Beef Biological Risk Management

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Introduction

Biological risk management (BRM) is an important and complex aspect of producing beef cattle; however few owners have plans in place or understand the basic practices that can be implemented to control and minimize the risk of infectious agents to their animals. This document highlights the importance of biological risk management (BRM) in beef cattle operations through risk perception, risk assessment, risk management, and risk communication.

Beef cattle production is a segmented and diverse industry. It is therefore impossible to address all possible risks that may be presented in different settings. However, it may help to gain an understanding about the most common practices within the industry. The most commonly recognized divisions are cow-calf, stocker/backgrounder, and feedlot.

The majority of cattle owners are cow-calf producers. Management styles vary greatly depending on geographic location, resources, and production goals. However, most utilize grass forages for maintaining cows, while deriving the majority of income from selling weaned calves. The exception to this would be seedstock operations, which breed purebred bulls and cows to sell for breeding purposes. Most cow-calf producers run small operations (1997 data suggests that approximately 80% of cow-calf operations own less than 50 head), and usually consider it a "hobby" or a source of supplemental income rather than principle means of earning income. For example, the beef herd was the primary income source on only 14% of all operations represented by the National Animal Health Monitoring System (NAHMS) Beef '97 study. Over one-fifth (21.8%) of the smallest operations had beef cows for some reason other than as a source of income such as pleasure or excess forage control. While finances must always be a consideration in developing herd management programs, it is not the primary concern for many producers.

Stocker/backgrounder operations purchase weaned calves and feed them, usually on grass, for a variable length of time, prior to the calves going to a feedlot. Cow-calf operators may retain ownership of their own calves during weaning and even through the feedlot phase. However, the risks of disease transmission are significantly different than if calves are combined from multiple sources. For our definition, the distinguishing characteristic of stocker/backgrounder operations is the purchase of animals from off-farm sources. Once again, size of operation and management varies among stocker/backgrounders. However, as a whole, these operations have a much larger number of animals purchased and sold than a cow-calf operation. The resulting commingling of cattle from different sources increases the possibility of disease transmission.

The final segment of beef production is the feedlot. These facilities house calves in relatively large groups (50 to several hundred) in dry lots, and feed a high concentrate diet for finishing. Feedlots are more likely than either cow-calf or stocker/backgrounder operations to be large and managed solely for profit. The number of small feedlots (<1,000 head capacity) outnumber the largest feedlots (>32,000 head capacity) almost 1000 to 1 (NAHMS data). However, because of their enormous capacity, large feedlots feed nearly twice as many animals per year. Feedlots experience unique biological risk management challenges, because of the large number of animals from a variety of sources that are confined in a limited area.

Importance of Beef BRM

Economics is the most apparent selling point for BRM. Endemic diseases cost producers millions of dollars each year, and the introduction of a foreign animal disease could devastate the entire industry almost instantly. One need look no further than the ramifications of the Foot and Mouth outbreak in the United Kingdom in 2001 to understand this. It took over seven months to eliminate the virus from the nation, and resulted in the destruction of 4.2 million animals, including nearly 600,000 cattle. Total costs were estimated at £10 billion (approximately $4.9 billion), with £4 billion ($2 billion) spent to reimburse for destroyed animals.

It is not necessary to suffer the effects of a foreign animal disease to demonstrate the benefits of a BRM plan. As reported in the *Journal of the American Veterinary Medical Association* (Nov. 1999) in the winter of 1997-1998, a 350 head commercial cow-calf herd in Canada had an abortion outbreak. Greater than 20% of the herd aborted in a three week period, and 38% were found to be open upon subsequent pregnancy examination. Neospora caninum was confirmed to be the causative agent. Although a definitive point of introduction was not identified, it was determined that contamination of the mineral mix with dog feces was the most likely source. This illustrates the importance of having a comprehensive BRM plan that addresses all routes of transmission, including animals other than cattle.

The financial costs can be enormous with many diseases, be they insidious, endemic agents, or dramatic outbreaks as illustrated above. While occurrence cannot be predicted, it becomes more likely when little effort is directed at prevention. The old adage "An ounce of prevention is worth a pound of cure" is very applicable in this regard. In addition to money saved through lower morbidity and mortality and less treatment costs, more marketing opportunities can potentially be found as a result of a comprehensive BRM plan. This is most apparent for seedstock producers, who may find new clients if they can demonstrate low risk for disease transmission. Producers who target "organic" and "natural" markets could also benefit from enhanced marketability. Such programs often require assurances of reduced disease risk, as well as prohibiting many pharmacological treatments; claims a comprehensive BRM plan could bolster.

Other arguments for implementing a BRM plan can be made on legal and ethical grounds. Many diseases affecting beef cattle are zoonotic, and pose a risk to owners, farm workers, neighbors and consumers. While appropriate BRM measures may not eliminate risk, they are likely to reduce the threat and liability and increase goodwill. Producers who have made earnest attempts to control introduction, spread and release of diseases face less opposition from environmental, consumer and regulatory representatives.

Risk Perception

The assessment of risk perception examines what those involved with the operation think about the real and potential risks of infectious and zoonotic diseases. These perceptions may be influenced by what has been encountered on the farm, or by what owners, managers, and employees have read in magazines or the internet. These perceptions may present obstacles and challenges to educating about risk management. Many individuals have negative perceptions associated with risk management, most of which are based on disbelief or economic concerns.

Common negative beliefs include:

- I already know this stuff
- We have always done it this way
- I've already had most everything on this farm
- I don't have enough time to mess with this
- It's too complicated
- It won't make any difference
- It's too expensive
- I don't have the space
- Our animals were tested once and we found nothing, it was just a waste of money
- Our farm is pretty safe

While it is difficult to prove and measure the benefit of things that don't happen, BRM can be advocated through three main arguments: there is a risk, it is economically worthwhile to prepare, and the overall impact must be considered.

- Infectious/zoonotic disease outbreaks can and do happen as the *Neospora* example illustrates
- Prevention is always less costly than treatment
- Protecting your financial investment and future assets from liability is worthwhile insurance
- Protecting employees saves time and money
- A BRM plan will help manage the threat of foreign animal disease entry and spread
- A focus on preventative medicine helps to maximize public and environmental health of your community

Hazard Identification

To properly assess the risks of disease occurrence facing an operation, we must identify what specific hazards exist. This involves answering several questions.

What diseases are already present in the herd?

An accurate estimation of what diseases are present, and at what levels, can greatly aid in determining what measures are necessary and justified to control them. The current effects that those diseases are exerting should be considered, as well as the consequences of their continued expansion or periodic flare-up. Often producers may be unaware of what diseases are present, and the herd veterinarian should play an integral role in reviewing the current and historical herd health status to determine what agents are likely present.

While few producers have a comprehensive BRM plan, most operations have some measures in place to limit disease. These may range from simply isolating sick animals, to vaccination and treatment plans, to closed farms or strict quarantine. As part of performing a hazard analysis, these measures should be identified and examined. Are they reasonable and science based, or random and arbitrary? Are they consistently applied? Have they had their desired effect on the disease(s) for which they were originally implemented? How about on other diseases? What are their costs, and do the benefits justify these?

What diseases could be introduced to the operation?

All operations in the U.S. are currently free of foreign animal diseases (FADs), and all animals would be equally naïve. There are many diseases that are considered endemic in the national herd that may or may not be present in a given operation. Additionally, there are many newly emerging diseases that are becoming more common or more widely recognized. Therefore a careful evaluation of the herd health history needs to be taken to establish what diseases pose the greatest risk or warrant the most attention. The herd veterinarian can provide an assessment of what diseases are most common in a given geographical area, as well as what diseases have been confirmed or suspected on that operation.

If a disease were introduced, would animals be at-risk?

Disease resistance is the first determinant of whether or not animals would be at-risk. Again, for FADs, all domestic livestock would be susceptible. For endemic diseases, some animals may develop resistance following exposure, but this should not be considered adequate to prevent spreading of the disease within the herd. Susceptibility can also be influenced by other characteristics of the population, such as age, sex, vaccination, nutritional status, etc. Generally speaking, healthy animals on a good nutritional plane, maintained in a favorable environment with limited stress are less susceptible to disease. These factors should never be neglected when attempting to establish a BRM plan.

If a disease were introduced, would it spread?

This relates to the ability of the BRM plan to prohibit spread of a disease. Ideally, BRM prevents the disease from entering a premise. Realistically, it must also be directed at preventing spread of disease within an operation. This must be considered not only in terms of rapid dissemination throughout the herd, but also gradual entrenchment. Disease agents that have a long latency period or persist in the environment pose a significant threat of becoming established in a herd, even before clinical signs are identified. Therefore, BRM should consider all routes of spread, and be fully adhered to at all times, whether or not it is suspected that diseases are present. The majority of this material is directed at assisting producers to design and implement a comprehensive plan to limit introduction and spread of disease within a farm.

Is human exposure a concern?

