dairy calves requires maximizing the calf’s level of immunity against disease while minimizing its exposure to infectious agents. Improving a calf’s disease resistance requires proper colostrum management, a quality nutrition and vaccination program, and minimizing environmental and other stressors. Minimizing the risk of exposure to infectious agents requires excellent environmental management, good housing, sanitation, and control of potential disease carriers such as people, animals or equipment. Producers should work with the herd veterinarian to design a calf health management program including a sound colostrum management program, a sound vaccination program for replacement heifers and cows, protocols for handling newborn calves, and protocols for the daily monitoring of calves to detect disease and make treatment decisions.

1. Review of Common Calfhood Diseases

A recent National Animal Health Monitoring dairy report showed that average calf mortality due to disease, was 10.8% for preweaned calves and 2.4% for weaned calves. However, rates of illness and mortality vary considerably among individual farms, depending on the calf management program. Calfhood diseases have a significant financial impact on dairies. The costs associated with calfhood disease include treatment costs, replacement costs, genetic loss, and impaired future performance. New York studies found that calf diseases, and especially chronic diseases such as pneumonia, have a negative impact on growth rates in calves. Studies have also shown that calfhood disease results in a decrease in a heifer's likelihood of surviving until calving, place her at increased risk of being culled prior to calving, and result in increased age at first calving.

Understanding the causes of common calfhood diseases and their methods of transmission is the first step in developing effective programs to minimize their impact on calf health. Diarrhea, pneumonia, septicemia and parasitism account for most calf illnesses and deaths. The following section will discuss the causes, methods of transmission, symptoms and methods of treating common diseases of calves. Methods of prevention will be discussed in the following section entitled ‘Developing a Calf Health Management Program’.

1.a Scours

Neonatal diarrhea, or scours, accounts for between 50 and 75% of deaths in dairy calves under three weeks of age. The cause of scours is often multi-factorial and includes exposure to one or more infectious agents as well as management and environmental factors including colostral management, sanitation, housing, grouping strategies, ventilation, stress, and nutrition. Infectious agents commonly causing scours include viruses, bacteria, and protozoa (described in Table 1). Many of these agents live for long periods in the environment. While other routes of infection are possible, the major route of infection for most of these agents is from contact with infective feces in the environment, or ingestion of fecally-contaminated feed or water.

Infectious agents or their toxins cause damage and inflammation in the lining of the small and/or large intestine. This results in an increase in the secretion of fluids and electrolytes into the intestine, an impaired ability of the intestine to reabsorb fluids and electrolytes, and an impaired ability to digest and absorb nutrients. The calf can lose blood, water, electrolytes, and nutrients such as proteins and sugars in the scours. Severe diarrhea leads to rapid dehydration and often death. Nutritional scours are usually caused by overeating and/or abnormal nursing schedules. White-colored scours are caused by undigested milk passing through the intestinal tract.

Symptoms. At less than 5 to 6% dehydration, the calf will likely appear normal but may have moderate diarrhea and wet hindquarters. As the loss of body fluids continues and dehydration exceeds 6%, the calf will exhibit depression, loss of appetite, loss of body weight, dry oral mucous membranes, sunken eyes, and
decreased skin elasticity. If untreated, this may progress to severe dehydration (greater than 10-12%),
recumbency, cool extremities, and death. The most common cause of death in scouring calves is dehydration.

Table 1. Common infectious agents causing scours in calves

<table>
<thead>
<tr>
<th>Infectious Agent</th>
<th>Age of affected calves</th>
<th>Most common methods of Transmission</th>
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<tbody>
<tr>
<td><strong>Bacteria</strong></td>
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<tr>
<td><em>Escherichia coli</em> (E. coli)</td>
<td>Usually less than 3 to 5 days.</td>
<td>Fecal/oral</td>
</tr>
<tr>
<td><em>Salmonella</em> (S. typhimurium)</td>
<td>Usually 2 to 6 weeks but can occur at any age.</td>
<td>Fecal/oral Colostrum or milk Saliva/Nasal In-utero</td>
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<tr>
<td><em>Clostridium perfringens</em> type C</td>
<td>Usually 5 to 10 days but can occur up to 2 months.</td>
<td>Fecal/oral</td>
</tr>
<tr>
<td><strong>Viruses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rotavirus</em></td>
<td>Usually 7 to 14 days.</td>
<td>Fecal/oral</td>
</tr>
<tr>
<td><em>Coronavirus</em></td>
<td>Few days to several weeks.</td>
<td>Fecal/oral</td>
</tr>
<tr>
<td><em>Bovine virus diarrhea</em> (BVD)</td>
<td>Any age.</td>
<td>Fecal/oral Colostrum or milk Saliva/Nasal In-utero</td>
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<tr>
<td><strong>Protozoal Parasites</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Coccidiosis</em> (genus Eimeria)</td>
<td>Usually from 17 days to 6 months.</td>
<td>Fecal/oral</td>
</tr>
<tr>
<td><em>Cryptosporidium</em></td>
<td>5 to 35 days.</td>
<td>Fecal/oral</td>
</tr>
</tbody>
</table>

