

VETERINARY MEDICINE: PREVENTING LIVESTOCK DISEASES, WITH EMPHASIS ON THE USA

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Summary

The prevention of disease in livestock populations is paramount to a successful agriculture industry. Countries that are able to prevent or control these diseases are

developed, and usually have low occurrence of zoonotic diseases. This chapter deals with various diseases that are considered significant to the livestock industry, particularly in the United States. There is a discussion on the diseases of public health importance (zoonotic) and their importance to individuals who work with livestock.

1. Introduction

The practice of veterinary medicine is based primarily on methods designed to prevent or control disease in various animal population groups. Prevention refers to steps taken to preclude the disease's introduction to a group of animals where the disease causing organism (pathogen) is not present. Control programs are designed to lower the occurrence of disease where the pathogen is known to exist in a population. The various groups can include livestock, companion animals, wildlife, and the human population. A common example of prevention, and usually more so control, is vaccination programs aimed at specific disease problems. However, vaccinations are not the only, or sometimes even the best means of keeping our animal populations healthy. Many times animals must live in environments that are contaminated with disease-causing organisms, and many other steps for control of disease occurrence must be instituted. Other examples of prevention and control include cleaning and disinfection, quarantine, test and slaughter, sick animal isolation, closed herds, all-in all-out (AIAO) operations, and probably most important and most overlooked, education.

Preventive Medicine Concepts. The introduction of a disease-causing organism to a naive group of animals could have devastating affects. The idea of prevention is stopping that introduction. Quarantining or sequestering new animals for 30 to 45 days is often the best means to stop inadvertent introduction of pathogens. Animals that have left the farm and have been around other animals should be quarantined when they return. Animal-transport vehicles should be clean and sanitary before hauling livestock or coming onto a farm. Visitors to the farm should have clean clothing and boots before working with animals. Large populations of wildlife, birds and feral cats can increase risks for introduction of new pathogens to a farm animal population. Vaccinations are recommended for diseases that are known to be in the state or county but not occurring on the farm. A disease such as rabies poses a threat and would have devastating consequences if introduced to a contained population of expensive animals. A closed-herd concept where all replacement animals come from on-farm breeding programs is a good preventive medicine concept because it prevents the introduction of new diseases through infected animals.

Disease Control Concepts. Any method devised to reduce or remove the risk of an animal acquiring a disease that has a history of being on a farm is considered control of disease. Good sanitation and vaccination programs are often the best means to lower the risk of disease. Good sanitation will remove or destroy pathogens and reduce exposure of susceptible animals to these pathogens. Vaccination programs increase resistance to infection by pathogens and also provide protection to the newborn through their mother's milk. Identification and removal of animals harboring pathogens is another method utilized in control of disease. Treatment of infected animals to destroy pathogens is an indirect method of control because the risk to other animals is removed when the diseased and infected animals are free of the pathogen. However, for most

diseases only a small portion of infected animals may actually show signs of disease. Because of this fact, isolation of sick animals does little to stop the spread of infection as there may be more infected normal-appearing animals than sick animals. All-in all-out operations are a good control strategy because pathogens are theoretically kept confined to groups of animals on the farm.

Disease Eradication. Disease eradication is an extreme disease prevention and control strategy. Eradication usually involves the destruction of infected animals and/or animals exposed to infected animals. Historically in USA such programs had been utilized for removal of diseases that would have far reaching effects when introduced to our animal populations. We have had eradication programs, which successfully eliminated foot and mouth disease, vesicular exanthema of swine, hog cholera, exotic Newcastle disease and certain avian influenzas. These eradication programs are very costly and in today's market the introduction of certain diseases could seriously affect the cost of meat produced in USA.