Many diseases that infect animals can also cause disease in humans. Children, elderly and immunocompromised are considered to be more vulnerable populations. Additional precautions should be taken to protect such individuals from potential exposures to infectious diseases. However, this does not mean that healthy adults are immune to zoonotic agents. Appropriate hygienic measures should always be taken to reduce the likelihood of contracting a disease from animals. Some practical suggestions are included in a later section.

What would be the consequences of exposure/disease?

Because so many diseases are endemic in most herds, it is often necessary to prioritize according to the likelihood of disease and the severity. Those diseases that cause the greatest morbidity and mortality should generally receive the most attention. However, for some diseases the monetary consequences may be severe, even if morbidity and mortality are not. Such losses can result from issues related to the lost revenue from interference with markets, lost value of genetics, and the cost of diagnosis, treatment, intervention (vaccination, etc.) , and disposal of affected animals.

Other issues to consider in assessing the consequences of disease include the risk to humans. These must be assessed in their full costs (direct and indirect), in regards not only to health risks, but also the costs of medical care, lost productivity, and possibly loss of employees (who may quit or be unable to return to work).

Livestock diseases can also have indirect impacts on the operation and community in general. Spread can occur to neighboring farms, affecting animals and operations beyond the original source. Dissemination of disease into wildlife can also occur, making eradication difficult or impossible, and again threatening other producers and perhaps the general public. Producers who do not fulfill their obligations to limit disease spread can suffer loss of goodwill from their customers (within the industry and food consumers) and a deterioration of the public perception of agriculture.

Risk Assessment

To increase its effectiveness and completeness, a comprehensive risk assessment should be performed from a variety of perspectives. To address the concerns regarding an infectious disease entering or spreading within a beef operation, the CFSPH has designed a biological risk management toolbox. It consists of educational materials, an online database containing assessment questions, management recommendations, and resources that enable veterinarians to objectively evaluate their client's beef facilities and to identify opportunities for improvement. The database and all other BRM Toolbox materials can be accessed at: www.cfsph.iastate.edu/BRM. Registration is required to utilize the online database. First and foremost, the general herd characteristics and policies of the farm should be examined through a pre-assessment questionnaire (part of BRM Toolbox). Subsequently, a more detailed assessment can be made through a comprehensive questionnaire. Some of the assessment topics apply equally to all operations, while others are more relevant to only one or two phases of production (cow-calf but not feedlot or stocker/backgrounder, for example). We have therefore attempted to separate our assessment questions and management discussion accordingly.

In reviewing this material, it is imperative to understand that the focus is on routes of transmission, not specific diseases. Assessing risk based on route of transmission provides a more complete and holistic approach and avoids emphasizing specific disease(s). The only references made to specific diseases, syndromes or infectious agents are for illustrative purposes only, and there are no specific recommendations provided as to vaccination, treatment or testing procedures. This focus will make the information applicable to a variety of audiences and remain relevant even as scientific advances improve our understanding of diseases.

Herd Characteristics

The characteristics of the operation greatly impact the nature and significance of disease risks, and the subsequent BRM plan. Each production method will have inherent strengths and weaknesses associated with it. For animals kept principally on pasture, owners have less control of the environment, including feed and water sources and contact with wildlife. However, these types of operations have a lower stocking density, which slows or limits the spread of infectious agents. The opposite conclusions would apply to dry lot operations.

The stage of production will also impact what diseases and routes of transmission are most important. Stocker and feedlots are almost exclusively producing animals bound for slaughter. Therefore they have little concern for diseases that have a long latency period, or reproductive diseases. Similarly, since these cattle populations are already weaned, they have little risk of traditional diseases of early calfhood (calf scours, septicemia from umbilical infection, etc.)

Operation goals and activities must be considered when developing BRM plans. Seedstock operators have greater economic incentive for comprehensive BRM plans, because of the need for assurance that breeding animals are disease-free, as well as the higher value per animal and the irreplaceable nature of genetics. However, they may also engage in activities that present a greater risk. These include traveling to shows and sales, and commingling breeding stock with animals from other herds in group settings (like bull test stations, or custom semen collecting or embryo flushing facilities).

Risk Management

This section illustrates the best available "standard operating procedures" for a wide range of management practices. Each veterinarian should perform a thorough assessment to identify opportunities for improvement. Then the management suggestions should be considered as to which ones are most practical, applicable, and economically feasible. Most recommendations can be implemented independent of others. This will result in tailoring the BRM program for each producer based upon his/her preferences, resources, risk perception and risk tolerance. Some suggestions may not be feasible for a given facility; but recognizing what is optimum helps establish long term goals.

General Management Issues

It is important to note that most management decisions are made for reasons other than disease control, but these practices have a significant impact on the operation's biological risk management. Various reasons may include reduction in labor, better employment of resources, greater productivity, or merely tradition. It must be recognized that some practices may provide benefits that far exceed the disease risks they introduce. However, their negative potential must still be appreciated in developing a comprehensive BRM plan.

One basic management practice that will impact most aspects of a comprehensive BRM plan is record-keeping. Without being able to identify the origin, history and production status of an animal, it is difficult to appropriately manage its risks. Furthermore, adequate record-keeping is greatly facilitated by the maintenance of individual identification. Animal records should include birth and/or purchase date, the ID of the sire and dam (in case congenital infections are detected), identification of all animals in the same cohort groups, as well as a record of all noted illnesses, treatments, procedures performed, etc. that are unique to that animal. Also, all aspects of the health program should be recorded, including when vaccinations, dewormings, etc. are performed, what products are used, serial numbers and expiration dates of products, any reactions, and so forth.

A fundamental practice for controlling disease exposure is limiting animal contact through segregation of various groups of animals. Because sick animals and new introductions pose the greatest risk, they are discussed in detail in a later section. However, disease transmission can result from contact between seemingly healthy animals from different sources, of different ages, or at different production stages. The extent and effectiveness of segregation measures will depend on physical proximity and other factors. For example, fence line contact may reduce transmission of some orally acquired diseases, but will not stop transmission of aerosol or direct contact pathogens. Separation by multiple fences over a distance is better, but some aerosol-transmitted diseases can travel long distances. Sharing of feed or water sources can pose a risk, such as a stream running through multiple pastures, common use of feed troughs or mineral feeders. Contact with neighboring operations and wildlife presents another threat to all animals on an operation. While these likely cannot be eliminated, they may be minimized by providing greatest protection to the most susceptible population(s).

Another variable that directly impacts the ease and rate of disease transmission is stocking density. Increased stocking density facilitates contact between carrier and susceptible animals, increases environmental pathogen concentration, eases vector and fomite transmission, and can result in decreased immune status (through stress, dusty conditions, decreased feed availability, etc.). Various management practices may increase stocking density, on a temporary or permanent basis. Examples would include placing animals in a dry lot (for weaning, heat synchronization or routine herd work), or decreasing pasture size (intensive grazing, winter feeding). These issues are examined separately throughout the risk management section, but basic recommendations would be:

- Limit stocking density to the minimum level feasible
- Limit areas of congregation (around feeders, water sources, etc.)
- Minimize amount of time animals are held in confinement
- Reduce stress in handling

A blanket recommendation cannot be made about stocking density, since acceptable numbers will vary by type of operation, geographic region and environmental factors. It should be borne in mind that most recommendations on stocking density are based upon local conditions, including feed or forage availability, precipitation and ability to manage waste. These do not necessarily reflect optimum density as it relates to disease transmission.

General Management: Cow-Calf

Calving represents a significant disease risk period for both the cow and the calf. The risks can be minimized by having a clean, hygienic calving environment, where animals have minimal opportunity to come into contact with infectious agents. In most situations, the best way to achieve this is by calving in an open pasture, with a low stocking density. Because calves serve as amplifiers of pathogens, the most important means of controlling disease is to limit contact between very young and older calves. The first step is establishment of a defined and strict calving season. This will result in a maximum age difference between calves of 60-90 days. Even this age differential presents risk of disease spread, so cow-calf pairs should be managed in multiple groups based upon calving date. The "Sandhills Calving System" is a recent innovation in accomplishing this, which has proved effective in reducing many calfhood diseases. This system involves placing all cows in a single pasture prior to calving. At a set interval (often two weeks), cows that have not calved are moved to another pasture, while cows which have calved are left in the pasture in which they calved. This process is repeated at the determined interval, until the calving season has ended. The herd can be re-assembled when the youngest calf is 4 to 8 weeks old. This approach minimizes stocking density in general, and prevents the co-mingling of young, susceptible calves with older calves that are likely shedding disease organisms. In no case should young calves (<4 weeks) be grouped with calves more than 30 days older.

Pastures used for calving should be well drained and away from bottomlands, with no standing water (which tend to collect contaminants). Depending on prevailing weather conditions, wind breaks and/or shade may be desirable. However, these should be located such that they do not completely inhibit air flow, nor should they serve as a congregation point. Suggestions for total area available per cow range from 1000 to 2000 square feet; regardless of pasture size, this goal is quickly defeated if all animals spend the majority of their time in close proximity to one another for any reason (feed, shelter, shade, pest control, etc.).