**Diagnosis and treatment of scours.** To determine the cause of scours, consult with the herd veterinarian and submit fresh fecal samples to a veterinary diagnostic laboratory. Hydration with fluids and electrolytes is the most successful way to treat scouring calves. Commercially available electrolyte solutions provide water, minerals, glucose, and amino acids to help rehydrate the calf, correct acidosis, and replace lost minerals, energy and proteins. A mildly dehydrated calf can be treated with one additional 2 L feeding per day of electrolytes. Moderate to severe dehydration will require more than one electrolyte feeding per day. The herd veterinarian should be consulted and intravenous fluid and electrolyte treatment given if the calf will not voluntarily drink the electrolytes. Milk or milk replacer feedings should be continued to scouring calves, but should be given at different times from the electrolyte feeding (e.g. feed milk approximately 2 hours before feeding electrolytes). Electrolytes should not be mixed with milk or milk replacer. Treatment of bacterial scour will usually include the use of antimicrobials. Antimicrobials may also be used in the case of viral or protozoal scour to prevent secondary bacterial infections. The herd veterinarian can recommend an appropriate antimicrobial product and treatment protocol.

**Warning – human health risk.** Many of the infectious agents that cause scours in calves can also cause disease in humans (e.g. E. coli, Salmonellosis, Cryptosporidiosis). Young children, the elderly, and people with suppressed immune systems are especially at risk of infection. People who handle calves or come into contact with calf facilities should routinely clean up afterwards, including proper hand washing.
1.b Pneumonia

Pneumonia is an infection that causes inflammation and damage to the calf's lungs, and is the second most common health problem for young calves. While this commonly occurs around 4 or 5 weeks of age, it can also occur in younger and older calves. Although the infection is caused by bacteria and viruses, the calf's environment and management are also very important factors in causing the disease. Humid, moist air, drafts, exposure to wet or chilling cold conditions, and sudden temperature swings are risk factors for pneumonia. Build-up of ammonia and other gases in confinement housing irritate the calf's respiratory tract, damaging its defense mechanisms against infection. Other stressors that increase the calf's risk for pneumonia include crowding, transportation, weaning, and exposure to infectious agents through the co-mingling of calves in group pens or by housing of calves with older animals. Thus, pneumonia is caused as much by poor environment and management as it is by exposure to infectious agents.

Bacterial respiratory pathogens include Pasteurella multocida, Pasteurella hemolytica, Corynebacterium pyogenes, Mycoplasma dispar, and Hemophilus somnus. Viral respiratory pathogens include Infectious Bovine Rhinotracheitis (IBR), Parainfluenza-3 virus (PI-3), Bovine Respiratory Syncitial Virus (BRSV), and Bovine Virus Diarrhea (BVD). Symptoms include an elevated temperature, reduced feed intake, lethargy, and increased respiratory rate. Treatment success will depend upon early diagnosis and treatment. The herd veterinarian can recommend antimicrobial agents and treatment protocols. Calves with chronic pneumonia that is unresponsive to treatment frequently do not fully recover, have dramatically reduced rates of gain, and should not be kept for dairy herd replacements.

1.c Septicemia

Septicemia often occurs during the first week of life and is defined as the presence of bacteria and their toxins in the bloodstream. While often caused by E. coli (septicemic colibacillosis), many other bacteria including Salmonella sp. or Mycoplasma bovis may also be involved. These bacteria may enter the bloodstream by crossing a damaged intestinal wall or through the open navel of the newborn calf. These bacteria may travel through the blood to infect other organs including the brain (meningitis), heart, lungs, liver, kidneys, eyes, or joints. Calves affected by septicemia become depressed, weak, enter a state of toxic shock, and may die within 12 hours of onset of clinical signs. Recovery requires early diagnosis and treatment with appropriate antibiotics and supportive therapy, such as fluids or anti-inflammatories, as directed by the herd veterinarian. Calves surviving the initial septicemia may experience complications such as painful septic arthritis that is difficult to treat. Mycoplasma bovis can cause pneumonia, swollen joints, and inner ear infections in calves.

1.d Parasites

Protozoal parasites include coccidiosis and cryptosporidiosis. **Coccidiosis** in cattle is usually caused by Eimeria bovis or Eimeria zuernii, a microscopic one-celled parasite. The life cycle begins when calves ingest infective oocysts from the manure-contaminated environment. These immature stages (sporozoites) then invade the cells lining the wall of the intestine. Maturation and repeated division of the parasite destroys the intestinal cell, thus interfering with the calf's ability to absorb water and nutrients. Eventually mature male and female parasites unite to produce oocysts that are shed in the manure. These oocysts then mature in the environment to become infective to new animals. The whole life cycle takes approximately 17 days to complete. Clinical signs include diarrhea (sometimes bloody), dehydration, straining, loss of appetite, and weight loss. The herd veterinarian can often diagnose coccidiosis by identifying oocysts in fresh fecal samples, although they will not always be present. Diagnosis can also be made by examining a section of affected intestine at necropsy. Treatment of scours caused by coccidiosis will include anticoccidial drugs (amprolium or sulfonamide drugs), antimicrobials (to prevent secondary bacterial infection), and fluid and electrolyte solutions. Coccidiosis may be prevented or controlled in groups of calves by medicating feed with drugs such as decoquinate, lasalocid, amprolium, or monensin.

