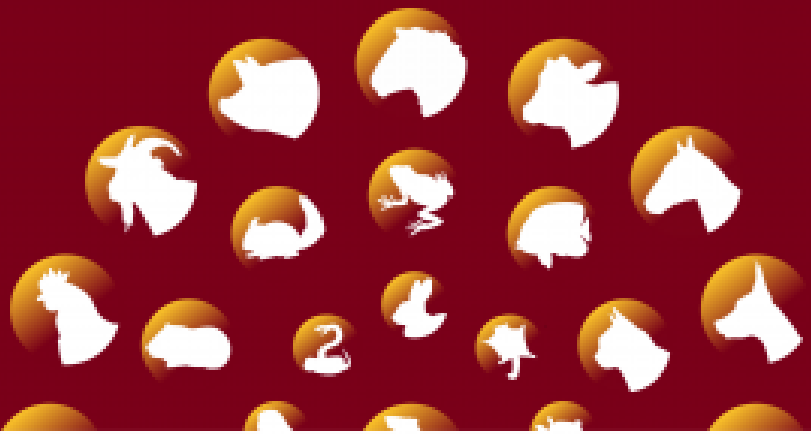

VETERINARY PREVENTIVE MEDICINE

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Veterinary Preventive Medicine

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Contents

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Margaret Root Kustritz

Visual Glossary

Animal Species & Groups

x Margaret Root Kustritz

	Dogs		Fish		Sheep
	Cats		Hedgehogs		Goats
	Chinchillas		Rats		Horses
	Guinea Pigs		Mice		Cattle
	Sugar Gliders		Gerbils		Beef Cattle
	Hamsters		Ferrets		Dairy Cattle

	Amphibians		Rabbits		Small Ruminants
	Reptiles		Caged Birds		Small Animals
	Snakes		Backyard Poultry		Large Animals
	Turtles		Swine		Non-Traditional Pets

Miscellaneous

	**“Checkpoint” Icon** These are designed to test your knowledge throughout each chapter for added retention of the material.
	**“Resources” Icon** These show where you can find articles or websites with additional information for each chapter.

1.

Terminology

Animal Terminology

POULTRY	**Broiler / fryer**	chicken raised for meat
	**Capon**	castrated male chicken or turkey
	Chick	new born chicken or turkey
	Cock or rooster	male chicken of breeding age
	Cockerel	young male chicken
	Hen	mature female chicken or turkey
	Hen poult	young female turkey
	Jake	young male turkey
	Poult	young turkey
	Pullet	immature laying hen
	Spent hen	egg-laying hen that is no longer producing eggs that are of grade A quality (approximately 2 years of age)
	Tom	male turkey of breeding age

CATTLE	Bull	male of breeding age
	**Bullock**	young male, typically less than 20 months of age
	Calf	newborn (generally any male or female less than 1 year of age)
	Cow	mature female; a female that has produced a calf
	Dry cow	a cow that has finished one lactation and has not yet given birth and started a subsequent lactation
	Heifer	young female; a female that has not produced a calf
	One-calf heifer	young female that has produced only one calf and is in her first lactation
	Heiferette	a heifer that has calved once, is not lactating, and is fed for slaughter
	Springer	breeding age heifer that has not yet given birth to her first calf
	Steer	castrated male
	Stocker	weaned cattle that are run on grass or are fed high roughage diets
	Yearling	male or female that is 1-2 years of age

HORSES	**Colt**	young male
	**Filly**	young female
	Foal	newborn
	Gelding	castrated male
	Mare	mature female
	Stallion or stud	male of breeding age

SHEEP	**Ewe**	mature female
	**Ewe lamb**	young female
	Lamb	newborn
	Ram	male of breeding age
	Ram lamb	young male
	Wether	castrated male

GOATS	**Buck or billy**	male of breeding age
	**Buck kid**	young male
	Doe	mature female
	Doe kid	young female
	Kid	newborn
	Wether	castrated male

SWINE	**Barrow**	castrated male
	**Boar**	male of breeding age
	Finishing Pig	pig aged from about 10 weeks to slaughter age (about 6 months of age)
	Gilt	young female; a female that has not had a litter
	Nursery pig	pig aged 21 days to 10-12 weeks
	Piglet	newborn, up to 21 days of age
	Shoat	young male
	Sow	mature female; a female that has had a litter
	Weaned pig	piglet that has been separated from the sow

DOGS	**Bitch**	intact female
	**Dog or stud**	mature male
	Puppy	newborn

CATS	**Queen**	intact female
	**Tom**	mature male
	Kitten	newborn

Production Terminology

POULTRY	**Aviary house**	cageless layer house with litter floor and multiple layers of perches and nests, allowing birds to freely move between all levels
	**Furnished cages**	large enclosed cages, holding 30-60 laying hens, that have perches and scratch pads
	Grandparent stock	first generation, highest biosecurity level poultry stock owned by breeder companies
	Litter	wood chips or seed (rice, peanut) hulls used for footing
	Multiplier stock	offspring of grandparent stock; owned by poultry companies and bred for production of growing turkeys, broilers, and layers