Some producers choose to group cows into confined areas or even in enclosures during calving season to facilitate monitoring and assistance, when needed. If this is the calving method chosen, the cow and calf should be promptly removed from the calving environment and placed in a clean environment (preferably a pasture) as soon as the calf has bonded with the cow and consumed colostrum. Additionally, diligent cleaning is required of any confined areas between introductions of pregnant animals.

Regardless of how and where calving is done, heifers should be managed separately from cows. Heifers tend to have greater calving difficulty, lower quality and volume of colostrum, and weaker mothering instinct. Therefore, a general recommendation is to have heifers calve at the beginning of the calving season, preferably separate from the mature cow herd. This enables calves from heifers to be born into a minimally contaminated environment with maximum observation for dystocia, failure to nurse, and other problems.

Because weather has a tremendous impact on the environmental conditions, producers should consider the impact that severe weather may have, and adjust calving season accordingly. Wet, cold weather is the most common culprit in making calves succumbing to disease, because many organisms thrive in this environment. Additionally, calves suffer stress in such conditions, and cows may not be in optimum body condition to produce high-quality colostrum. If calving occurs during a wet time of the year, the herd should be moved from the normal feeding area approximately 1 month prior to the start of calving. This minimizes pathogen contamination, both in the environment and on the hair coat and udders of the cows.

In well managed herds, care needed for the nursing calf is usually minimal. However, potential BRM risks include introduction of foster calves or cows into the herd. Because of the susceptibility of the calf crop to novel pathogens introduced from an outside operation, this practice should be discouraged. If foster calves are introduced, they should be isolated from all animals except the foster mother for at least a month, and should not be retained for breeding purposes. A similar concern arises regarding the use of recipient animals for embryo transfer. In order to minimize dystocia and maximize pre-weaning growth of embryo transfer (ET) calves, it is common to use older cows with great milking ability as recipients. This has resulted in some operations using culled large-frame dairy cows for recipients. This poses a significant risk of disease introduction both to the embryo that she would carry, and to animals in the herd. Instead, optimum recipients would be chosen from within the herd, or at least from a herd with a known and comparable health status and BRM program. If the recipient is from an outside herd, she should undergo rigorous screening and quarantine procedures equal to or exceeding the standards for new introductions. Testing should also be done for diseases that are vertically transmitted.

Cow-calf operations must acquire both breeding females and males to replace animals that are culled. New introductions are discussed in a later section (page 18); this section will focus on operations that develop breeding animals from within the herd, particularly heifers. Because these animals will be entering the breeding herd, the methods employed to control disease during this phase will impact the health status of the herd for years to come. As always, the housing method will impact BRM efforts for replacements. For example, heifers may be kept in a dry lot, so that they can be fed a concentrate ration to ensure adequate growth. As mentioned previously, this has inherent risks and strengths. Another option involves the contract development of replacements. In this situation, the heifers are selected from the calf crop of the herd of origin, but are sent to an outside operation for growing and breeding. The heifers return to the herd of origin after breeding, or in some cases, just prior to calving. In BRM terms, the re-introduction of these animals is essentially equal to the purchase and introduction of new animals. Because the owner has not been in control of the environment, it is impossible to confirm that the animals were maintained in accordance with his or her BRM plan. However, some precautions can reduce the risk associated with this practice, such as ensuring that the heifers are not commingled with animals from another source, and are not exposed to an environment potentially contaminated from animals from another source.

Finally, in considering BRM in relation to life cycle, one should consider the separation of animals by age and production groups. It is generally conceded that pregnant animals are at greatest risk, in that many disease agents threaten not only the dam but also the in-utero calf. Stressed calves would seem to pose the greatest threat of multiplying and shedding many organisms, but this varies by disease. Additionally, young animals may be more susceptible to some diseases than are older animals. Therefore, intermingling of animals at different stages increases the risk to all populations. Each operation should establish an order of disease susceptibility for the populations on their farm. All herd work should then proceed from lowest risk-most susceptible populations to highest risk-greatest resistance populations. This would include the order of feeding (although it would be preferred to use different equipment for each group), and location of designated pastures, barns and facilities (most susceptible should be prevented from potential contact with manure lagoons, neighboring operations, isolation and treatment facilities, and other areas of high risk).

General Management: Weaning

The weaning period is one of the greatest periods of stress and disease that calves face. Appropriate vaccination can reduce disease occurrence in weaned calves, with the most effective method being to vaccinate the calves several weeks to months prior to weaning. However, due to the variation in the beef industry, the newly weaned calf may be the responsibility of a cow-calf producer, stocker/backgrounder, or feedlot. When stocker/backgrounders and feedlots purchase newly weaned calves, they often have no knowledge or reliable information about pre-weaning management. These buyers should consider requiring suppliers to verify health procedures are done according to the buyer’s wishes. Alternatively, they should work closely with their veterinarian to develop vaccination protocols that work best for them.

The environment in which weaning takes place greatly impacts the likelihood of disease. Weaning in a dry lot has advantages (controlled environment) and disadvantages (increased stocking density), as discussed previously. Pasture weaning offers many benefits, and is considered by many to be the best method of weaning. For stocker/backgrounder and feedlot buyers, the major question is whether to insist calves have been weaned and/or vaccinated prior to purchase. This minimizes the combined stresses of weaning, shipping, environmental change, etc. Another consideration is how many different sources of calves are used, and whether or not to co-mingle calves from multiple sources. In answering this, multiple sources must be considered in relation to the calf's experience; even calves owned by the same producer but kept on separate farms, pastures or locations should be considered to be from multiple sources because they have had different exposures and treatments. The preferred approach is to limit the number of sources, and not co-mingle. If co-mingling is required, it should be done at a single time, rather than continuing to add calves to a group. This limits continual exposure to new pathogens while also eliminating the stress of repeatedly establishing social dominance groups.

New Introductions & Animal Traffic

The most certain way to prevent introducing a new disease would be to maintain a "closed herd." That is not an option for feedlots and stocker/backgrounder operations. It would be nearly impossible in most commercial cow-calf operations, where at the least, new bulls are purchased on a regular basis. Understanding these limitations, producers should strive to limit animal traffic to the minimum amount necessary. All operations should avoid "cattle trading," and new introductions should be limited to the lowest frequency possible. Additionally, animal traffic must be understood to include animals that travel and then return to the herd as well as new introductions. Further precautions can reduce the risk when transport and return or new introductions are necessary. These are discussed in the Traffic section (page 37).

Cow-Calf: New Introductions

Expectations for BRM status should be very high for animals entering a breeding herd. A complete health history should be obtained, including known diseases and unexplained problems (abortions, stillbirths, etc.) for both the animal(s) purchased and the entire source herd. Sources of breeding animals should have a BRM plan in place comparable or superior to that of the destination farm.

There are inherent risks associated with purchasing animals of certain ages. This should be recognized and used to guide purchase decisions. For example, purchasing young animals has a greater risk of introducing calfhood diseases such as scours and respiratory disease. They are also more likely to suffer from a congenital infection. Animals that have mated previously are more likely to introduce reproductive diseases. Older animals are more likely to have contracted chronic or latent infections, particularly those that are not restricted to calfhood acquisition. For example, the most susceptible population for Johne's disease is young calves. Therefore, any animal purchased after weaning could already be infected. Other infections become more common with age, like BLV and Neopsora. Older animals are therefore more likely to introduce these into the herd. Susceptibility and/or clinical signs can also change with age. Older naïve animals introduced to an anaplasmosis endemic area are more likely to show clinical signs than are younger animals. Frequently, however, older animals have developed resistance to a disease and may not show clinical signs but could be a carrier. These issues should be considered when choosing what diseases to test for and what age of animals to purchase.

It is generally recommended that animals that are newly acquired be quarantined. The same policy should also apply to animals returning to the farm, whether they are returning from a weekend show or a 75 day bull test. The isolation facility should be capable of preventing contact with all other animals, from the herds of origin, destination, neighboring operations and wildlife. The isolation must protect from all of the potential routes of transmission, and receive the same BRM scrutiny as all other areas of the operation. Like all other facilities, the isolation area should be cleaned and disinfected between uses. Length of isolation will depend on the degree of risk considered acceptable, and the diseases of concern. A standard recommendation has been 21 days. This will allow adequate time for clinical signs to develop if the animal is incubating an acute infection. However, it does not eliminate the risk of chronic or latent infections that may not show symptoms for years, if ever.

When introducing animals, doing so in groups that can be housed, fed, and treated together helps minimize the costs and inconvenience of special handling. People are more apt to follow protocols for a whole group rather than one animal. Continual introductions to an established group result in social stress and repeated exposure to new pathogens.