**Cryptosporidium** is another protozoan parasite that is much smaller than coccidia. After ingestion it adheres to the lining of the intestine wall and causes damage to the microvilli, the finger-like projections that are important for absorption of water and nutrients. There is no effective treatment that works directly against cryptosporidiosis. Treatment of affected calves consists of supportive fluid and electrolyte therapy and antimicrobial therapy to prevent secondary bacterial infection. Both coccidia and cryptosporidia are resistant to antimicrobials. Additionally, cryptosporidium is highly resistant to most disinfectants. As with all other causes of scours, prevention and control hinges primarily on sanitation to reduce the calf's exposure to infective manure in the calf's environment.
**Nematode parasites** include stomach worms (Ostertagia ostertagi, Trichostrongylus axei, and Haemonchus spp), intestinal worms (Cooperia spp., Strongyloides papillosus, Trichostrongylus colubriformis, Nematodirus helvetianus, Bunoostomum phlebotomum, Oesophagostomum radiatum and Trichuris discolor), and lungworms (Dictyocaulus viviparous). Mature worms produce eggs that are passed in the cow's feces. New infections usually begin when the calf ingests infective eggs while grazing. Nematode infections can cause diarrhea, weight loss, mild-to-severe anemia, rough hair coat, stunted growth and, in the case of lung worms, coughing and difficulty breathing. Calves raised in clean, well-managed facilities usually do not need to be dewormed. However, calves raised under unsanitary conditions or with access to pasture may become heavily infected and require deworming. Producers should consult with the herd veterinarian to establish a deworming program for all pastured animals.

**Trematode and Cestode parasites** include liver flukes (Trematodes) and tapeworms (Cestodes). Unlike the nematode parasites, these require an intermediate host to help complete the life cycle. In the case of liver fluke infections the intermediate host is a species of lymnaeid snail. These snails tend to live in water-saturated soil in poorly drained pastures, irrigation ditches, or around springs. Adult flukes living in the cow's bile ducts release eggs that are passed out through the intestine and into the feces. Immature stages infect the snail and continue to mature. Later, they leave the snail and are ingested by grazing cattle. Infected cattle suffer depressed growth, poor feed conversion, impaired reproduction, and occasional deaths. Control includes preventing access to wetlands, proper pasture drainage to control snail populations, and strategic deworming programs. Tapeworm infections develop when infective mites are eaten during grazing and, in the case of severe infections, also cause depressed growth rates.

**External parasites** include lice and flies. Sucking lice often cause poor weight gain and reduced efficiency of feed conversion. Heavy infestations can result in sufficient blood loss to cause anemia, weakness, and death. Biting lice cause hair loss and irritated, red, raw skin due to rubbing, scratching, and licking by the affected animal. Management factors such as overcrowding, poor ventilation, poor nutrition, and the presence of other diseases make cattle more susceptible to lice infections. Flies of importance include horn flies, stable flies, and house flies. Horn flies and stable flies cause blood loss, reduced weight gain, poor feed conversion, and irritation. House flies are an important vector for the transmission of pinkeye. Lice and fly control methods include pour-on insecticides, dust bags, sprays, back-rubbers, and medicated ear tags. However, because of their rapid reproductive rate, flies are quick to develop resistance to insecticides, making them difficult to control. One very important part of fly control is the frequent removal of manure and wet bedding that serves as a breeding and nesting area for flies.

1.e Other Health Problems

**Ringworm**

Circular areas of hair loss and crusty, scaly skin, commonly on the head and neck, caused by a fungal infection, Trichophyton verrucosum. The fungus survives for long periods in the environment and is spread by direct contact with infected calves or with a contaminated environment (e.g. rubbing on feed bunks). Calves kept in crowded facilities under hot, moist conditions are at increased risk of infection. While unsightly, the infection generally does not cause economic loss and is self-limiting, healing within 4 to 16 weeks. Exposure to sunlight and topical treatment with fungicides may hasten recovery.

**Warts**

Caused by a papilloma virus, warts are tan or grey small growths with a firm, dry, horny surface. Warts usually occur in young animals and are self-limiting, persisting for 8 to 12 weeks or longer before falling off the skin. Removal of the wart is possible by crushing, pinching, or cutting close to the base of the wart. An autogenous wart vaccine may help to clear up warts more quickly.

**Umbilical hernia**

A condition where the abdominal wall does not properly close at the navel. In the case of large hernias, abdominal contents may protrude through the hole in the abdomen wall, leading to a swelling under the skin in the umbilical area. While this condition may be inherited in cattle, it is thought that umbilical infections may also increase the risk for hernias. A veterinarian should examine all swellings in the umbilical region to determine if is an umbilical infection or a hernia, and to determine the most appropriate course of treatment. Smaller
hernias may close on their own over time, or may close after wrapping the abdomen with tape. Larger hernias may require surgical correction.

**Pinkeye**

Also called infectious bovine keratoconjunctivitis, pinkeye in cattle is caused by a bacterial infection, Moraxella bovis. Pinkeye infects the membranes on the eye's surface causing pain, redness, swelling, and watery discharge from the eye. More severe cases may result in corneal opacity (white or cloudy eye surface), ulcers, rupture of the eye, and blindness. Pinkeye is highly contagious and is shed in the nasal secretions of carrier cattle. Flies are a common method of transmission in groups of calves that are housed in confined conditions. The herd veterinarian should be consulted to confirm the diagnosis, since other diseases may cause similar eye lesions, and to recommend treatment. Early antibiotic treatment will minimize damage to the eye. Fly control is an important part of prevention. Available vaccines may reduce the incidence and severity of disease, but cannot completely prevent pinkeye.