2. Disease control in the USA

2.1. Introduction

Strategies for prevention and control of livestock diseases in USA have long been advocated by veterinarians, regulatory officials and livestock producers. Programs have been designed to not only safeguard the health of the animals but to ensure a safe food supply. Animal agriculture is a business of food production. Changes within the livestock sector and society as well as environmental concerns have created an evolution in control programs. In USA the number of livestock operations is decreasing while the number of animals in each operation has increased dramatically. Although some producers purchase a few animals to supplement their herds, expansion usually necessitates the purchase of many new animals, often from outside sources. This greatly increases the risk of introducing new diseases into the farm's population. An additional complication is that livestock now move rapidly from region to region. Therefore, without adequate safeguards and regulations, diseases can move over long distances in short times. Veterinarians in both private practice and regulatory agencies provide identification and inspection, and required testing of these animals. Producers recognize the need to reduce the use of antibiotics. Prevention and control of animal diseases are vital if we are to reduce the risk of antibiotic residues in food products and to minimize the potential development of antimicrobial resistance. Biosecurity refers to practices implemented to prevent the introduction of new disease into a population or to control the spread of an existing disease within a population. Quarantine of new animals, restricted movement of animals and proper sanitation are means of preventing the introduction of new diseases onto a farm. Programs that include testing, culling and vaccination are used to control the spread of diseases present within the farm's livestock population. Effective strategies for prevention and control require a multi-factorial approach. The contributing factors to disease are closely interrelated. Although many factors must be considered, the infectious agent, nutritional status, environment and housing, and immunity/vaccinations are the most important. Infectious agents include viruses, bacteria, parasites and fungi. These agents vary in their ability to survive outside of the host, their mode of transmission from infected to non-infected animals

and their resistance to disinfectants. There is also often considerable variation among different strains of the same organism. Knowledge concerning the causative agent forms the basis of the preventive program and successful vaccination programs. In recent years, the effects of nutrition on health and disease have been studied extensively. Proper nutrition is vital to maintaining overall health. For example, trace minerals and vitamins are associated with the animals' ability to produce antibodies and neutralize disease-causing agents. Examples include vitamins A, C, and E, selenium, copper and zinc. Undernourished animals are more prone to contracting infectious diseases. Livestock diets are usually scientifically formulated to promote maximum body weight gain, milk or egg production and reproductive efficiency. The goal is to maximize these effects while minimizing health risks. The diets can be adjusted to meet the needs of different breeds, ages and environmental conditions.

As livestock operations move more to confinement rearing, the effects of environment and housing have become more closely related to control of disease. Livestock facilities serve not only as management tools but must provide an environment for the animals as well. Farm animals must be given an environment that allows them to grow, mature, reproduce and maintain health. If the basic needs of the animals are not being met, no amount of management or type of vaccine can assure health. Providing adequate ventilation is a key component of good livestock housing. Adequate ventilation is needed to remove excess moisture from the environment and to prevent the buildup of virulent pathogens and airborne pulmonary irritants. Modern facilities may be designed with either natural or mechanical ventilation systems. Some vaccines are used to increase the animals' resistance to disease while other are designed to decrease the severity of a disease. While vaccines should be considered as part of the total health management plan, they cannot be used as a sole correction for management or environmental mistakes. Veterinarians consider the cost to benefit ratio when designing livestock vaccination programs.

2.2. Disease Control in the Beef and Dairy Industry

The US dairy industry provides milk for fluid consumption and for processing into butter, cheese and other dairy products. In addition, adult cows are sold as market cattle when their productive life is through. Dairy farms also sell young calves that enter the veal market. Beef cattle are raised as meat animals. The beef industry is usually divided into the cow-calf segment and the feedlot segment. Cow-calf producers maintain herds of breeding cows and bulls. These animals are usually raised on pasture and the calves are sold to feedlots after they are weaned. Feedlots are confined feeding operations where cattle are fed rations that are high in energy. Incoming calves are purchased from many sources, sorted according to size and then fed until they are ready to be slaughtered. Diseases such as bovine tuberculosis, brucellosis, and salmonellosis are diseases that pose food safety concerns. These diseases can be spread to both humans and other animals through infected milk and body secretions. Proper preparation of meat products and pasteurization of milk and milk products reduce the risk of these diseases infecting people. Federally regulated programs have been in place for many years in attempt to eliminate zoonotic diseases (see last section of this chapter) from dairy cattle. Federal and state-sponsored programs regulate cattle moving in interstate or intrastate commerce. Testing may be required before the animals are certified for movement. The

testing and certification of animals is done by state and federal regulatory veterinarians as well as private veterinarians who are accredited by the United States Department of Agriculture (USDA). On the farm level, dairy producers and veterinarians must control diseases which have the potential to cause sickness or death, abortion and reproductive inefficiency, sub-optimal production and growth, and udder health problems of dairy cows. Although there are numerous diseases that affect cattle, this section will describe those that occur more frequently.