Purchasers should vaccinate newly acquired animals, utilizing a program that matches the receiving herd to the greatest extent possible- always read and follow the recommendations of the vaccine manufacturer. Testing for diseases of interest should be considered as well. Many additional factors should be considered in this decision, including the risk of disease introduction by this animal, potential consequences associated with disease introduction, how the disease is transmitted, and whether there are other effective ways to manage or control the disease (vaccination or treatment, for example). Characteristics of the test should also be considered, such as sensitivity, specificity, cost, convenience and potential risks associated with testing, and time required obtaining meaningful results. Results must always be interpreted in light of other evidence. A positive test result should always be of concern and could justify additional testing (for more definitive diagnosis) or termination of the sale. A negative test result does not guarantee freedom from disease and should not be accepted as the sole determinant of risk. The clinical appearance of the animal, history, and status of the herd of origin must all be used to provide meaning to a negative test result, and limit the risk posed by a newly introduced animal.

When animals are taken off of the operation and then return (such as to shows, bull test stations, and ET facilities for embryo collection) they should be handled as a new introduction. Additional measures should also be taken during their time away to limit their risk of contracting a disease. This includes prohibiting sharing of trailers, stalls, feed or water with animals from other operations. Other items to consider include: halters and lead ropes, grooming supplies, feed and water containers, reproductive equipment (artificial vaginas for semen collection, AI guns, uterine pipettes, etc.), needles and syringes, among others. These items should either not be shared or properly cleaned and sterilized between animals. Diligent efforts should be made to prevent contamination of feed, water or the immediate environment by other animals. Direct contact with other animals should be minimized, and reproductive activity should be prohibited.

Stocker/Backgrounder & Feedlot: New Introductions

For stocker/backgrounder and feedlot operations, all animals in a given group should be purchased at approximately the same time. Continual introductions to an established group of animals result in social stress and repeated exposure to new pathogens. Purchases should be limited to a minimal number of sources, preferably with a known and trusted herd health program. It is not unreasonable to request records of vaccinations, illness and treatment of purchased calves. Risk categorization can assist producers to choose the level of risk they are willing to accept, and the level of biosecurity they are willing to pay for. Most authors have established risk levels that examine the source and background of the calves in the following manner:

- Highest risk: Livestock market- unknown history, commingled
- Medium risk: Livestock market- known history (Pre-conditioned sale, etc.)
- Lowest risk: Purchased on-farm from reputable source

Visitors & Human Foot Traffic

While animal traffic is the most significant problem, human traffic also poses a considerable disease risk. Vehicles compose a large portion of the threat presented by human travel, and will be discussed under Routes of Transmission: Fomites (page 33). This section will deal only with foot traffic. People walking through a farm may include hunters, hikers and neighboring property owners, in addition to the people who drive onto the farm. Everyone should be required to sign a visitor's log book, and should be instructed on what areas are acceptable or unacceptable for foot traffic. It is prudent to inquire about visitors' contact with animals on other operations, and ask those at high risk of transmitting disease to take additional precautions (shower in and change clothes or return at another time). Regardless, restricted areas should be delineated and animal contact should be limited.

Producers should also consider requiring all visitors to wear clean coveralls and overboots. Disposable overboots can be provided rather inexpensively (less than $1.00 per pair) and provide the added benefit of protecting visitors shoes from soil and manure. Alternatively, a bootbath may be installed at the main entrance with a requirement that all visitors disinfect their footwear. There are limitations to the effectiveness of this, however. All gross debris must be cleaned off first, and the disinfectant solution must be kept under appropriate conditions (proper temperature and concentration, free of organic debris, etc.) A bootbath that does not meet these conditions may in fact create a false sense of security while providing little or no protection.

Herd Health Protocols

Arguably, the greatest impact on herd BRM is determined by the measures directly taken to prevent and treat disease. The first step is to develop a standard written herd health protocol. These can build upon industry-wide quality assurance programs, which establish basic standards of animal handling, and outline the need for animal identification, record keeping, appropriate drug withdrawal, etc. However, herd health protocols must go further, and in greater depth to define goals and outline specific means of ensuring the objectives are achieved. This should include standard operating procedures (SOPs) for:

- Identifying, examining, separating and treating sick animals
- Disposing of dead stock
- Administration of routine health procedures and schedules (vaccinations, castration, etc.)
- General husbandry procedures.

It is imperative to realize that herd health protocols do not merely mean an established vaccination program. Vaccines are available for many diseases, but these do not eliminate the need for proper BRM measures. Rather, they can serve as adjunctive measures to complement a comprehensive BRM plan. Immunity conferred by any vaccine can be overcome by an overwhelming challenge. Thus, one of the principle goals of BRM is to limit the exposure to disease agents, such that a robust immune system can overcome the pathogen.

General husbandry issues include the proper handling and use of biologicals and other products. It is imperative that records be kept so that proper withdrawal times can be observed and use is properly restricted. For maximum efficacy, vaccines should always be stored, handled and administered according to label directions. Prudent antimicrobial practices should be followed to limit the development of resistance among pathogens. Appropriate guidelines for antimicrobial use can be obtained from numerous sources, including American Veterinary Medical Association (www.avma.org), American Association of Bovine Practitioners (www.aabp.org), American Academy of Veterinary Consultants (www.avc-beef.org) and Food Animal Residue Avoidance Databank (www.farad.org).

In order to detect a disease early and prevent its spread, a producer must frequently observe animals for signs of disease, and promptly separate unhealthy animals. While it would be ideal to have a separate isolation facility for each production group and disease, this is usually not feasible. Thus calves with pneumonia may be kept with calves with footrot. This should be limited to the greatest extent possible, and should seek to avoid commingling animals from different age groups; older calves with pneumonia should not be kept with scouring baby calves, and sick calves should not be kept with sick cows. The duration of isolation will depend on the disease, the operation and the animals at risk. For feedlots, separation of calves with respiratory disease is usually only for the duration of clinical signs. This is generally considered acceptable because the disease pathogens are ubiquitous, and return to home pen becomes more stressful the longer a calf is isolated. For calves with scours, it has been recommended to keep them separated for at least three weeks. Because it is common for animals to remain infectious after clinical signs end, optimal isolation would continue for at least a week after clinical signs terminate.

The ability to effectively isolate sick animals will be greatly impacted by the quality, location and management of treatment and isolation facilities. Preferably, treatment areas for sick animals should not be used for processing of healthy animals; at the very least, thorough cleaning and disinfection should be done after use for ill animals. Additionally, all treatment items (syringes, needles, rectal sleeves, etc.) should be thoroughly disinfected or properly disposed of after use. Producers, veterinarians, employees and anyone else interacting with the animals should be certain to limit the potential of spreading disease from affected to susceptible animals. This involves always treating, feeding, or handling the most susceptible animals first and sick animals last, while taking appropriate disinfection precautions between groups. When diagnosis is uncertain or a disease of severe consequence is suspected (Foreign Animal Disease), producers should recognize the importance of stopping animal movement and having a veterinarian examine affected animals, perform necropsies, and collect and submit proper diagnostic samples.

Finally, appropriate protocols must be developed for handling dead stock, as this presents a very real threat of disease spread and a serious challenge to producers. There are many different ways for disposal of carcasses, and no one preferred way for all producers. Rendering services, where available, are probably the easiest and most cost effective method. However, producers should limit access of rendering vehicles to the farm, as they pose a risk for introducing new disease. Therefore, dead animals should be taken to a pre-determined location for pick-up, preferably at the perimeter of the farm. Other methods include burial, burning and composting. Each presents challenges, and producers should confirm what methods are deemed suitable by state and local regulations (some state regulations can be found at: www.biosecurity.org/carcass.htm). If burying, one must ensure that an adequate depth is achieved, and it is far enough away from water sources to prevent ground and surface water contamination. Burning requires adequate fuel to achieve proper temperature to not only reduce the carcass but also destroy pathogens. One should also consider the negative effects, such as environmental pollution (particularly if a petroleum based fuel is used), destruction of growth in the area where the burning is done, and disposal of ashes. Composting requires sufficient and continuing supply of substrate, as well as significant labor input to ensure complete digestion of the carcass. Moreover, an ultimate disposal method of the finished product is needed. One method that should not be considered acceptable is leaving carcasses for scavenging. Such a practice presents a tremendous risk of disease spread on the farm, amongst wildlife and onto neighboring operations. It also contributes to a negative public perception of the agriculture community.

Once the general management program has been reviewed, more specific recommendations can be made to limit disease transmission based upon routes of transmission.

Routes of Transmission: Aerosol

Aerosol transmission occurs when pathogenic agents contained in aerosol droplets are passed from one animal to another, or from animal-to-human. The ability of pathogens to survive and be transmitted in the air varies by organism. However, pathogen concentration in the air decreases exponentially with distance; thus doubling the distance between a carrier and a susceptible animal decreases concentration approximately ten times. In this regard, many control methods are shared with the direct contact route- exposure to wildlife, animals from other operations, and new introductions should all be minimized.

Appropriate ventilation is extremely important in reducing airborne disease transmission. Most beef animals spend very little time in an indoor environment, where assisted ventilation is provided or required. However, the importance of air movement and exchange should not be overlooked when constructing shelters used for calving, housing sick animals, or other purposes. Housing of animals in air tight structures does more harm than good, under most normal management conditions.