CATTLE	**Backgrounding**	growing program for feeder cattle from time calves are weaned until they are on a finishing ration in the feedlot
	**Biological type**	refers to size of cattle (small, medium or large), growth rate, milk production (high, medium or low), and age at puberty
	Calf crop	number or percentage of calves produced within a herd in a given year relative to the number of cows and heifers in the breeding herd
	Calving	act of giving birth
	Conditioning	treatment of cattle by vaccination and other procedures before introducing them into the feedlot
	Cow-calf operation	a management unit that maintains a breeding herd of cows and produces weaned calves for sale
	Crossbred	an animal that is the product of the crossing of two or more breeds
	Culling	removing cattle from the herd for sale or slaughter
	Dry period	rest period at the end of a lactation before a cow gives birth again

	Feeder cattle	those requiring more growth and/or fattening before slaughter
	Feedlot	beef cattle enterprise where cattle are placed in confinement, fed harvested feeds, and fattened for slaughter
	Finished cattle	cattle whose time in the feedlot is completed and are now ready for slaughter
	Freestall	loose housing system for cows indoors, in which cows can move freely in groups within a large space
	Fresh cow	cow that has given birth within the last 3 weeks
	Freshening	calving
	Lactation	period between two calvings during which the cow gives milk, usually lasting about one year. A cow that has just given birth to her second calf is in her second lactation
	Preconditioning	preparation of feeder calves for marketing and shipment, may include vaccinations, castration, training calves to eat and drink in pens
	Seedstock producer	enterprise that produces breeding animals for the commercial segment of the industry

	Serving	act of breeding
	Tiestall	confined housing system with cow tethered by their head and held in one place

HORSES	**Foaling**	act of giving birth
	**Covering**	act of breeding

SHEEP	**Lambing**	act of giving birth
	**Tupping**	act of breeding

GOATS	**Kidding**	act of giving birth
	**Serving**	act of breeding

PIGS	**Farrowing**	act of giving birth
	**Coupling**	act of breeding
	Farrowing rate	(# farrowing / # bred) x 100
	Non-productive days	days a given sow or gilt of breeding age is present in the herd but is not pregnant or lactating
	Not-in-pig	female diagnosed pregnant (usually by ultrasound) that does not go on to farrow = mortality of all fetuses during gestation

DOGS		
	**Whelping**	act of giving birth

CATS		
	**Queening**	act of giving birth

2.

Vaccines and Vaccinations: Introduction

Learning Objectives

- Explain the benefits of vaccination on an individual and herd level
- Explain how vaccination confers protective immunity
- Describe types of vaccines and how type alters the animal's response and vaccination frequency
- Explain why young animals receive a series of vaccinations
- Describe regulatory aspects and to whom one reports vaccine reactions
- Describe risk factors considered when determining a vaccine regimen
- Describe adverse effects of vaccines and vaccination

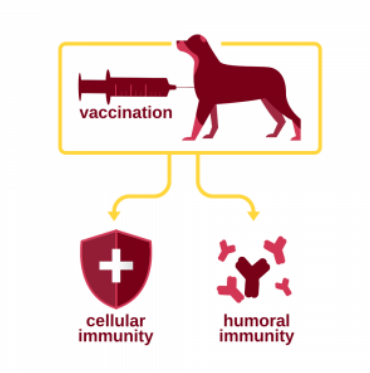
BENEFITS OF VACCINATION

The primary benefit of vaccination is the decrease in the number of animals becoming infected with and dying from infections. When many animals are vaccinated, this "herd effect" has benefit for the vaccinated animals, which are unlikely to become ill from a disease for which they have been vaccinated, and for all animals in the population, who are less likely to be exposed to the disease. This also has public health significance; rabies would be a significant threat to human health in the United States without vaccination of domestic animals.

Objectives of Vaccination

- To vaccinate the largest possible number of individuals in the population at risk
- To vaccinate each individual no more frequently than necessary
- To vaccinate only against agents to which the animal has a realistic risk of exposure and subsequent development of serious disease

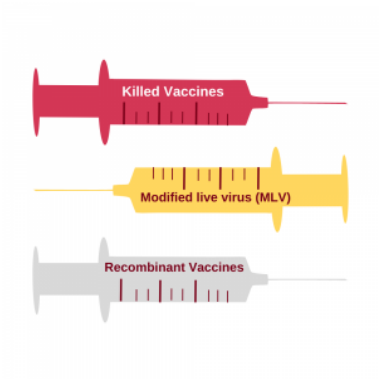
VACCINATION CONFERS PROTECTIVE IMMUNITY



Vaccination is controlled exposure of an animal's immune system to something that causes disease. Vaccination is the act; immunization is the desired result. In veterinary medicine, most vaccines are developed against viruses; some protect against specific bacteria or toxins. When an animal is vaccinated, its immune system recognizes the foreign proteins and builds up a response to them. Part of that response is the creation of antibodies, proteins that bind to the pathogen and lead to its destruction (humoral immunity). Another part of that response is creation of cells within the animal's body that will destroy that pathogen (cellular immunity). Some of those cells are memory cells and are capable of generating a faster and stronger response every time the animal is re-exposed to the pathogen. This means that vaccinated animals, which have created a store of memory cells, can respond quickly to any natural exposure to the pathogen and are significantly less likely to become ill.

Describe as you would for a client how administration of vaccines protects individual animals from disease at the cellular level.