2.2.1. Respiratory Diseases

Both beef and dairy cows and calves are susceptible to respiratory diseases caused by many viral and bacterial agents. The viruses include:

- Infectious bovine rhinotracheitis (IBR) virus
- Bovine virus diarrhea (BVD) virus
- Bovine respiratory syncytial virus (BRSV)
- Parainfluenza-3 (PI-3) virus

Bacterial agents capable of causing respiratory disease include the following:

- *Pasteurella multocida*
- *Manheimia hemolytica*
- *Haemophilus somnus*
- *Mycoplasma* species

All of these agents are widespread in US cattle population. The signs they produce in the animal are often quite similar and it is often difficult to diagnose the exact cause in respiratory disease. A positive diagnosis of the positive organism often requires assistance of a diagnostic laboratory. Laboratory tests are used to detect the presence of the virus or bacteria or antibodies to them. Infectious bovine rhinotracheitis (IBR), “red nose”, is a highly contagious disease. Beef and dairy cattle of all ages are susceptible, but young animals and animals under stress are more susceptible. Because the virus interferes with the animal’s natural protective mechanisms, infected cows are very susceptible to infection by other agents. In feedlot cattle, this condition is often referred to as “shipping fever” because it often follows the stress of movement. In addition to respiratory disease, IBR virus has also been associated with bovine “pinkeye”, reproductive losses and milk production losses of dairy cows.

Bovine virus diarrhea (BVD) has become increasingly important in recent years. It also is widespread in the US cattle population and can infect cattle of all ages. An important component of BVD virus is its ability to suppress the animal’s immune system. This allows other disease agents such as *Salmonella* spp. or *Pasteurella* spp. to produce severe disease. Because the animals’ natural ability to fight infection is reduced, they do not respond well to conventional treatment. This can have devastating effects in feedlots. In dairy and cow-calf herds, BVD can cause serious reproductive effects. BVD-virus can cross the placenta and infect the fetus. Abortion usually occurs if the infection occurs during the first 3 months of pregnancy. Infection during the second trimester may result in birth defects. If infection occurs around 100 days of pregnancy,

the calf may be born alive but infected with the virus. These calves are considered persistently infected with the virus and can shed the virus to other animals in the herd.

Although not recognized in the US until the mid-1970s, bovine respiratory syncytial virus (BRSV) is a significant problem of dairy and beef herds. Young animals are most severely affected. BRSV damages the cells lining the cow's respiratory tract, which allows invasion by other viruses and agents. The clinical signs of BRSV are normally confined to the respiratory tract. *Pasteurella multocida* and *Manheimia* (formally known as *Pasteurella hemolytica*) are frequently involved with bovine respiratory disease. Both bacteria can be found in the nasal passages of normal cows and calves. Infection by viral agents such as BVD and BRSV and/or exposure to stressful situations such as overcrowding, poor nutrition or weather extremes, increase susceptibility. These weaken or destroy the animals' natural defenses and allow the bacteria to enter the lungs. *Pasteurella multocida* is more common in dairy cattle and *Manheimia hemolytica* is more common in beef calves. Antibiotic therapy is necessary to control disease caused by these infections.

Like *Pasteurella*, *Haemophilus somnus* infection often follows a disease or event that compromises the animals' immune systems. In some cases, these bacteria can also cause disease of the upper respiratory tract without a pre-existing event. The organism is transferred from cow to cow through contaminated aerosols. *H. somnus* can also cause reproductive disease (see section below on reproductive disease), a nervous system disease called thromboembolic meningoencephalitis (TEME) and infection of the joints and heart. When present as a secondary invader of the lungs, it can cause severe pneumonia. Treatment with antibiotics is necessary for control of this disease.