Stocking density is very important in determining aerosol spread within a population. This is particularly important when animals are in a confined environment, such as at a feedbunk, waterer, or in a holding pen. Excitement and stress of animals play a role in aerosol transmission in these situations as well. Increased activity in a confined space creates dust and raises the respiratory rate of the animals, leading to more coughing, increased respiratory effort, and decreased efficacy of clearance mechanisms. These increase the airborne pathogen load shed by infected animals, and the amount inhaled and transported to deep lung tissue by susceptible animals. The discussion on stocking density (page 14) should be reviewed in consideration of these issues.

Routes of Transmission: Oral

Oral transmission involves the consumption of pathogenic agents in contaminated feed, water or licking/chewing on contaminated environmental objects. This section will focus on **Feed** (page 26), **Water** (page29) and **Waste & Manure Management** (page 30). Other sources of oral transmission are discussed in the **Routes of Transmission: Fomites section** (page 33).

General: Feed

All consumed products should be evaluated for their risk of introducing and/or transmitting disease. This includes harvested feeds (hay and grain), mineral mixes, and other supplements. Are some feed stuffs purchased or are all raised on the farm? Those raised on the farm should meet standards similar to those for pasture (discussed below). Feeds purchased from other sources should be accompanied by an acceptable quality assurance program and documentation. This should verify that reasonable measures have been taken to protect the feed from contamination with potential disease-causing material, including ruminant derived protein.

The best feed can become a threat if not handled and stored correctly. While it is impossible to exclude wildlife from a pasture, every effort should be made to prevent access of animals to stored feed and feeding areas. Birds and vermin are quite effective at transmitting disease and are common in feed storage areas. Producers should recognize that even domestic animals pose risks because dogs, cats, goats, sheep and horses can all introduce disease to cattle by contaminating feed with urine, feces or other body fluids.

For certain feedstuffs, like silage and grain, proper handling also means protection from weather (to prevent spoilage and mycotoxin development), as well as special efforts in ensiling and/or processing to ensure appropriate conditions (freedom from oxygen, pH, etc.) are achieved to protect the feed. Spilled feeds should be frequently cleaned up and disposed of, particularly adjacent to storage or feeding areas. Spilled feed attracts wildlife, fosters spoilage, and serves as breeding ground for pests. In most cases, stored feeds should be used in a first-in-first-out manner, and new feed should not be added to or poured on top of older feed.

Similar diligence is needed in utilizing the feed. For silage stored in trenches, the face must be maintained appropriately by removing an adequate amount each day to prevent spoilage (this is generally recommended to be 6-12 inches off of the entire face each day; however, this will vary with weather conditions). For grains and other feeds, feeding in troughs rather than on the ground may reduce exposure to pathogens. However, troughs often present an opportunity for pathogens to be shared by having animals eat from the same surface repeatedly. If this surface is soiled with feces, urine, nasal discharge or even saliva, it can serve as a fomite. Therefore troughs should be cleaned frequently enough to remove all visible gross debris, and should be disinfected if they are to be used for a different group. Concrete bunks can deteriorate over time; cracks and holes serve as an incubator of organisms if they get packed with feed and moisture. Things such as plastic bunk liners, polyethylene coating, and ceramic tiles can be used to keep the surface smooth. At no time should anyone walk through feed, as feces, urine and soil from footwear can contaminate the feed. Gates or people-passes (walkthroughs) should be used so that personnel are able to enter the pen without climbing through the feed bunk or over fences.

In feedlot and stocker operations, it is often intended that feed be available throughout the day. Therefore a large amount of feed is delivered once or twice a day. It is important in these situations to ensure all feed is removed or eaten before introducing new feed. Piling new feed on top of old presents an ideal environment for proliferation of spoilage and disease organisms. Accumulation of old feed also serves as a breeding ground for flies and other pests which can spread disease (discussed more in **Routes of Transmission: Vector** section- page 39).

Cow-Calf: Feed

The first feedstuff consumed by a calf should be colostrum. Milk and colostrum are very effective means of transmitting disease organisms from dam to calf and from the environment to calf (via soiled or fecal-contaminated teats and udder). One might consider the optimum biosecurity program would include testing cows for diseases of concern (Johne's and BLV among others), and only using colostrum from test negative animals. In a beef situation, this is rarely practical. Therefore single source, dam to calf colostrum is generally considered the preferred method. An alternative source is sometimes required when a dam is agalactic, has severe mastitis in multiple quarters, or is otherwise unable to provide an adequate source of colostrum for her calf. In this case, colostrum should be provided from an older, healthy cow from the same herd. Colostrum from such animals should be collected early in the calving season, and can be frozen for up to one year without significant deterioration in quality. A less desirable alternative would be the acquisition of colostrum from a single animal from another herd, preferably one with a known and comparable BRM program. The source of last resort would be colostrum collected and pooled from multiple cows from another operation.

Disease transmission through nursing remains possible until the calf is weaned. It can be minimized by keeping the herd in a relatively clean environment, such that the teats and udder are not heavily contaminated with mud, manure and other organic debris.

Cow-Calf & Stocker/Backgrounder: Feed

Feeding practices can greatly impact disease transmission via virtually all routes, but oral transmission is the greatest risk. Any situation where animals frequently congregate in a relatively small area increases stocking density and environmental pathogen load. Winter feeding is often the greatest challenge with precipitation resulting in very wet and muddy conditions around the feeders. Additionally, feed may serve to draw other animals, including wildlife, into the same area. These effects can be minimized by:

- Dispersing feed (roll out large round bales and use multiple feeders for concentrates)
    - Feed amount that can be consumed in timely manner to avoid animals laying or soiling on hay
- Moving feeding areas frequently
- Minimizing the number of animals per area
- Scraping mud and manure from feeding areas frequently
    - Concrete aprons facilitate this, but are only beneficial if appropriately maintained. Cracks and holes collect organic matter and serve as a harbor for pathogens
- Providing good drainage from feeding areas

Intensive or rotational grazing has become a popular method of maximizing forage utilization. It has many advantages, but also produces increased stocking density and the potential for contamination of the environment. This poses the greatest risk for pathogens that may survive the rest period provided to the pastures between grazing periods (these would include intestinal parasites, spore forming bacteria like anthrax, and Mycobacterium avium, subspecies paratuberculosis, among others).

Numerous other pasture management issues should also be considered. Do animals of different production stages use the same pasture at different times or are pastures restricted to repeated use by only a specific group? For example, if replacement heifers are kept in a pasture previously used for mature cows, they may be exposed to persistent organisms shed by non-clinical animals. Similar threats exist in the use of organic fertilizer. These will be discussed in the **Manure & Waste Management** section (page 30).

Various pasture management practices may introduce the possibility of interaction with other species. It has been recognized that forage use is more efficient when cattle and sheep are grazed together. However, some diseases can affect both species, and therefore a certain degree of risk is created by housing these animals together (Johne's, brucellosis, Q-fever, and others). Similar concerns exist for numerous species, including swine (psuedorabies, Foot and Mouth), horses (brucellosis), as well as wildlife (tuberculosis, brucellosis, leptospirosis, and many others). Even dogs and other carnivores pose a risk of introducing Neospora to a herd. The risk created in these situations may not be enough to warrant elimination of these practices, but they should be recognized and considered in making management decisions.

Water

Water sources are another risk factor for oral transmission. Water may be derived from natural sources (ponds and streams) or specifically designated sources (troughs). Natural sources are often used because of convenience and reduced expense. Generally speaking, troughs are preferable because of the increased ability to control quality and contamination. There is wide variation in types of troughs used, which impacts the measures necessary to properly clean and maintain the water supply. Regardless, troughs should be examined and cleaned regularly. All organic debris (manure, feed, leaves and other plant material) should be removed frequently, as this provides a source and sustenance for many pathogens. Measures should be taken to minimize animals standing or defecating in the trough, while still allowing access to water.

The source of the water for the trough should also be examined regularly. If the trough is served from a surface water source (creek, pond or cistern), the animals are at risk from contamination by wildlife and other livestock operations (leptospirosis, among other diseases) and other natural threats (blue-green algae, for example). The source should be protected as much as possible and monitored for problems. Deep wells and municipal sources afford greater protection from potential contamination. Nevertheless, producers should consider doing occasional cultures for coliform bacteria to assess the quality of the water source.

If cattle drink directly from ponds, producers should consider fencing the pond off and providing limited access. This access area can be protected by concrete or large rock to prevent soil erosion into the pond, and limit runoff into the water. By preventing animals from entering the pond, fecal and urine contamination is greatly reduced. Similar measures can be taken to prevent contaminating streams, although it may be harder due to the length of the stream. Streams pose an additional disease threat due to potential contamination from upstream, although running water is generally less contaminated than stationary because of the potential for dilution.