TYPES OF VACCINES



There are three types of vaccines available for use by veterinarians. Killed vaccines *(*also called *inactivated vaccines)* contain inactivated whole viruses or bacteria. Killed vaccines are more stable for handling and storage and are incapable of causing disease in the animal but require use of an adjuvant, which may be associated with vaccine reactions, and may not generate a long-lasting immune response, often requiring them to be given more frequently to be effective. The first time a killed vaccine is given, it primes the immune system but does not evoke an immune response; the animal must get a booster or be naturally exposed for an immune response to occur. Modified live virus (MLV) vaccines (also called *attenuated vaccines)* contain whole viruses that are not dead but are treated such that they can no longer cause disease. Because the organism in the MLV vaccine is alive and can replicate, these may occasionally cause diseases in vaccinated animals. These

vaccines generally stimulate a much stronger and long-lived immune response.

Because these may occasionally cause disease in vaccinated animals, their use must be timed carefully; for example, many MLV vaccines cannot be given to pregnant animals as they may cause abortion. Caution also must be used in giving these vaccines to immunosuppressed animals. Recombinant or *subunit vaccines* use portions of viruses or bacteria to generate an immune response. These cannot cause disease in vaccinated animals but do not always generate an adequate immune response. Recombinant technology is improving steadily and it is anticipated that in the future, recombinant vaccines will be the preferred type. Because an animal's response to vaccination is not dependent on "dose" of vaccine provided, the same amount of vaccine is given to all animals in a given species.

VACCINATION SERIES

The earliest age at which vaccines can be given and the need for boostering is defined by the manufacturer. Young animals that nursed from their dam within the first day of life will have antibodies from her first milk (colostrum) that were taken up across their GI tract into their general circulation (passive immunity). Those antibodies will interfere with vaccines and often we do not know when those antibody concentrations decline. Young animals also are variable in timing of function of their own immune function (active immunity). Because of this, young animals often receive a series of vaccines, with timing of boosters

defined by the manufacturer. In adult animals, some vaccines are boostered when first given and others are not; directions for use on the vaccine label always should be followed.

The goal of boostering vaccines in adult animals is to create an elevation in immune response to protect against disease challenge. Timing of boosters is dependent on the type of vaccine used (killed versus MLV, for example) and on the characteristics of the organism itself. The manufacturer provides guidelines for optimal intervals for boostering of vaccine. What if the animal (young or adult) is overdue for vaccines? There are no published studies evaluating immune response in animals vaccinated with an inappropriately long boostering interval. Veterinarians must use their common sense and knowledge of immunology (or in the case of rabies, they must follow the law). Guidelines are available from the American Animal Hospital Association and American Association of Feline Practitioners to answer this concern for dogs and cats.

REGULATORY ASPECTS OF VACCINATION

There is a lot of controversy regarding how many antigens one should include at one time for vaccination against disease. Some argue that the immune system has built-in systems to be duplicative, so even if only a couple of B cells respond to a given antigen, that will trigger production of more B cells and a quick amplification of antibody concentrations. Others argue that the body can only respond to so many attacks at one time because there are a finite number of B cells and T cells available as

antigens are introduced, so the animal (or person) either won't respond to some of the antigens or will do so improperly. Those who argue this latter point often make the jump that what we are doing is inducing an abnormal immune response, and autoimmune disease, where antibodies or T cells are triggered to destroy host tissue. None of this is particularly well evaluated using the scientific method. A non-medical piece to the puzzle is client compliance; if you get one chance to vaccinate that animal, is it wisest to vaccinate against all diseases of concern, recognizing that the client may not return with that animal for further vaccines if you choose to limit what you offer at a given time?

All vaccines used by veterinarians must be approved by the United States Department of Agriculture (USDA) and demonstrated to be pure, safe, potent, and effective. It is from this USDA approval process that the manufacturer determines what information will be on the vaccine label. The USDA considers a vaccine safe if it does not cause "undue local or systemic responses." After the vaccine is licensed and marketed, no continuing measurement of risk is required. An adverse reaction is defined by the USDA as "any undesirable side effect or unintended effect (including lack of desired result) associated with the administration of a licensed biological product". All adverse reactions reported by veterinarians to the manufacturer are reported to the USDA. If veterinarians do not report adverse effects, the manufacturer may not be aware they are occurring. Here is information from Dr. Richard Ford: "In veterinary medicine, there is no mandate to report a vaccine adverse reaction, whether the reaction is known to have been caused by a vaccine or merely suspected to have been. Although encouraged to do so, formal reports from the veterinarians to the USDA are seldom filed. Veterinarians

who do report known or suspected reactions tend to contact the manufacturer directly. However, neither the licensing agencies nor the vaccine manufacturers are under obligation to provide a veterinarian with additional information regarding either the number of type of vaccine adverse events. Today, there are no data available to veterinarians that specifically address surveillance or documentation of vaccine adverse reactions in companion animals. Manufacturers are under no obligation to compensate the owner or the veterinarian for diagnostic or treatment services related to a known or suspected adverse event."

True effectiveness of a vaccine often is unknown. Challenge testing, in which unvaccinated and vaccinated animals are exposed to the virus and the number that become ill compared, is not always performed. Duration of immunity (the amount of time an animal is protected from disease after vaccination) is not known for all vaccines approved by the USDA.