**Sudden Death Syndrome (Enterotoxemia)**

Usually occurring in calves 3 to 8 weeks of age, this is caused by Clostridium perfringens bacteria that are found naturally in the soil and in the gut of normal calves. Clostridial organisms multiply rapidly under conditions when calves are overfed grain and/or milk, producing a powerful enterotoxin that damages blood vessels, the brain, and other tissues, and causing sudden death. Some protection may be provided by vaccinating dry cows with Clostridium C and D toxoid at approximately 6 weeks and 3 weeks prior to calving. This will increase the concentration of immunoglobulins against these specific clostridial organisms in the colostrum, providing some increased resistance against the disease in the calf. In the case of ongoing disease problems in young calves, calves may be vaccinated at 1 to 2 weeks of age and repeated 2 to 3 weeks later. However, management factors should also be examined and corrected.

**Bloat**

Abomasal or ruminal bloat is an abnormal accumulation of gas in a calf's stomach. This is usually caused by abnormal fermentation of milk when the calf is allowed to drink large quantities at infrequent intervals. However, other causes of bloat also exist. If bloatting is severe, the pressure can interfere with the calf's ability to breath, resulting in sudden death. The herd veterinarian should be consulted and treatment initiated immediately to release the accumulated gas. In severe cases the gas may need to be released using a stomach tube, a trocar, or a large needle. The diet and feeding management should be evaluated to prevent the condition.

**Colic**

Calves may develop abdominal pain due to abdominal distension after overeating, drinking cold water, intestinal accident (obstruction, displacement), infection, or other causes. Symptoms may include kicking at the belly, grinding the teeth, grunting or groaning, treading with the hind feet, restlessness, frequent getting up and lying down, and depression. If colic has not abated within a couple of hours the animal should be examined by the herd veterinarian.

2. Developing a Calf Health Management Program

**Goal:** To increase the calf's immunity while decreasing its exposure to pathogens.

Preventing the introduction and spread of disease, or biosecurity, is essential in calf health management. This involves increasing calf's level of immunity against disease while decreasing the calf's contact with infectious agents. Improving a calf's disease resistance requires proper colostrum management, a quality nutrition and vaccination program, and minimizing environmental and other stressors. Minimizing the risk of exposure to pathogens considers environmental management, housing, grouping of animals, sanitation, and control of potential carriers of disease such as people, animals or equipment. The following are general recommendations that should be part of all calf rearing programs. Producers should work with the herd veterinarian to design a calf health management program, including protocols for handling newborn calves,
detecting disease, and making treatment decisions. Examples of such protocols are provided at the end of this section.

2.a Maximizing the calf’s immune status.

2.a.1 Passive Immunity – the Colostrum Management Program

A sound colostrum management program is an essential part of raising healthy dairy calves. Antibodies are protein molecules produced in response to natural exposure to a disease or injection of a vaccine. These antibodies then act as an important line of defense in preventing new infections. It usually takes 7 to 14 days after natural exposure or vaccination to produce protective levels of antibodies. Because calves are born without circulating levels of antibodies, they are extremely vulnerable to disease in the first few weeks of life. Colostrum is the first secretion produced by the mammary gland after calving, and contains very high concentrations of antibodies (or immunoglobulins). It is essential that the calf consume an adequate amount of high quality colostrum as soon as possible after birth in order to achieve immediate immune protection against infectious diseases (passive immunity) until its own immune system can begin to produce antibodies after about 4 weeks of age. Failure to absorb enough colostral antibodies from the intestine results in low levels of circulating antibodies in the blood and is termed ‘failure of passive transfer’. This puts the calf at significantly higher risk of illness and death. A survey of 1,811 U.S. dairy farms reported that 40% of dairy heifers had low serum antibody concentrations at 48 hours of age, indicating failure of passive transfer (USDA, 1993). This study estimated that more than 22% of all deaths in dairy heifer calves could be avoided by preventing failure of passive transfer.

Considerations in designing a colostrum management program:

1. **Timing of colostrum feeding.** The intestine of the newborn calf begins to lose its ability to absorb the large antibody molecules in the colostrum within 1 hour after birth (called ‘closure’ of the gut). By 9 hours after birth there is a 50% reduction in ability to absorb antibodies. Gut closure is complete by 24 hours of age. While we used to think that feeding colostrum by 12 hours was adequate, we now know that this is not true. It is critical that the first colostrum feeding occur as soon as possible after birth in order to maximize absorption of colostral antibodies.

2. **Volume of colostrum fed.** The first feeding of colostrum should equal 12% to 15% of the calf’s birth weight. For a 90 lb calf, this equates to approximately 4 quarts of colostrum fed at the first feeding. This should be fed using a tube feeder if the calf will not consume it voluntarily. A second feeding, of the same volume of high quality colostrum, should be repeated 10 to 12 hours later. Feeding large volumes in a single feeding ensures adequate passive transfer is achieved and has not been reported to cause discomfort or scours.