Manure & Waste Management

Because many of the diseases contracted through the oral route originate from fecal contamination, waste management is vitally important in controlling these pathogens. The survival of pathogens within manure depends on a variety of factors including sunlight, drying, freezing/thawing cycles, temperature, pH, exposure to oxygen, ammonia concentration, types of pathogen present, and the adsorption of the pathogen to soil. Practically speaking, the risk of spreading disease is lowered by exposing the waste material to environmental conditions. The most important means of accomplishing this is to adequately disperse the material. Dragging pastures to break up and disperse fecal pats is an effective practice for natural fecal deposition. But adequate time should be permitted between distributing the manure and returning animals to pasture. Avoidance of overgrazing also reduces exposure to pathogens found in feces, by not forcing animals to graze close to the ground and near to fecal pats.

If manure deposition is quicker than biodegradation, additional measures are required. Where accumulation occurs, waste should be removed on a frequent basis. The required frequency will vary with weather conditions, size of pen, stocking density, etc., but the more frequent, the better. It should then be used as fertilizer on low risk applications (discussed below) or transported to a designated storage or disposal area, out of contact with animals. If waste and runoff is to be stored, it should be kept in a well constructed lagoon, with adequate capacity to handle large precipitation without overflow. All manure handling should be done with designated equipment. This equipment should not be used for other purposes, such as feed delivery, crop handling, etc.

For larger operations, requirements for waste handling are determined by state or federal environmental regulations. These regulate when and where waste can be spread to minimize environmental impact, as well as storage and transportation. Our focus is only on possible disease transmission; local, state and federal regulations will provide more specific guidelines, and should be understood and followed.

Composting or deep-stacking manure permits use of nutrients with minimal BRM concerns. Advantages include a great reduction in volume and water content, and a significant reduction in pathogen levels. Disadvantages include the time required for completion of the process, the equipment and labor demands, and loss of nutrients. If waste is not composted, producers should be cautious in what locations and at what times manure is applied.

If non-composted manure is to be used, cropland provides minimal risk of sustaining pathogens if the waste is applied early in the growing season. However, for some persistent pathogens like Mycobacterium avium subspecies paratuberculosis, as well as protozoal oocysts and helminth eggs, a single growing season is not sufficient to eliminate infectivity. Pastures are more of a risk, because there is no further processing to kill the organisms (like fermenting silage, drying hay, etc.). The safest recommendation would be to not spread manure on pastures in which susceptible animals would be placed. Similar or even greater caution should be exercised in accepting manure or organic waste from another source. Even manure from other species can carry some risk, such as poultry litter which can introduce Clostridium botulinum, and potentially Salmonella if not stored and handled appropriately. Producers must recognize that they may be unwittingly permitting exposure of their animals to waste from other farms by streams and waterways or direct runoff. Such exposure may be transient (such as following a hard rain), but no less significant. A thorough examination of the operation's perimeter is required to assess where such points of access may occur and how they can be controlled.

In addition to direct contamination, fecal-oral transmission can occur through many indirect methods. Any item that could potentially contact fecal material poses a risk. These are termed fomites, and will be discussed in the **Routes of Transmission: Fomites** section (page 33).

Routes of Transmission: Direct Contact

Direct contact transmission requires the presence of an agent or organism in the environment or within an infected animal. A susceptible animal becomes exposed when the agent directly touches open wounds, mucous membranes, or the skin through blood, saliva, nose to nose contact, rubbing, or biting. Diseases caused by direct contact can be controlled more easily than many other diseases. One of the most important efforts to reduce transmission via direct contact is the isolation and prompt treatment of affected animals. As mentioned previously, it would be preferable to have a dedicated facility for care of sick animals. Regardless, the facility should be cleaned and disinfected after housing sick animals, particularly if the animals suffered from an agent that persists in the environment.

Unfortunately, not all infected animals show signs of disease. In order to minimize transmission from these carriers, fence line contact should be limited, both to animals from other operations (neighboring farms) and to animals from different production groups on the same operation. Additionally, stocking density should be kept at the lowest acceptable level, and congregation of animals minimized.

Fomites play a major role in transmission of direct-contact diseases. It is imperative that producers recognize that virtually anything that contacts an infected animal then a susceptible animal can transmit infection. As the **Routes of Transmission: Fomites** section (page 33) is reviewed, consideration should be given to direct contact diseases.

Reproductive

The main risk associated with reproductive transmission is the new introduction of breeding animals. However, this topic was previously covered in the **New Introductions & Animal Traffic** section (page 18). This section will focus on diseases transmitted through reproductive activity or in-utero, two forms of direct contact.

Artificial insemination (AI) can greatly reduce or eliminate venereal diseases, assuming that semen is obtained from a reputable source and the bull(s) has been tested for diseases of concern. It is imperative that appropriate technique is used to prevent transmitting disease via a contaminated AI rod, OB sleeve or other materials. Similar precautions should be taken when collecting and transferring embryos.

If bulls are used, they should be purchased as young, virgin animals and only used within the herd (not as part of a multi-user lease or community pasture situation). Bulls should undergo a breeding soundness exam to assess potential infection of the testes or accessory sex organs. The penis should be extended and examined for penile warts or injury. Owners should also consider testing bulls for reproductive diseases if a low conception rate is achieved or if a disease is diagnosed in the group of animals the bull serviced.

Vertical or in-utero transmission often involves a chronically infected dam; however, it may also relate to exposure of the dam during a critical stage of gestation. Test and cull strategies should be considered for certain vertically transmitted diseases. While whole-herd testing may be cost prohibitive, producers should be encouraged to test suspect animals, such as repeat or "hard" breeders, cows that show erratic estrous cycles, and animals that abort. Testing the dam and offspring of cows that are diagnosed with a disease that can be transmitted vertically (BLV, BVD, and Neospora among others) should also be considered. This demands maintenance of complete and current records to facilitate identifying dams and offspring of affected animals.

Additional control measures relate to protection of the dam at critical stages of pregnancy. This varies by pathogen and generally necessitates the treatment of pregnant animals as the most susceptible population on cow-calf operations.

Routes of transmission: Fomites

Fomite transmission requires an inanimate object to carry a pathogen from one susceptible animal to another. Often, humans play the principle role in facilitating this exposure. Virtually any object can serve as a fomite, and many can harbor and introduce diseases classified in one of the other transmission routes (oral or aerosol for example). Therefore, in order to have a successful BRM plan for the other routes of transmission, it is vitally important that all potential fomites be recognized and handled appropriately.

One of the most important means of controlling fomite transmission is appropriate recognition and separation of diseased animals. Subsequently, ill animals should be handled and treated only after all healthy animals have been processed. More specifically, the order of interaction should follow the protocol of lowest risk-most susceptible to highest risk-greatest resistance populations as previously discussed. Additionally, the preferred option would be to have dedicated equipment, facilities and devices for treatment. This may not be feasible in some circumstances, and careful disinfection can accomplish similar results. In other situations, items may need to be disposed of properly rather than re-used.

While clinically diseased animals pose the greatest risk, objects that could potentially become contaminated with blood, saliva or nasal secretions, urine, feces, or come in contact with skin or tissues of other animals must be considered fomites, as well. Oral transmission may occur via fomites such as oral speculums, stomach pumps, and drench and balling guns; or by items that the animal may lick, chew or swallow including buckets, mineral feeders, and discarded OB sleeves and feed bags. Direct-contact fomites readily identified would include halters and grooming supplies, but there are many others.

On-farm vehicles, tractors and implements, four wheelers and other machinery pose multiple risks as fomites. Often these are used in several settings within an operation. Thus they can transport infectious material from one group of animals to another, or deposit it in the environment or on feed or water to be disseminated to other animals. Additionally, because cattle are curious animals it is quite common for them to smell, lick and rub against these items, particularly if other animals have done so previously. To reduce this risk, vehicles should be restricted to designated areas as much as possible, kept as clean as is practical, and kept from contact with animals to the greatest extent reasonable. While it would be preferable to have dedicated equipment for each task, this often is not possible. Nevertheless, it is essential that separate equipment be used for handling manure and feed. Finally, producers should avoid contaminating feed and water by running over or through it with any type of equipment.

Even immovable objects present a potential for spreading disease, when animals from different groups are brought into contact with them. Examples would include fences, gates, panels, buildings and trees. For this reason, it is best to designate areas for each group of animals, and limit access of multiple groups of animals to any given area.

Humans can also serve as fomites. This is most commonly the result of contaminated clothing, shoes or skin. Efforts to limit humans acting as fomites should include basic hygienic standards, including washing hands frequently and wearing clean clothing and boots when working with animals. Additional measures may be necessary after exposure to a high risk environment (working with sick animals), such as showering and changing clothes or even avoiding contact with animals after being in very high risk situations (such as foreign travel). For certain zoonotic diseases, humans can actually shed the organism into the environment. While this does not fit the strict definition of fomite, it nevertheless requires that people follow proper BRM protocols.

The risk associated with exposure to fomites can be separated by the risk level of the situation from which they are derived. For example, any object that has been potentially exposed to a location with a large number of animals of unknown health status, and from a wide variety of sources should be considered a **high risk**. Such locations would include livestock auctions, slaughter plants, feedlots and other points of animal concentration, even veterinary clinics.