RISK FACTORS OF VACCINATIONS

Risk factors to be considered include host factors specific to that animal, environmental factors, and agent factors specific to that vaccine. Animals that are malnourished, are ill with another disease or condition, or are stressed are unlikely to respond well to vaccination. Young animals (for example, puppies and kittens less than 16 weeks of age) may still have significant levels of antibodies from their mother, taken in when they nursed in their first day of life. These antibodies may inactivate the vaccine, rendering it

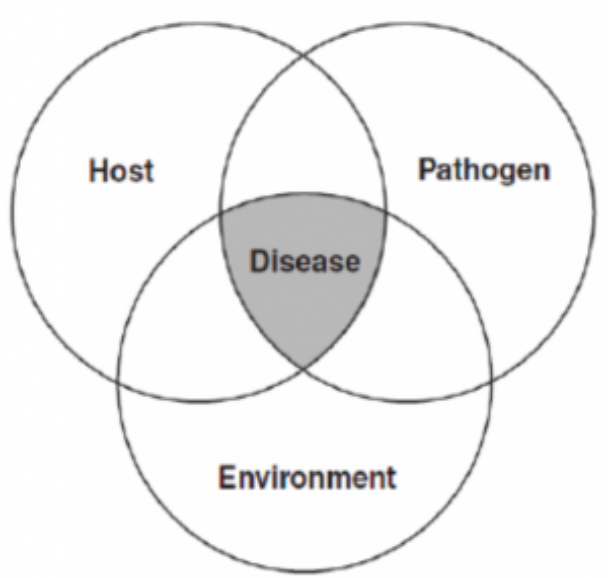
useless. Environmental factors look at the population as a whole. The more animals there are in the population, the greater the likelihood any one animal will be exposed to a given virus. Those animals that are exposed to new animals, for example by introduction of a new pet, or by boarding or grooming, are at greater risk. The final thing to assess is the virus and disease itself. Rabies is an example of a virus that kills all the dogs and cats it infects and can kill exposed humans if they are not treated promptly. Any risk of vaccination is outweighed by the huge risk of death if infected with the virus.

Examples of Risk Factors of a Vaccine Regimen for Horses

- Risk of infection and disease (geography, horse age, occupation, movement patterns)
- Medical, economic, and logistic consequences of disease should it occur
- Potential for spread of infection to other horses and/or humans
- Farm size and type
- Vaccine cost, availability, and efficacy
- Risk of adverse reactions to vaccination

Factors to Consider in Disease Prevention

Diseases occur due to multiple factors. Their relationship is sometimes called the infection triangle.All three factors (environment (e.g. management practices), host, and pathogen) are important for the development or prevention of disease and all three need to be considered during disease prevention.

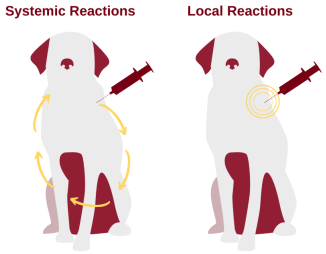


"The Epidemiological Triad", *https://www.nap.edu/read/13147/chapter/1#xviii*

ADVERSE EFFECTS OF VACCINATION

Adverse effects of vaccination have been attributed to preservatives in the vaccine, contaminants, the organism itself, products added to enhance the immune response (adjuvants), and to the administration of multiple vaccines at one time. In most cases, neither the cause nor the exact likelihood of an adverse effect is known.

There are two main types of vaccine reactions, systemic and local. Systemic reactions occur throughout the body, not just at the site of administration of the vaccine, and usually are non-specific. Examples include lack of appetite, fever and soreness. Allergic reactions may occur. These may be sudden, with onset immediately after vaccination and clinical signs lasting for up to two days. Signs of an allergic reaction include swelling of the face and respiratory distress. Some advocate giving less vaccine to minimize allergic reactions but since neither allergic reactions nor immunization are “dose” dependent, there is little wisdom in this practice. Autoimmune diseases are those conditions in which the immune system of an animal or person starts to destroy that individual’s normal tissue. While people have hypothesized that autoimmune disease could be induced by vaccination, there is little scientific evidence of such a connection.



Local adverse vaccine reactions include pain at the injection site, hair loss or change in hair color at the injection site, and swellings. Swellings that develop fairly soon after the vaccination, are non-painful, and feel soft usually are benign sites of inflammation. They resolve over weeks to months. Pain may develop if the vaccine is inadvertently administered near a nerve. Some vaccines cause more pain than others when administered because of their chemical composition.

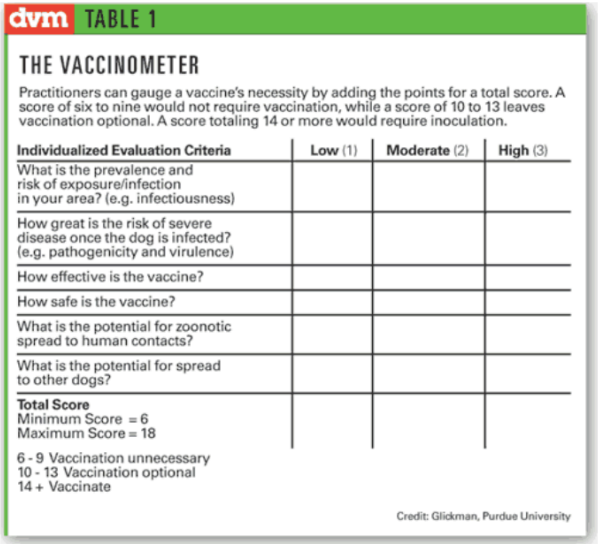
A final possible adverse effect of a vaccine is vaccine virulence, in which the vaccine causes the disease it was designed to protect against. This can only occur with modified live vaccines, which contain the whole virus. Likelihood of this occurring is very dependent on the host into which the vaccine is being injected. For example, a vaccine that is safe for adult animals may cause disease in very young animals. Some modified live vaccines can induce birth defects if given to pregnant animals. Vaccines are more likely to become virulent if used in the wrong species (for example, using an unapproved feline vaccine in ferrets) or if given by the wrong route (for example, cats that lick at the injection site may take some vaccine in by mouth, with a return to virulence when the vaccine contacts the mucous membranes of their gums).