Control of bovine respiratory disease (BRD) on dairy and cow-calf farms requires quarantine of new additions, minimizing stress that results from poor housing, poor ventilation and inadequate nutrition and use of strategic vaccinations. Many producers routinely vaccinate young, replacement animals for IBR, BVD, PI-3 and BRSV. Adult cows should be revaccinated at least annually to protect them and to provide increased antibodies that are transferred to the calf through the mother's colostrum or first milk. Use of vaccines against *P. multocida*, *M. hemolytica* and *H. somnus* is usually only practiced in herds that have ongoing problems with these infections or in operations that are bringing new cattle into the herd. Control of BRD in feedlots is very important because it is the major cause of deaths and sickness in feedlots. Feeder cattle are usually purchased from multiple sites and then co-mingled at the feedlot. Some of these calves may be transported for many hours before reaching the feedlot. The co-mingling and transportation are serious stresses that weaken the animals' immune system, which could allow infection with many of the agents that could cause BRD. Feedlot cattle are usually vaccinated against IBR, BVD, PI-3 and BRSV upon arrival at the feedlot. Bacterial vaccines against *P. multocida*, *M. hemolytica* and *H. somnus* may also be given. Many cattle producers now rely on preconditioning programs to prepare calves for shipment to feedlots. These programs require that calves be vaccinated, acclimated to confinement feeding and be treated for parasites several weeks prior to shipment. Preconditioning allows adequate time for the vaccines to fully immunize the calves and helps reduce the stress caused by co-mingling.

2.2.2. Reproductive Diseases

Several diseases impact reproductive performance by interfering with conception or by causing abortion and embryonic death. These diseases are important to both dairy and cow-calf producers. Dairy cows do not produce milk until the birth of their first calf. Following calving, the cow's milk production steadily declines over time until she has another calf. Female calves are utilized as replacement animals for the herd. When there is reduced reproductive performance, dairy farm profits are impacted by both reduced milk production and loss of possible replacements. Cow-calf producers are in the business of selling calves. Any disease that results in a reduction in conception rates or loss of pregnancy will reduce the number of calves that the herd can sell. With the exception of leptospirosis, other common reproductive diseases do not pose threats to humans.

Infection by either IBR or BVD can result in fetal infection and cause abortion. BVD is considered by many to be the most significant reproductive disease of dairy cattle. Infection of the fetus with BVD virus during the first 3 months of pregnancy usually results in abortion. IBR abortions occur from a few days to 3 months after infection by the virus. Prevention of IBR and BVD abortions requires semi-annual or annual vaccination of breeding animals and implementing steps to prevent introduction of these diseases into the herd when new animals are purchased.

Leptospirosis is a common cause of cattle abortions and can also infect humans. There are five strains (called serovars) of *Leptospira* found in US cattle: *L pomona*, *L hardjo*, *L grippotyphosa*, *L canicola* and *L icterohemorrhagica*. These organisms can remain in the kidneys of infected animals for many months and are shed in the urine. Other animals, such as swine, dogs, rodents and other wildlife, can serve as carriers of the disease. The leptospires can survive in standing water for over ten days. Abortions that result from leptospirosis usually occur during the last four months of pregnancy. Control of leptospira infections involves semi-annual vaccination, fencing off ponds and standing water, preventing contamination of feedstuffs by rodents and identification and elimination of cows carrying the organism (carrier cows).

Although recognized only recently, abortions caused by *Neospora* have become a significant reproductive problem in cattle, especially dairy cows. *Neospora* are single-celled protozoa. Infection of cattle results in fetal death or birth of a calf infected as a fetus (congenital infection). Most abortions occur between the fourth and sixth month of the pregnancy. Infected cows do not show signs of disease. Presently, there is little information on the biology of the parasite, including the mode of transmission. This has made it difficult to formulate effective methods for control and prevention. Other species, such as dogs, may be involved in the transmission of *Neospora*. For this reason fecal contamination of feed by dogs and other animals should be prevented.

Campylobacteriosis (formerly called vibriosis) and **trichomoniasis** are reproductive diseases transmitted venereally. The widespread adoption of artificial insemination (AI) by the dairy industry has reduced the importance of these two diseases to dairy producers but they still pose significant threats to the cow-calf industry. Most beef cowherds in USA still use natural service by bulls to breed cows. Campylobacteriosis is

cause by a bacterium, *Campylobacter fetus*. Following infection of the cow's reproductive tract, *Campylobacter fetus* can cause infertility, early death of the embryo or abortion. The overall health of the cows and bulls is not affected. Control of the disease is based on vaccination of all cows and bulls prior to the breeding season. Like Campylobacteriosis and neosporosis, trichomoniasis does not cause outward signs of disease in the infected adult animal. The causative agent, *Trichomonas fetus*, is confined to the reproductive tracts of bulls and cows and is spread by sexual contact (venereal disease). Although abortion can occur, the most common signs associated with trichomoniasis are poor conception rates and pyometra. Pyometra refers to the accumulation of pus within the uterus. After infection, most cows develop immunity to the protozoa and return to normal. Infected bulls, however, do not rid themselves of the infection and remain as carriers, capable of further spreading the infection to cows. Control of trichomoniasis is based on preventing the disease from entering the herd. Purchase of virgin bulls and heifers is recommended. If it is necessary to purchase mature bulls, they should be tested before entering the herd.