Medium risk locations may consist of shows and exhibits, other farms or operations, and areas that congregate healthy animals from a single or limited number of sources. Items from these areas still have a significant risk of transmitting disease, but may pose less of a threat because the animals have a lower likelihood of being overtly ill and shedding high numbers of pathogens. **Low risk** situations could include interstate travel without contact with other animals. Items from these areas still pose a risk of contacting and carrying an organism, but it is much lower than in previously described conditions.

It should be understood that this classification scheme is arbitrary and in no way complete. It is intended to stimulate thought about what items may have contact with animals, and what the risks would be of that contact. It is also not to suggest that stern restrictions should be put in place to prevent use of some things while ignoring others, simply based on this classification scheme. But there should be standard operating procedures that inform employees, visitors, vendors and service personnel (including veterinarians) what measures the owner considers necessary to limit risk of introducing or spreading disease on the operation.

Examples of SOPs that should apply to all operations include:

- Expectation of use for disposable items- No disposable items that were used on other operations should be re-used on a different farm;
- Sterilization/disinfection of re-usable equipment- Equipment should be cleaned and disinfected between uses at different operations;

- Use of personal protective equipment- Personnel who have been in contact with animals at another location should change clothes or put on clean coveralls. Shoes or boots should be changed or disinfected, or disposable covers used.

Specific SOPs that will vary between operations would include:

- Expectation of use for disposable items- For animals on the same operation, are needles, OB and rectal sleeves used on multiple animals or become single use?
- Sterilization/disinfection of re-usable equipment- Does owner want dehorners disinfected between calves?
- Use of personal protective equipment- Are employees required to change coveralls and disinfect footwear between groups of animals?
- Sanitation requirements- Are employees and visitors required to use a bootbath prior to entering the premise; are vehicles cleaned and sanitized prior to entry?

Iatrogenic

Iatrogenic transmission is the unintentional transmission of disease by a human using a contaminated item. Fomites play a major role in transmission of iatrogenically induced diseases. The **Routes of Transmission: Fomites** section (page 33) above should be reviewed and considered in relation to iatrogenic transmission of diseases.

Use of products from a multi-dose source can present a risk of iatrogenic spread of disease. Producers should use aseptic technique in drawing medication from multi-dose bottles. Even antibiotics can support growth of some organisms, and serious complications can result when contaminated products are administered parenterally. The most effective way to eliminate this risk is to use a new needle and syringe every time an injection has to be given. This adds expense but decreases disease risk, so the cost/benefit needs to be evaluated for each operation. Another suggestion is to have a "bottle specific" needle that remains in the rubber seal of a product. Then a clean syringe can be attached to it and the appropriate dose obtained. To administer it to an animal, remove only the syringe with the product and attach a new needle for injection.

The presence of carrier animals in the herd presents an ongoing threat to iatrogenic spread. A well designed and carefully implemented BRM plan can eliminate virtually all risk of iatrogenic transmission. However, some producers are reluctant to commit to some of the more tedious and expensive components of such a plan, including a separate needle for each animal, and disinfection of some equipment between each animal. In these situations, it may be advisable to test for diseases of interest and treat or cull carrier animal(s). Alternatively, physically separating them, and working with susceptible animals as a separate group has shown some success in limiting spread of certain diseases.

Traffic

Unique and specific risks are presented by vehicle traffic movement on a farm. The discussion in the **Routes of Transmission: Fomites** (page 33) section dealt principally with traffic within the farm, from one group of animals or one area to another. This section will discuss the risks associated with traffic bringing diseases onto the farm.

Vehicles present a tremendous opportunity for transporting many organisms and efficiently delivering them to susceptible animals in a short time. The first step in controlling the threats posed by vehicle traffic is to understand who brings vehicles onto the operation, what vehicles, where have they been, where (on the farm) they go, why, and how often. This scrutiny should be applied equally to all people, including farm owners and family members, employees, buyers, veterinarians, renderers, delivery and service vehicles and visitors. It should also examine all vehicle types, from cars and trucks to tractors and other equipment, trailers, portable chutes and any other mobile object that is brought on the property. An effective means of doing this is to create a visitors log, where everyone is required to sign in and provide the above information. Additionally, all visitors should be requested to contact the operator ahead of their arrival, and make arrangements to have someone meet them at the appropriate time. This limits the need for people to wander around the farm, searching for an office or personnel. It also makes it easier to identify uninvited or unapproved people who may pose a threat to livestock health. Standard operating procedures and posted signage should also be made available so people follow proper protocols on the facility to minimize disease spread.

The simplest and most effective vehicle control measure is to have a designated parking area on the perimeter of the farm, and request that all visitors be restricted to use of farm-owned vehicles. This is not always possible, as in the case of feed deliveries, veterinarians, and equipment service personnel. In these cases, the "target" may best be brought to them. This could include having a limited access area (again on the perimeter of the property), where equipment can be left for servicing, dead stock can be taken for pick-up (preferably out of sight from main roadways and neighboring properties), and so forth. In some situations, access of certain vehicles cannot be adequately restricted. If visitors are required to drive onto the facility, ensure their drive path does not have direct animal contact. Feed deliveries are likely the most common example where the storage facilities cannot reasonably be relocated and the travel path of delivery coincides with that used by on-farm equipment to deliver feed to animals. Such deliveries should be made as infrequently as possible. The farm may request to be the first delivery of the day but this may not be practical or acceptable for the feed company. In this case, a wheel wash facility should be strongly considered.

Similar to parking, animal delivery/load out facilities should be placed in a designated area, on the perimeter of the farm. All transport trucks and trailers should be cleaned regularly, preferably after each use. Cleaning should include the outside and undercarriage as well as the interior of the trailer. Parking and load-out areas should be well maintained, with gravel, asphalt or concrete surfaces. Adequate drainage away from the farm should be provided to ensure contamination is kept away from animal areas. Additional precautions can also be taken, such as providing a wash-down facility and/or a tire washing area with a disinfectant.

Implementation of some of these ideas may be beyond the commitment most producers are willing to make. Potential or perceived obstacles, including facility redesign, new construction, and perceived inconvenience to visitors may discourage many producers. However, for some high traffic- high risk operations, or for producers with extremely valuable genetics, all of these options should be considered. Furthermore, cost and convenience should never serve as an excuse to compromise the BRM plan of an operation. No one should be permitted to drive a soiled vehicle into an animal area. It is not unreasonable to request visitors maintain a reasonably sanitary vehicle or park off of the farm. Similarly it is not unreasonable to insist that visitors do not drive through areas of concern, such as feed areas, water sources, calving pastures and such.

Routes of Transmission: Vector

Vector transmission occurs when an insect acquires a pathogen from one animal and transmits it to another. Diseases can be transmitted by vectors either mechanically or biologically. Mechanical transmission means that the disease agent does not replicate or develop in/on the vector; it is simply transported by the vector from one animal to another. The vector may obtain the disease agent from the animal (nasal and ocular secretions, for example), or from the environment (contaminated feces, feed, etc.). Biological transmission occurs when the vector uptakes the agent, usually through a blood meal from an infected animal, replicates and/or develops it, and then regurgitates the pathogen onto or injects it into a susceptible animal. Moraxella bovis, the causative agent for pinkeye, can be transmitted mechanically by flies. Ticks can serve as biological vectors of anaplasmosis and babesiosis to susceptible cattle.

Regardless of whether transmission is mechanical or biological, the most effective means to prevent transmission is the elimination of the insect, or at least separation of vector from host. Chemical control is a mainstay in insect control, but is invariably ineffective as a sole measure. An integrated approach is best, with efforts directed at eliminating the vectors, reducing their breeding areas, and limiting contact/exposure of cattle.

Eliminating the Vector

Means of killing insects include direct treatment of cattle (with pour-ons, ear tags, or face rubs), spraying premises with insecticides, and biological control (such as parasitic wasps which feed on fly larvae, or birds which eat insects, such as chickens and guineas). Direct treatment of cattle can be effective, but often has a short-lived duration and resistance is becoming a more common problem. Premise spraying is effective, but inefficient, and should only be used where a discrete area is identified as a problem, but cannot be eliminated. Biologic control can be very effective, but may require repeated introduction of the control organism. Chemical control methods directed at the target insect may also have a negative effect on control organism, either directly (the insecticide kills the parasitic wasp, for example) or indirectly (the insecticide kills the pest, then the pest is eaten by a bird and the bird accumulates the insecticide). Therefore it is very important that these be implemented in a well planned and coordinated manner.

If chemical components are used, it is imperative that the manufacturer's instructions be followed closely. Inappropriate use can present a hazard to the animals and/or environment, can greatly reduce efficacy (using a water based product just prior to rain), and lead to insect resistance (not removing impregnated ear tags when their efficacy is reduced).