Vaccines are designated as core or non-core (risk-based). Core vaccines are those that are recommended for administration to every animal, based on (1) universal susceptibility to disease caused by a specific infectious organism; (2) significant risk that animals in the area will

become infected; (3) likelihood of significant medical consequences to the animal as a result of infection and disease; (4) availability of a vaccine that is both safe and highly effective; and (5) possible risk of zoonosis. In other words, core vaccines are those for infectious diseases for which the benefit-risk-cost relationship is clear for all animals and the decision to vaccinate is straightforward. Non-core, or *risk-based*, vaccines are recommended only when an animal's lifestyle is such that they are at increased risk of exposure to the disease. These diseases usually will resolve spontaneously or respond readily to treatment. One method of determining whether or not a vaccine should be given to a specific animal is to use some sort of scoring rubric such as that below.

Define "core" and "non-core" as related to vaccinations.

Scoring Rubric for Vaccination Needs



dvm TABLE 1

THE VACCINOMETER

Practitioners can gauge a vaccine's necessity by adding the points for a total score. A score of six to nine would not require vaccination, while a score of 10 to 13 leaves vaccination optional. A score totaling 14 or more would require inoculation.

Individualized Evaluation Criteria	Low (1)	Moderate (2)	High (3)
What is the prevalence and risk of exposure/infection in your area? (e.g. infectiousness)			
How great is the risk of severe disease once the dog is infected? (e.g. pathogenicity and virulence)			
How effective is the vaccine?			
How safe is the vaccine?			
What is the potential for zoonotic spread to human contacts?			
What is the potential for spread to other dogs?			
Total Score Minimum Score = 6 Maximum Score = 18			

6 - 9 Vaccination unnecessary
10 - 13 Vaccination optional
14 + Vaccinate

Credit: Glickman, Purdue University

"Researcher creates tool to gauge vaccine needs", *http://veterinarynews.dvm360.com/researcher-creates-tool-gauge-vaccine-needs*

List your five (5) take-home points – What are things you want to remember from this chapter as you progress through the curriculum and into your career?

EXTRA RESOURCES

- AVMA Vaccination principles: https://www.avma.org/KB/Policies/Pages/Vaccination-Principles.aspx

3.

Vaccines and Vaccinations: Individual Animals

Learning Objectives

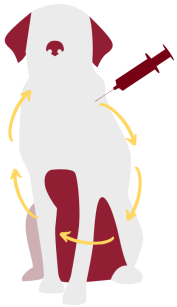
- Describe adverse effects of vaccines and vaccination in dogs, cats, and horses
- Describe cause and clinical manifestations of conditions for which we vaccinate dogs, cats, and horses
- Define what is meant core and non-core (risk-based), in regards to vaccinations
- List core and non-core (risk-based) vaccinations in dogs, cats, and horses
- Create appropriate vaccine protocols for dogs, cats, and horses

This chapter is largely taken from a book for pet owners (Root Kustritz MV (ed), The University of Minnesota Guide to Dog and Cat Wellness, ASIN: B00GCC0YN8).

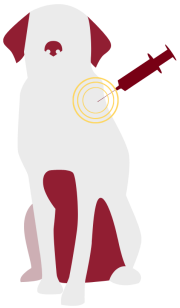
ADVERSE EFFECTS OF VACCINATION IN DOGS AND CATS

Currently there is much controversy among small animal veterinarians and pet owners regarding how frequently vaccinations should be administered to animals. There is no vaccine that is 100% effective and no vaccine that is 100% safe. Vaccines do not induce the same degree of protection in all animals. Knowing, this, how can we decide whether or not to vaccinate a given animal? Your veterinarian does this by assessing the risk factors for your animal and by considering possible adverse effects.

Systemic reactions occur throughout the body, not just at the site of administration of the vaccine. These can be non-specific, causing lack of appetite, fever and soreness that lasts for up to 36 hours after vaccination. This non-specific response is most likely to occur after multiple vaccines are administered and in patients greater than 1 year of age. Allergic reactions may occur. These may be sudden, with onset immediately after vaccination and clinical signs lasting for up to two days. In dogs, 51% of these reactions affect



the skin, usually as swellings of the face and ears, and 40% affect the intestinal tract, causing vomiting with or without diarrhea. In cats, 66% of these reactions affect the intestinal tract, 22% affect the respiratory tract, and 12% affect the skin. No particular type of vaccine or manufacturer has been demonstrated to be more likely to cause allergic reactions in dogs and cats. Autoimmune diseases are those conditions in which the immune system of an animal or person starts to destroy that individual's normal tissue. While people have hypothesized that autoimmune disease could be induced by vaccination, there is no scientific evidence of such a connection in dogs and cats.