Intestinal diseases. Diseases of the intestinal tract are important causes of poor growth, poor overall performance and possibly death. While cattle of all ages may be susceptible to intestinal disease, young animals are often more severely affected. Viruses, bacteria, protozoa and parasites may be involved. Many of these organisms can survive in carrier animals and in the farm environment. This allows these diseases to remain on farms for long periods of time and contributes to the difficulty of their control. Diarrhea is the most common sign of intestinal infection. Many producers refer to diarrhea of young animals as scours. Calf scours is the number-one cause of death loss in baby dairy and beef calves. Although many agents can be responsible, five of the more common ones are discussed below. *Escherichia coli* bacteria are a common cause of diarrhea in calves younger than five days of age. *E. coli* are common in the calves' environment. The disease often begins with a yellowish diarrhea and may terminate in death. Diarrhea caused by *E. coli* infections results in a loss of fluid and electrolytes from the intestinal tract and these result in dehydration and accumulation of acid within the blood. Rotavirus and coronavirus may infect calves between 5 to 21 days of age. Ingestion of feces or suckling objects contaminated by feces containing the virus transfers the agents. Both viruses invade the lining of the calf's intestinal tract and destroy the intestinal villi. Villi are fingerlike projections from the intestinal lining which increase the intestine's capacity to absorb nutrients and fluid. The infected calves develop dehydration and are more prone to infections by other agents. Although both diseases produce diarrhea, rotavirus infection is more common in calves younger than 10 days of age and coronavirus usually affects calves between 7-21 days of age. The control of *E. coli*, rotavirus and coronavirus diarrheas is based on reducing exposure of the calves to the agents and increasing their resistance. Raising calves in separate pens, known as hutches, provides isolation from other calves and reduces the risk of calf-to-calf transfer. Bottles, buckets and other feeding implements should be thoroughly cleaned and disinfected between calves. Immunity is provided from antibodies supplied through the mother's colostrum, or first milk. Colostrum is rich in antibodies and white blood cells and is the single most important source of protection against early calf hood diseases. In many cases, producers vaccinate cows before calving to allow the mother to produce more antibodies to specific diseases.

Cryptosporidiosis is a common cause of diarrhea in young calves and may also cause disease in humans. Cryptosporidia are protozoan organisms that can invade the calf's intestine. The organisms are present on most farms and survive well in the environment. Calves between one and two weeks of age are usually affected and develop a greenish diarrhea. There is no effective treatment for cryptosporidiosis, but it is self-limiting in healthy calves. Control is based on sanitation. Most common disinfectants are not effective, but freezing and steam cleaning can be used effectively.

Bovine coccidiosis is another protozoan disease that is characterized by diarrhea. It is a common cause of diarrhea in calves from one to twelve months of age. Most mature cattle are immune to coccidiosis due to exposure as young animals. The organism is transferred by ingestion of organisms in manure-contaminated feedstuffs. Affected calves have mild to severe diarrhea and are unthrifty. In its most severe form, diarrhea caused by coccidia infection often results in bloody diarrhea. Most calves in the group are affected. Coccidia are well protected in organic matter, so they can persist for long periods in the calves' environment. To control coccidiosis, producers rely on strict sanitation of group pens and the use of anti-coccidial drugs. These drugs, known as coccidiostats, may be routinely fed to calves to prevent the coccidia from developing within the calf's intestinal tract.

In adult cows, Johnes' disease and salmonellosis are two common causes of diarrhea. Both diseases have become increasingly important as herds purchase animals for expansion. Johnes' disease is caused by the bacterium, *Mycobacterium paratuberculosis*. Although young animals are most susceptible to infection, clinical signs do not appear until the cattle are two years of age or older. Many infected cows never exhibit clinical signs but become infected carriers that pass the organism in their manure and milk to other animals that may become clinically affected. Signs of Johnes' disease include chronic weight loss, diarrhea, poor production and eventual death. Cows affected by Johnes' disease continue to eat and do not have fevers. The organism is usually transmitted by the fecal-oral route, but transfer via milk or colostrum and across the uterus can occur. There is no treatment for infected cows. Control of the disease requires testing of adult cows to identify carrier animals and strict sanitation to prevent young animals from contacting manure from older cows. Purchased adult cattle should be tested prior to entering a new herd.