Breeding Area Control

Reduction of insect breeding ground occasionally requires specific knowledge about the vector of interest, due to the unique lifecycles of some insects. However, most common pests can be controlled by two main measures:

- Elimination of wet, muddy areas, and
- Elimination of decaying organic matter

Wet areas may occur around watering troughs, or in shaded areas where animals spend a great deal of time, as well as areas not directly associated with cattle (under air conditioner units, in old tires, etc.). Measures to control these include limiting animal congregation areas, frequent cleaning around troughs, draining or fencing off shallow ponds and marshes, and elimination of standing water from various sources.

Decaying organic matter may include spoiled feed, soiled bedding, open manure piles, etc. Prompt elimination of these materials limits the ability of insects to reproduce and feed on them. Dragging pastures to disperse fecal pats also inhibits reproduction of many insects. A similar approach involves the use of insect growth regulators in feed, which prevents maturation of insect eggs laid in fecal pats. This practice can also be detrimental to other insect species as well, including some considered favorable.

Separating Host/Vector

Separation of host and vector is needed when a specific region is heavily contaminated with insects and premise treatment is not practical. This may be necessary to prevent exposure to marshes which breed mosquitoes, streams where black flies reproduce, wooded areas heavily infested with ticks, and such. In these cases, the most effective measure may be to fence off access to these regions during principle insect seasons.

In some cases, the presence of carrier animals in the herd presents an ongoing threat to further spread by vectors, regardless of how effectively control is implemented. In these situations, it may be advisable to test for the various diseases of interest and treat or cull carrier animal(s). Alternatively, physically separating them from susceptible animals has shown some success in limiting spread of certain diseases (BLV, for example). Vaccination of susceptible animals can also be practiced for some diseases, but this is generally considered a minor adjunctive measure.

Preventing Zoonotic Disease Transmission

Zoonotic transmission occurs when diseases are transmitted from animals to humans. Human exposure will actually occur through one of the other five routes of transmission, but because of its importance it is addressed as a separate route of transmission. There are numerous diseases that beef cattle can transmit to humans. The risk of this occurring is greatest for certain at-risk individuals, including: children under the age of five, pregnant women, the elderly, and immune compromised individuals. While the most profound immune suppression is caused by HIV/AIDS, other diseases and conditions that can compromise the immune system include bone marrow or organ transplants, radiation, chemotherapy or chronic corticosteroid therapy, chronic renal failure, or implanted medical devices. Persons with diabetes, alcoholism with liver cirrhosis, malnutrition or autoimmune diseases, splenectomy patients, and those on long-term dialysis also have compromised immune systems. It is important to note that some of these conditions may have a social stigma, making it difficult for a client to share their personal health information. This makes it vital for veterinarians to educate their clients about zoonotic diseases.

The 2002 Census of Agriculture reported the average age of today's farmer is 55.3 years, with over 25% of farmers older than 65. While there is no physiological definition of when a person "older" or "elderly," it is known that the immune system does not function as efficiently in older adults as it does in younger people. Illness may be more difficult to fight in this population, making prevention even more important. There are many zoonotic diseases associated with cattle that older farmers should be aware of. Diseases such as brucellosis, salmonellosis, Q fever, E. coli, cryptosporidiosis, leptospirosis, ringworm, and rabies are all diseases that cattle could pass to humans. There are ways to prevent such infections, such as wearing personal protective equipment (gloves, masks, rectal sleeves, coveralls, boots and others) in situations that may predispose them to exposure. Calvings, abortions, artificial insemination, passing esophageal tubes or balling gloves, necropsies, and handling vaccines or antimicrobials are all situations that may expose producers to disease agents, and therefore warrant protection.

Children are the future of farming and are a part of many beef operations in the United States. Children under the age of five have naïve immune systems, which makes them more susceptible to infectious disease. Children on beef operations often participate in caring for calves, either because the calf is orphaned or as an FFA or 4-H project. They may also assist during calvings, when sick animals are treated, or at routine herd working. However, these situations may pose risks of disease if proper precautions are not taken. Children should be taught proper hygiene:

- Wash hands after handling animals
- Wear gloves when possible
- Never eat or play around a contaminated environment
- Wear designated clothing for chores and change after animal handling

Over time, children's immunity to many pathogens will build up, but some will always remain a zoonotic threat. Thus older children and adults should remain diligent in protecting themselves.

Another consideration on today's beef operations, particularly feedlots, is the immigrant worker. These workers often come from countries with a high prevalence of diseases that can result in compromised immune systems. These in turn could predispose them to infection with a zoonotic disease. The communication barrier may increase their risk of exposure, so working with knowledgeable translators and ensuring proper medical care will keep this at risk population safe and continue their employment on the farm.

Studies show that veterinarians are the most knowledgeable and the expected purveyors of information on zoonotic disease. Studies also show that immune compromised individuals are not offered adequate information about zoonoses prevention, either from physicians or veterinarians and may not be comfortable discussing their immune status with their veterinarian. Physicians and veterinarians must share in the responsibility of education about zoonotic disease.

While the possibility of exposure and transmission of zoonotic diseases from animals to people cannot be totally eliminated, it can be minimized. By providing immune compromised clients with correct and up to date zoonotic information, we can encourage them to keep their animals healthy and minimize exposure. This can be accomplished by:

- Making producers aware of information available if they or family members are immune compromised
    - Through conversations, clinic newsletters, or outreach to community organizations
- Making producers aware that immune status can be affected by many conditions

- Speaking with immune compromised clients regarding animal handling guidelines and recommendations
- Providing a handout/brochure on zoonoses with web links for further information

Human health can also be threatened by biological agents used for beef cattle. Oxytocin and prostaglandins have detrimental effects on pregnancy and should never be handled by pregnant women, regardless of procedure used. Other products may have infectious or toxic potential if accidentally injected or adsorbed via mucous membranes. Personal protective equipment and proper care in handling can reduce these risks. Veterinarians must inform clients of these risks when dispensing medications, and ensure that precautions are understood and employed.

Risk Communication

Risk communication is a two-way, interactive process that has been occurring throughout the risk assessment between the producer/facility owner, risk assessor (veterinarian), the staff and other interested parties. Information has been collected and analyzed, and now conclusions needs to be delivered to those affected by the risk assessment and risk management plan.

One of the major barriers to effective risk communication is inadequate planning and preparation. Before designing an educational program it is important to consider who is best suited to communicate the message, what message will be most effective, and when and where the information should be communicated. In large operations, the BRM plan may be formulated by upper management, and some employees may not understand the importance of the plan. Risk management plans must be understood, supported, and adopted by every employee for effective implementation. Because many employees may not understand disease transmission routes and the chain of events involved in disease spread, this communication can be difficult and employees may not fully appreciate the significance of the measures they are asked to follow. Effective risk communication can overcome these impediments.

Characteristics of effective risk communication:

- It must be adapted to the needs of the audience. If bilingual information is required, provide it
- Present the important information in more than one way (appeal to both visual and auditory learners)
- Keep sessions focused to a maximum of three main points
- Limit meetings to a maximum of 45 minutes
- Sessions are more valuable if they are timely and participants can apply the information immediately
- Sessions should cover what, when, where, how, by whom, and why
- If possible, limit groups to 20 people. It is easier to interact with smaller groups
- Give participants the opportunity to discuss, share information, and provide input
- Schedule meetings earlier in the day. Meetings at the end of the working day are less effective

Educational programs that inform employees and other affected individuals of the risk assessment and management plan can take many forms, and may include:

- Face to face/group meetings (one of the best communication forms if the participants have open dialogue)
- Newsletter or bulletin
- Videos, CD's or web-based instruction
- Posted signs or information panels placed around the workplace
- Employee questions and suggestions (question/answer board, suggestion box, etc.)
- Mentoring of new employees by experienced employees
- Knowledge testing
- Recognition or incentive program that rewards employees when BRM goals are reached

Educational programs should not be limited to one form. Facility owners may incorporate many of the above mentioned education forms to create a program that fits the needs of their facility.

Numerous addendums have been provided to assist in the assessment and communication of BRM with clients.

For assessment, these include: a pre-farm questionnaire to better acquaint an investigator with the practices of the operation and an online database listing some questions that can aid in assessing the BRM plan of the farm; these should be considered neither complete nor exhaustive.

For communication: graphs, management recommendations report, current practices report can be created from the online database to help with a BRM assessment. Handouts showing diseases and routes of transmission, a chart showing the potential to introduce a novel disease through new animal purchasing practices (Probability Graph), and a sample visitor log and questionnaire are all available as part of the BRM Toolbox from our website: www.cfsph.iastate.edu/BRM .

Proper communication of the risk management plan is of utmost importance for effective infectious disease control. When communication is effective and efficient, disease spread can be minimized and controlled. However, few management plans are successful if records are not kept or some form of BRM audit performed so that progress can be measured. Part of the risk communication process should include helping to ensure that some system is put in place to measure progress.

Conclusion

Biological risk management is an essential component of keeping any beef cattle operation as secure and successful as possible. Risks of disease transmission cannot be completely eliminated, but by employing some basic hygienic and BRM principles, these risks can be effectively managed and significantly reduced. It may take time and dedication to persuade producers and their employees to adopt these principles, but the results of your efforts will reflect the efficacy of this program, and others will follow suit.