Local adverse vaccine reactions include pain at the injection site, hair loss or change in hair color at the injection site, and swellings. Swellings that develop fairly soon after the vaccination and are soft and non-painful usually are benign sites of inflammation. They resolve over weeks to months and are most commonly seen in dogs after vaccination with rabies vaccine or the distemper combination, and in cats after receiving the rabies vaccination.

Dogs with a history of adverse reactions, especially allergic reactions, may be treated with an antihistamine, a corticosteroid, or both, prior to vaccination. This should not impact how they respond to the vaccine as a single

dose of a corticosteroid is not sufficient to cause immunosuppression.

Vaccine-associated feline sarcoma is a malignant tumor that may develop following vaccination in cats. It is reported to occur in 1 in every 1000-10,000 vaccinated cats and is most frequently associated with killed rabies vaccines and vaccines against the feline leukemia virus. Tumors develop weeks to years after vaccination. These tumors are highly invasive, requiring surgical removal and possible chemotherapy. The American Association of Feline Practitioners (AAFP) recommends using non-adjuvanted rabies vaccines for cats in an attempt to decrease the risk of developing vaccine-associated sarcomas. It is unknown at this point if use of non-adjuvanted vaccines decreases the incidence of sarcomas. Because of concerns about development of sarcomas, it is recommended that vaccines not be given in the scruff of the neck, where surgical removal of tumors would be difficult. In North America, vaccines are commonly given in the distal limb, with many practices creating specific practices ("leukemia left, rabies right, rest in the front", for example, with feline leukemia and rabies vaccines given in the distal left and right rear limbs, respectively, and other vaccines given in the distal forelimbs). Another alternative, described in only one study to date, is vaccination in the tail.

Recommended Vaccination Techniques to Minimize Pain and Fear in Dogs and Cats

- Use one needle to reconstitute and draw up the reconstituted vaccine, and use a new needle to inject the animal.
- Use the smallest gauge needle possible.
- Deaden the area to be vaccinated using a topical anesthetic cream, such as lidocaine or prilocaine.
- Distract the animal by giving a tasty treat, petting or massaging the animal, catnip, or any other delightful distraction appropriate to the animal and the setting.
- Before vaccinating, dimple or pinch the skin in the area where the needle will puncture the skin.
- Deliver the vaccine slowly.

—*"Fear Free"*, *https://fearfreepets.com/veterinary-professionals/*

CONDITIONS FOR WHICH WE VACCINATE DOGS AND CATS

Diseases of Dogs and Cats for which Vaccines are Commonly Recommended

DISEASE	CAUSATIVE ORGANISM	CLINICAL SIGNS	CURABLE?	U
CANINE DISTEMPER	Distemper virus	This does not cause a change in the dog's behavior or temperament. Clinical signs include coughing, sneezing, runny eyes, and neurologic changes.	No specific treatment is available.	c f
INFECTIOUS CANINE HEPATITIS	Adenovirus	Clinical signs are of liver disease with decreased appetite, fever, vomiting, diarrhea, and edema of the cornea, and discharge from the eyes and nose.	No specific treatment is available.	c

CANINE PARVOVIRUS	Parvovirus	Clinical signs are of severe destruction of the intestinal tract with vomiting and bloody diarrhea.	No specific treatment is available.
KENNEL COUGH	*Bordetella bronchiseptica* and parainfluenza virus	Infected dogs have a chronic harsh cough.	Bacterial infection is treatable with antibiotics.
CANINE INFLUENZA	Canine influenza virus (H3N8, H3N2)	Upper and lower respiratory signs (nasal discharge and cough, respectively), lethargy	No specific treatment is available.
LEPTOSPIROSIS	*Leptospira* spp	Clinical signs are those of kidney and liver disease and include fever, lack of appetite, vomiting, and increased thirst.	Yes, with antibiotics.

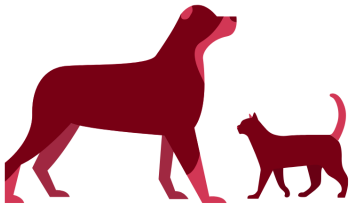
LYME DISEASE	*Borrelia burgdorferei*	The most common clinical signs are lameness shifting from leg to leg, and fever.	Yes, with antibiotics.
RABIES	Rabies virus	Clinical signs are neurologic; there is a "dumb" form (paralysis) and a "furious" form (aggression, seizures).	No – this disease is invariably fatal.
FELINE DISTEMPER	Panleukopenia virus	This does not cause a change in the cat's behavior or temperament. Clinical signs are of severe destruction of the intestinal tract with vomiting and diarrhea.	No specific treatment is available.
CALICIVIRUS	Calicivirus	Clinical signs are of severe respiratory disease.	No specific treatment is available.

FELINE RHINOTRACHEITIS	Herpesvirus	Rhinotracheitis is inflammation of the nose and respiratory tract, evidenced as discharge from the eyes and nose and sneezing.	No specific treatment is available.	
FELINE LEUKEMIA	Feline leukemia virus	The immune system is suppressed so chronic infections may be seen. Associated problems are anemia and cancer.	No specific treatment is available.	
FIV	Feline immunodeficiency virus	The immune system is suppressed so chronic infections may be seen.	No specific treatment is available.	