3. **Quality of colostrum.** Only use high quality colostrum containing high concentrations of antibodies for first two feedings. Colostrum may be of poor quality if:
   a) The dam had a short dry period (less than 45 days dry).
   b) There was poor nutrition of dam during the dry period.
   c) The dam experienced heat stress during the dry period.
   d) The dam leaked milk prior to calving.
   e) Age. First-calf heifers produce poorer quality colostrum than mature cows.
   f) Thin, watery colostrum is often of poorer quality.
   g) The dam produces large volumes of milk at first milking (more than 18 lbs).
   h) There is delay in collecting colostrum from the dam. Antibody levels are highest at the first milking and immediately after calving. Their levels in the colostrum and transition milk drop quickly over the next 1 to 2 days.

A colostrometer may be used to estimate the antibody concentration in colostrum. Thin, watery, or poor quality colostrum should not be fed for the first feeding if other better quality colostrum is available. Use fair or poor quality colostrum and transition milk only for the 3rd or 4th feeding and for older calves.

4. **Method of feeding.** Studies have shown that calves left to nurse the dam frequently do not ingest enough colostrum soon enough after birth, and so are at increased risk for failure of passive transfer. This may be due to a weak or injured calf, poor suckling drive, poor mothering ability, injury to the dam, difficulty nursing
(especially in older dams with large teats and pendulous udders), and many other factors. Additionally, leaving the calf to nurse the dam increases the risk and duration of exposure to infectious agents in the dam’s environment. In order to guarantee early ingestion of an adequate volume of colostrum, producers should milk the dam and administer the first feeding of colostrum themselves using a bottle or tube-feeder.

5. Calf stress. Calves suffering from hypoxia (lack of oxygen) after a difficult delivery, heat stress, or cold stress have reduced ability to absorb colostral antibodies across the intestine. This is an important reason to try to minimize such stressors on calves. This also makes it even more important that these high risk individuals receive adequate amounts of high quality colostrum as soon as possible after birth.

6. Colostrum Cleanliness. Always wash the udder and teats well before collecting colostrum. Filtering colostrum may help to remove some debris. Store colostrum in closed, sanitized containers. Heat-treating colostrum using a low-temperature, longtime approach, or using preservatives, may be additional options for reducing bacteria in fresh stored colostrum (research underway at U of MN. Contact S. Godden (612-625-8177) for further information.

7. Storing colostrum. Colostrum may be stored at:
   a. Room temperature for 1 to 2 days.
   b. Refrigeration for up to 7 days.
   c. Freezing for up to 1 year. Freeze in 1 or 2 quart baggies. Thawing using high heat will destroy antibodies. Colostrum should be thawed using warm, not excessively hot, water baths, or by using a microwave at low or medium power and removing the thawed colostrum frequently before it overheats (heating at high power for 1 minute will begin to destroy antibodies).

8. Colostrum substitutes or supplements. Commercially available oral products are usually derived from dried milk, whey, colostrum, or bovine serum. Their use will not provide any additional benefit if an adequate volume of good quality colostrum has already been fed. Also, if given alone, these products are generally less effective in providing adequate passive immunity to newborn calves than if they were fed good quality fresh maternal colostrum. However, these products may be useful as an extender or to supplement poorer quality colostrum, or may be used if an adequate quantity of good quality fresh or frozen colostrum is not available. Of the oral products available, the serum-derived products offer the best antibody absorption. Injectable immunoglobulin products produced from purified bovine blood may be useful to increase circulating antibody levels in calves with failure of passive transfer that are older than 24 hours of age (gut closure has already occurred).

9. Colostrum from Johne's positive cows. Up to 22% of Johne's disease test-positive cows may shed the Johne's organism, Mycobacterium paratuberculosis, in colostrum or milk. Producers who are already testing for Johne's disease should avoid feeding colostrum or milk from test-positive cows to their calves. These calves may be fed frozen colostrum previously stored from test-negative dams. If producers are not testing for Johne's they can still take valuable steps to minimize the risk of transmitting this disease:
   - remove the calf from the dam as soon as possible after birth.
   - do not pool colostrum or milk from multiple cows for feeding to calves.
   - feed the colostrum from a dam to her calf only (one cow => one calf rule)
   - feed commercial milk replacer instead of raw transition or waste milk.

Another option may be to feed pasteurized transition or waste milk. Studies have shown that pasteurizing transition or waste milk will dramatically reduce, if not completely eliminate, the Johne's bacteria. Research is still necessary to investigate if on-farm pasteurization of colostrum will be successful without destroying the antibodies that are so important to provide passive transfer to the calf.

10. Measuring the success of a colostrum management program. The goal of a well-managed colostrum management program is to achieve passive transfer of immunity in all calves. This can be measured indirectly by recording and monitoring the rates of illness and death in the first week of life. To achieve this a record keeping program must be implemented to record calf information such as calf I.D., birthdate, sex, disease events, and treatments. Record systems will vary with the size of the operation but may include either paper records or one of several available computer software programs. Another rapid and effective method may be to
measure the immunoglobulin (Ig) status of calves. This may be accomplished by using an on-farm test kit to measure Ig levels in the blood between 2 and 7 days of age. Another method is to measure the serum total protein concentration at 24 to 48 hours of age (goal > 80% of calves tested have serum total protein concentration above 5.0 g/dl). Producers should discuss the options with their veterinarian for implementing such a monitoring program.