Many species of *Salmonella* bacteria can cause salmonellosis. These bacteria are widespread in the cattle population and can survive in many environmental conditions. Unlike Johnes' disease, both adult and young animals can be infected. Diarrhea is the primary sign and may be accompanied by dehydration, pneumonia and death. Salmonellosis frequently follows other diseases or stresses that lower the animals' resistance to infection. Treatment is based on aggressive therapy with antibiotics and fluid therapy. Salmonella infections can affect other species of livestock and humans, so care must be taken when handling animals suspected of having the disease. Control is based on sanitation and hygiene and preventing the introduction of carrier animals into the herd.

Other diseases of cattle. Mastitis is an infection of the bovine udder caused by invasion of the udder by bacteria and mycoplasma. Mastitis caused by *Staphylococcus aureus*,

Streptococcus agalactia and *Mycoplasmas* is referred to as contagious because the organisms are most often transferred from cow-to-cow during the milking process. Bacteria that reside in the cows' environment cause environmental mastitis. Examples include *Streptococcus uberis* and the coliform (fecal) bacteria. Mastitis is the most costly disease in the dairy industry. The major costs associated with mastitis include:

- Lower Milk Production: each case amounts to loss of approximately 1600 pounds of milk.
- Altered Milk Components: loss of calcium, fat, protein and milk sugar
- Altered Milk Quality: shorter shelf life, reduced cheese yields
- Increased Cost of Production: current estimates are \$185 loss per case per year
- Increased risks of antibiotic residues

Signs of clinical mastitis include swollen udders, fever, and production of abnormal milk. Some cows also have depressed appetites. Infection of the udder without outward signs is called subclinical mastitis. Although no abnormalities of milk are visible with subclinical mastitis, the milk does contain increased numbers of white blood cells. Whether the mastitis is clinical or subclinical, infected quarters produce less milk than non-infected quarters. This is because there is destruction of milk-producing cells by the bacteria or their toxins. In the US, regulations require that milk sold for fluid consumption must have a somatic cell count of 750 000 cells per ml or less. Somatic cells are white blood cells that accumulate in presence of infection within the udder. Health departments regularly check the level of somatic cells. Milk is also checked for the presence of antibiotics and other inhibitors. Milk that contains antibiotics must be destroyed. Control of mastitis is based on reducing exposure of the teats to mastitis-causing bacteria, use of proper milking procedures, antibiotic treatment of non-milking cows and vaccination. Reducing exposure requires bacterial culturing to identify cows infected with “contagious pathogens”.

These cows are treated, removed from the milking herd or segregated and milked separately. Disinfectant solutions are applied to the teats before and after milking to reduce the number of bacteria on the teat skin. Careful preparation and drying of the teats before milking helps remove bacteria from the environment. Likewise, sanitation of cow housing areas is necessary to limit the number of bacteria to which the teats are exposed between milkings. Proper maintenance of milking equipment and adoption of recommended milking procedures and hygiene are essential to protect the health of the teat ends, reduce the spread of mastitis bacteria and reduce the number of environmental bacteria which can enter the milk. Improperly operating milking equipment can transfer bacteria from cow to cow and injure the teat ends, which are the cows' first line of defense. Recommended milking practices reduce the number of bacteria on the teat end, minimize the negative effects of machine milking and allow for thorough removal of all milk from the udder.

Antibiotic preparations are infused into the udders of cows at the end of their lactation. Referred to as dry cow therapy, these infusions aid in eliminating existing infections and help to prevent new infections that originate during the dry period, or the period when the cow is not milking.

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Biographical Sketches

John C. Gordon is Associate Professor in the Department of Veterinary Preventive Medicine at The Ohio State University, Columbus, Ohio. Dr. Gordon was trained in Public Health while in the U.S. Army, and has taught public health subjects for over 25 years. His research has focused on zoonotic disease epidemiology, particularly those of food-borne origin. He is responsible for the fourth year veterinary students' experience in veterinary preventive medicine and is chair of the veterinary preventive medicine graduate studies program.

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