- Veterinarians are required to follow the label directions for use of all vaccines
- Frequency of rabies vaccination

legally is controlled by municipalities and may be linked to animal licensing

- Puppies and kittens require a series of boosters and revaccination at about 1 year after completion of the initial vaccine series to develop protection against disease
- Vaccines can be designated as “core” or “non-core”



Some vaccination protocols in small animals are being questioned. The vaccine protocols that are being questioned are those for the core vaccines administered to adult dogs and cats. Some data suggest that adult animals may maintain immunity for 5-7 years after their initial vaccinations as young animals, suggesting that the annual revaccination veterinarians had recommended for years is not necessary. Certainly in human medicine, adults are not revaccinated frequently for serious disease but instead in many cases maintain lifelong protection after childhood vaccination. It has been suggested that measurement of antibody concentrations (titers) in animals could be used to determine if vaccination was indicated in a given animal; however, there is confusion regarding how best to measure

antibodies in animals and we do not know what concentration of antibody actually is protective against disease. This also is an inaccurate measure of immune status of the animal as it does not account for cell-mediated immunity.

Increased antibody titers have been demonstrated to be well correlated with protection for canine distemper, canine parvovirus, canine adenovirus (hepatitis), and feline parvovirus (panleukopenia). Antibody titers, if high, can be used to support the contention that vaccination has induced immunity. However, if they are low, that does not mean that an anamnestic response cannot be generated by the animal. Examples of patients for whom antibody titer testing may be useful are young animals at the end of their core vaccine series, dogs from breeds with genetic lack of response to parvovirus vaccination (rottweilers, Doberman pinschers, pit bull terriers), dogs with a history of adverse vaccine reactions, dogs with chronic disease, and aged dogs.

Rabies is a special case on all fronts. Frequency of rabies vaccination is mandated by law and that law may not be based in science. Veterinarians do not have the authority to waive the legal requirement for rabies vaccination for dogs with a history of adverse reactions or chronic disease. All rabies vaccines are boostered one year after initial vaccination. Rabies antibody titers are a legal indicator of adequate vaccination and are not considered a legal index of immunity.

The American Animal Hospital Association (AAHA) and AAFP have developed guidelines for vaccination protocols for adult animals.

Vaccination Protocols for Adult Animals

VACCINES	**DOG**		**CAT**		
	CORE	NON-CORE	CORE		NON-CORE
CANINE DISTEMPER VIRUS	X				
CANINE PARVOVIRUS	X				
CANINE ADENOVIRUS-2 (hepatitis)	X				
RABIES	X		X		
FELINE PANLEUKOPENIA VIRUS (distemper)			X		
FELINE HERPESVIRUS-1			X		
FELINE CALICIVIRUS			X		
FELINE LEUKEMIA VIRUS			X*		
CANINE PARAINFLUENZA VIRUS (kennel cough)		X			
LEPTOSPIRA SP.		X			

BORDETELLA BRONCHISEPTICA (kennel cough)		X			
CANINE INFLUENZA VIRUS		X			
BORRELIA BURGDORFEREI (Lyme disease)		X			
CANINE CORONAVIRUS		X			
CHLAMYDIA (CHLAMYDOPHILA) FELIS					X
FELINE INFECTIOUS PERITONITIS VIRUS					X
FELINE IMMUNODEFICIENCY VIRUS (FIV)					X

* Considered core for cats less than 2 years of age and for cats that are outside part- or full-time and for cats that live inside but are exposed to outside cats

The University of Minnesota Veterinary Medical Center's currently recommended vaccination protocols for pediatric and adult dogs and cats are based on the reports and recommendations of the American Veterinary Medical

Association (AVMA), AAHA and AAFP. Pros and cons of use of a given vaccine are discussed with the owner, who works in concert with the veterinarian to create the protocol that will be used for their animal. As more research results become available, the recommended vaccines and vaccination intervals may change.

Young animals receive a series of boosters to try to ensure immunization while waiting for maternal antibodies to wane and for the young animal to become immunocompetent. Antibody titers in the bitch can be used as a rough guide to help determine how quickly antibody titers will wane in their offspring; bitches with high titers will have higher concentrations of antibody in their colostrum so pups that receive that colostrum will have transfer of more passive transfer of antibodies and it will take longer for those maternal antibodies to clear, suggesting that those pups will not benefit from very early vaccination. Vaccines should not be given any more frequently than every two weeks, as cytokine release at the time of vaccination may interfere with new vaccines introduced too quickly.

Preventive Health Care Recommendations for Puppies

VISIT NUMBER: **AGE**	**VACCINATIONS GIVEN**	**PARASITE CONTROL**
Visit One: 6-8 weeks	• **Distemper / Hepatitis / Parvovirus** • Kennel cough	• **Fecal examination** • **Deworming medication** • **Heartworm medication** • **Flea and tick prevention** (check label for appropriate age to start a given product)
Visit Two: 9-12 weeks	• **Distemper / Hepatitis / Parvovirus** • **Rabies** (follow label directions – give at 12 weeks)	• **Deworming medication** • **Heartworm medication** • **Flea and tick prevention**

Visits Three +/- Four: 14-16 weeks	• **Distemper / Hepatitis / Parvovirus** • Leptospira (repeat in 2-3 wk) • Lyme disease (repeat in 2-3 wk)	• **Heartworm medication** • **Fecal examination** • **Flea and tick prevention**

- The core vaccines (those recommended for all dogs) and parasite control necessary for every puppy are in **bold** print.
- Vaccinations are boostered every 3-4 weeks until 16 weeks of age. Rabies is given once at 12 weeks of age and again 1 year later.