2.a.2 Specific Immunity – the Strategic Vaccination Program

A solid vaccination program is an essential aspect of disease prevention. When administered to an animal, vaccines are designed to cause the animal to produce its own protective antibodies against a specific disease agent. Cattle require 7 to 14 days to form protective levels of antibodies after vaccination. Depending on the type of vaccine used, immunity may last for months, years, or for life. Vaccination programs usually start at 4 to 6 months of age but also include vaccination of yearling heifers, and then vaccinating the dam during the preceding lactation and the preceding dry period. Vaccinating the dam will result in increased concentrations of disease-specific antibodies being secreted in the colostrum, thus improving the passive immunity provided to the calf.

Diseases commonly vaccinated for include Infectious Bovine Rhinotracheitis (IBR), Bovine Viral Diarrhea (BVD), Parainfluenza-3 Virus (PI-3), Bovine Respiratory Syncitial Virus (BRSV), the clostridial diseases, Leptospirosis, E. coli mastitis, and Brucellosis. Other vaccines that may be considered for use under special conditions include Pink Eye, Rotavirus scours, Coronavirus scours, E. coli scours, Pasteurella hemolytica and multocida, Salmonella typhimurium, Rabies, Tetanus, and Haemophilus somnus.

One decision is whether to select killed or modified live (MLV) vaccine products. Killed vaccines generally require repeated injections (boosters) to maintain immunity. Modified live vaccines often result in improved level and duration of protective immunity, but are not recommended in pregnant animals (unless specified on label – e.g. Pfizer's BoviShield Gold FP). Producers should work with the herd veterinarian to create a customized vaccination schedule for replacement heifers and the adult herd. An example of a core vaccination schedule is presented in Table 2.

Handle and administer vaccines according to label directions. A new sterile disposable needle should be used for injecting each animal. Reasons for vaccine failure include:

- Improper storage and temperature.
- Mixing of two vaccines together prior to administration.
- Administering an inadequate dose.
- Administering by an improper route.
- Inactivation of vaccine by residues of disinfectants used to clean syringes.
- Vaccination of animals too young to respond.
- Vaccination of sick, unthrifty or stressed animals (e.g. vaccinating too close to transport, time of calving, or during high ambient temperature).
- Failure to administer a booster or waiting extended periods between boosters.

Important: While vaccination is an essential component to a good health management program, vaccination programs only supplement, but do not replace, other disease-control measures such as colostrum management, sanitation, etc. Poor management will overwhelm a good vaccination program.

2.a.3 Enhancing General Immunity

- Minimize stress. Stress inhibits the immune system making the calf more vulnerable to disease. Sources of stress include feed or water deprivation, sudden feed changes, poor ventilation, crowding, sudden weather changes, heat stress, cold stress, transportation, vaccination, and weaning. Provide calves with comfortable housing and maintain consistent feeding practices. Failure to provide adequate shelter and to meet excess energy demands in cold weather can result in frostbite or rapid death from hypothermia or can result in more chronic signs of cold stress including physical weakness, depression, loss of vigor, reluctance to stand, a weak suckle reflex, and death. Shade, good ventilation and unrestricted access to clean fresh water should be provided in hot weather to minimize the effects of heat stress. Producers should try to minimize stress at weaning by avoiding scheduling procedures such as deworming, vaccination, dehorning, or transportation too close the time of weaning. These added stressors can increase the risk for pneumonia and other diseases.
Such procedures should be scheduled at least 1 to 2 weeks preceding or following weaning. Guidelines on minimizing stress during transportation is provided in the following section (section 3).

• **Nutrition.** Nutritional management impacts on the calf's health and vigor and has a direct impact on disease resistance. Fresh, high quality feed and clean, fresh water should be available at all times. Feeding high quality milk replacer and having access to starter rations and high quality forages will help to meet calf's nutrient requirements and allow for proper body weight gains. Feeding pasteurized nonsaleable milk is another option that has shown good economic, growth, and health improvements in calves (contact S. Godden at 612-625- 8177 for more information). Producers should talk to their nutritional consultant about increasing the nutrient intake level of calves during winter months to help calves maintain health, growth, immune function, and maintenance needs in the face of cold stress.

2.b Minimizing the calf's exposure to infectious agents

2.b.1 Sanitation of the calving environment. The calving facility, along with care of the calf after calving should be managed to minimize stress and decrease calf's exposure to infectious agents. Maternity pens should be physically removed from other dry cows or sick cow pens, and should provide a clean, dry, well-bedded, and draft-free environment. Maternity pens should be cleaned and disinfected after each calving. This will result in minimal exposure of the dam and the newborn calf to infectious agents in the maternity pen environment.

2.b.2 Care of the newborn calf. The viruses, bacteria, and protozoal parasites that commonly cause scours, septicemia, and pneumonia are generally found in the dam’s environment (manure, air, nasal discharge, uterine fluids, contaminated wet bedding, dirty hair coat, dirty udder skin, etc.). To minimize exposure to these infectious agents the calf should be removed from the dam immediately following calving. Also, we can decrease the potential for navel cord infections by dipping navels in at least seven percent iodine solution as soon as possible after birth and repeating in 12 to 18 hours.

2.b.3 Housing. House calves in a clean, dry, well ventilated, and draft-free facility that is physically removed from the adult herd and older heifers. Removing calves from the home farm and rearing them on a well-managed heifer rearing facility is one excellent option for achieving this. Calf facilities should be designed to minimize injuries and stress and optimize health by providing adequate space, shelter from the sun, wind and rain, good ventilation, and ease of handling. Use of individual calf hutches helps to prevent direct contact between young calves. After weaning, calves can be housed in small groups according to age and size. Thoroughly clean and sanitize housing between calves. A more detailed discussion of housing is provided in the section describing facilities.

2.b.4 Waste milk. Raw transition and waste milk can be a source of disease agents including Salmonella, Bovine Viral Diarrhea Virus (BVD), Bovine Leukosis Virus (BLV), Mycoplasma bovis, and Mycobacterium paratuberculosis, the bacterium causing Johne's disease. The risk for these diseases may be reduced by feeding a high quality commercial milk replacer. Alternately, some farms are now successfully using on-farm pasteurizers to feed pasteurized transition and waste milk to calves. Research at the University of Minnesota has shown significant economic, growth, and health benefits to feeding pasteurized waste milk instead of a conventional 20:20 milk replacer (contact Dr. S. Godden for more details at 612-625-8177).

2.b.5 Hygiene. Clean and disinfect all equipment between uses on individual calves. This includes instruments used for tagging, castrating, tattooing, removing extra teats and dehorning. Sanitize containers and utensils used for feeding milk (e.g. buckets, nipples, esophageal feeders), feed, or water between each feeding. Never use the same equipment for feed and manure handling.

2.b.6 Sick calves and cows. To avoid the rapid spread of disease, isolate sick or abnormal animals from the healthy ones. Once isolated, minimize the potential for humans to transmit disease to other calves by caring for sick animals only after completion of chores for the healthy calves. Separate feeding containers should be used. Hands should be washed, clothing changed, and boots disinfected after handling sick calves or cows.
2.b.7 Other biosecurity risks. Animals, people, vehicles, and other equipment may carry disease between farms, or between different groups of animals on the same farm. Infectious agents may be carried in manure on boots, clothing, or tires of equipment, in dust, and in blood or other body secretions on hands, clothing, and boots. Visitors should use plastic boots or sanitize their footwear before entering animal facilities. Clothing should be free of manure and hands washed before handling calves. Confining all vehicles and equipment entering the facility to designated areas. This is especially important of the deadstock truck and its operator. Livestock transport vehicles should be cleaned and disinfected between uses and before entering the farm. Discuss quarantining new animals with the herd veterinarian. Also examine practical methods of controlling fly, rodent and bird populations, as they are also capable of spreading disease.

3. Sample Protocols

Note: Sample protocols are meant as general guidelines only. Producers should work with their herd veterinarian to create customized protocols suited to the individual dairy.

3.a Protocol for Care of the Newborn Calf

The following steps should be taken in management of newborn calves:

1. The calf should be born into a clean, dry, well-bedded, and draft-free maternity pen.

2. Remove the calf from the dam as soon as it is found.
   - The longer the calf remains with the dam and her environment, the greater its risk of infection from exposure to infectious pathogens in manure in bedding, nasal secretions, uterine fluid, air, and manure-contaminated coat or udder skin.
   - Do not wait for the calf to nurse on its own before removing it from the dam.

3. Disinfect the navel by dipping it using a strong tincture of iodine (at least 7%).
   - This will inhibit infectious bacteria from entering the open umbilical cord.
   - Alcohol in the iodine solution will also help to seal and dry the cord.
   - Dipping the navel should be repeated in 12 to 18 hours.
   - Do not use diluted iodine solutions such as teat dip.

4. Feed the first feeding of colostrum as soon as possible by bottle-feeding or tubefeeding (ideally within 1 to 3 hours of birth).
   - Feed 12 to 15% body weight (4 quarts for a 90 lb Holstein calf).
   - Force-feed (tube-feed) any colostrum the calf does not voluntarily drink.
   - Use fresh colostrum from the dam if it is good quality, or use frozen colostrum if the dam cannot provide good quality colostrum.
   - Use a colostrometer to estimate colostrum quality (antibody concentration).
   - Do not feed colostrum from cows that were leaking prior to calving, bloody or mastitic colostrum, or thin, watery colostrum.
5. Place the calf in a separate clean, dry, warm, well-ventilated, and draft-free area where it is not in direct contact with cows or other calves (e.g. a calf hutch).

- Do not place a newborn wet calf directly outside into a hutch in cold weather until it has been completely dried and given its first feeding of colostrum.

6. Give the same volume of high quality colostrum in a second feeding 10 to 12 hours later.

7. Use fair or poor quality colostrum and transition milk only for the 3rd or 4th feeding and for older calves, or switch to feeding a commercial milk replacer product.

3.b Protocol for Daily Monitoring of Calves for Disease

3.d Guidelines for Transporting Calves
Goal: To minimize stress during transportation.

Potential Stressors:

1. Psychological
   a. Handling during loading and unloading
   b. Social stress during regrouping
   c. Unfamiliar housing environment

2. Physical
   a. Food and water deprivation
   b. Fatigue
   c. Injury
   d. Temperature

Why minimize stress during transportation?

Transportation involves both psychological and physical stressors. Minimizing stress during transportation is essential because stress suppresses the immune system, leading to an increased susceptibility to disease. Studies have shown death rates in transported calves of up to 23%. These calves generally did not die during transport, but die soon after, due to an inability to fight off diseases such as pneumonia. Humane handling and transport along with critical awareness of the animal's welfare during transportation will aid in decreasing the potential economic losses associated with the transportation of calves.

Effect of calf age

Age is a significant factor in determining calves ability to cope with the stress of transport. It should be a particular consideration when transporting calves less than four weeks old, as their physical immaturity leads to a decreased ability to adapt to transport. Various studies report the incidence of illness and death in young calves decreased as calf age increased. They also suggest death rates are lower when calves are transported after four weeks of age.

Vehicle considerations and stocking rate

Vehicle and stocking decisions are important aspects of minimizing stress, due to injury or disease, during transit. Transporting calves in vehicles specifically designed for this purpose may decrease the incidence of injury. However, regardless of vehicle design, inspect any surfaces the animals may come in contact with for safety (such as slippery floors and sharp corners). Modify potentially dangerous areas in order to prevent injury. To decrease the risk or exposure to pathogens, always transport calves in a clean, disinfected vehicle. Stocking density should minimize fatigue by allowing calves the ability to stand or lie down during transport. This is important as excess space or overcrowding will increase injuries due to falls.

Health regulations

When transporting calves, become informed about state health regulations such as required tests, vaccinations and certificates. General information on state health regulations can be obtained by calling 1-800-545-8732

Handling

Loading and unloading animals evokes a very high stress response and is often the most traumatic part of the transport process. This is often due to unfamiliarity with direct contact with people and therefore is a particular
Temperature

Thermal stress decreases when calves are transported within their thermal neutral zone of 50 to 80 degrees Fahrenheit. Avoid transporting calves during extreme hot or cold temperatures. During hot weather, provide calves with proper ventilation, shade and access to water. Also, protect calves against wind chill as research has reported calves have difficulty maintaining body temperature in cold conditions. Vehicles should be well ventilated but should not create drafts on the animals. A thick layer of clean straw or other bedding may be used as insulation when transporting calves in cold weather.

Rest stops

When transporting calves between states, federal law mandates a rest stop after 28 consecutive hours of transport. During this time, animals must be unloaded and provided food, water, and rest for a minimum of 5 successive hours. However, this regulation does not apply when animals are moved in vehicles equipped with food, water, and enough space to allow rest. When transporting calves within a state, be aware of pertaining laws. If a law does not exist, rest stops have been recommended for calves after 24 hours of transport. However, this time is variable and should be based on minimizing stress while ensuring the well being of the calves.

Table 1. Example of a basic vaccination program of a commercial dairy herd

<table>
<thead>
<tr>
<th>Class of Animal</th>
<th>Age / Stage of Life Cycle</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-breeding youngstock</td>
<td>4 months of age</td>
<td>IBR, BVD, PI3, BRSV (MLV)</td>
</tr>
<tr>
<td></td>
<td>5 months of age</td>
<td>Leptospirosis – 5 way</td>
</tr>
<tr>
<td></td>
<td>12 months of age</td>
<td>Clostridium – 7 way + tetanus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repeat ‘4 month’ vaccines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brucellosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repeat ‘4 month’ vaccines</td>
</tr>
<tr>
<td>Pre-fresh heifers with above history</td>
<td>35 days prior to due date</td>
<td>35 E. coli</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scoursgard 3K/C (K99 E. coli, Rotavirus, Coronavirus)</td>
</tr>
<tr>
<td></td>
<td>21 days prior to due date</td>
<td>Repeat ‘35 day pre-fresh’ vaccines</td>
</tr>
<tr>
<td>Pre-fresh older animals with above</td>
<td>35 days prior to due date</td>
<td>35 E. coli</td>
</tr>
<tr>
<td>history</td>
<td>21 days prior to due date</td>
<td>Scoursgard 3K/C (K99 E. coli, Rotavirus, Coronavirus)</td>
</tr>
<tr>
<td>Lactating heifers and older animals</td>
<td>14 DIM</td>
<td>35 E. coli</td>
</tr>
<tr>
<td>with above history</td>
<td>30 DIM</td>
<td>IBR, BVD, PI3, BRSV (MLV – if open)</td>
</tr>
<tr>
<td></td>
<td>At Pregnancy confirmation (or</td>
<td>Leptospirosis – 5 way</td>
</tr>
<tr>
<td></td>
<td>twice/year or April/October)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clostridium – 7 way + tetanus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional if Purchased pregnant</td>
<td>60 days prior to due date (or</td>
<td>IBR, BVD (Killed), PI3, BRSV</td>
</tr>
<tr>
<td>with unknown/questionable history</td>
<td>upon arrival)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 days prior to due date (or</td>
<td>Leptospirosis – 5 way</td>
</tr>
<tr>
<td></td>
<td>21-30 days post-arrival)</td>
<td>Clostridium – 7 way + tetanus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repeat ‘60 days prior to due date’ vaccines</td>
</tr>
</tbody>
</table>

Note: this is not necessarily an exhaustive program. It should be reviewed and, if necessary, modified to fit the requirements of individual producers. Additional vaccines that may be used under special conditions include: Pasteurella multocida, Pasteurella hemolytica, Salmonella typhimurium, Haemophilus somnus, Vibriosis, Trichomoniasis, Pink Eye, Staphylococcus aureus, warts, Anaplasmosis, Rabies

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