Preventive Health Care

Recommendations for Kittens

VISIT NUMBER: **AGE**	**VACCINATIONS GIVEN**	**PARASITE CONTROL**	
Visit One: 6-8 weeks	• **Distemper / Calicivirus / Herpesvirus**	• **Fecal examination** • **Deworming medication** • **Heartworm medication**	
Visit Two: 9-12 weeks	• **Distemper / Calicivirus / Herpesvirus** • **Feline leukemia** • **Rabies** (follow label directions – give at 12 weeks)	• **Deworming medication** • **Heartworm medication**	

Visits Three +/- Four: 13-16 weeks	• **Distemper / Calicivirus / Herpesvirus** • **Feline leukemia**	• **Deworming medication** • **Heartworm medication** • Flea and tick prevention (if outdoors)	

- The core vaccines (those recommended for all cats) and parasite control necessary for every kitten are in **bold** print.
- Vaccinations are boostered every 3-4 weeks until 16 weeks of age. Rabies is given once at 12 weeks of age and again 1 year later.

Preventive Health Care Recommendations for Adult Dogs

EXAMINATION	VACCINES	PARASIT CONTROL
1 YEAR OF AGE		
• **Annual physical examination**	• **Distemper / Hepatitis / Parvovirus** – booster at 1 year* • **Rabies** – booster at 1 year* • Leptospira – booster at 1 year* • Lyme disease – booster at 1 year* • Kennel cough – repeat in 1 year	• **Dev ng medic** (if fec exami positiv • **Hea rm medic** • **Flea tick preve**
2-6 YEARS OF AGE		

• **Annual physical examination**	• **Distemper / Hepatitis / Parvovirus** – booster every 3 years • **Rabies** – booster every 3 years • Leptospira – booster every year • Lyme disease – booster every year • Kennel cough – booster every year	• **Dev ng medic** (if fec exami positiv • **Hea rm medic** • **Flea tick preve**
GREATER THAN 6 YEARS OF AGE		

• **Annual physical examination**	• **Distemper / Hepatitis / Parvovirus**– booster every 3 years • **Rabies** – booster every 3 years • Leptospira – booster every year • Lyme disease – booster every year • Kennel cough – booster every year	• **Dev ng medic** (if fec exami positiv • **Hea rm medic** • **Flea tick preve**

* or at the 1 year anniversary of the last vaccine received as a puppy

- The items in **bold** print are recommended for every dog. Items not highlighted may or may not be recommended based on the lifestyle of your pet.
- *Leptospira* vaccine is recommended

for all dogs in Minnesota. In general, it is recommended for breeding dogs, duck hunting dogs and farm dogs, or any dog that has routine access to sources of standing water.

- The Lyme vaccine is recommended for dogs that travel in areas where Lyme disease is known to occur commonly, including New England and the upper Midwest. In Minnesota, the area where dogs are most at risk is north of the Twin Cities. Tick prevention is strongly recommended to prevent this disease and other tick-borne illnesses.
- Kennel cough vaccine is recommended for dogs that are exposed to a large number of other dogs, such as dogs that are boarded, show dogs, breeding dogs, and dogs that are housed at "doggy day care" or visit dog parks. Some grooming facilities require this vaccine.
- Frequency of rabies vaccinations legally is mandated by local, not state or federal, law.
- **Veterinarians are required to follow the label directions for use of all vaccines.**

Preventive Health Care Recommendations for Adult Cats

EXAMINATION	VACCINES	PARASIT CONTROL
1 YEAR OF AGE		
• **Annual physical examination**	• **Distemper / Calicivirus / Herpesvirus** – booster at 1 year of age* • **Rabies (Purevax)** – booster at 1 year of age* • **Feline leukemia** – booster at 1 year of age*	• **Dev ng medic (if fec exami positiv** • **Hea m medic** • Flea tick preven (if out
2-7 YEARS OF AGE		

• **Annual physical examination**	• **Distemper / Calicivirus / Herpesvirus** – booster every 3 years • **Rabies (Purevax)** – booster every 3 years • Feline leukemia – booster every year	• **Dev ng medic** (if fec exami positiv • **Hea m medic** • Flea tick preven (if out
GREATER THAN 7 YEARS OF AGE		

• **Annual physical examination**	• **Distemper / Calicivirus / Herpesvirus** – booster every 3 years • **Rabies (Purevax)** – booster every 3 years • Feline leukemia – booster every year	• **Dev ng medic** (if fec exami positiv • **Hea m medic** • Flea tick preven (if out

* or at the 1 year anniversary of the last vaccine received as a kitten

- The items in **bold** print are recommended for every cat. Outdoor or patio cats should receive all of the above vaccinations, parasite control measures, and tests.
- Frequency of rabies vaccinations legally is mandated by local, not state or federal, law.
- **Veterinarians are required to follow the label directions for use of all vaccines.**

Make a chart showing physical examination findings for the following diseases in puppies: canine distemper, infectious canine hepatitis, canine parvovirus, parainfluenza, rabies – the goal is to help you remember what body system(s) is/are most commonly affected with each disease so your chart may include history findings and clinical signs.

VACCINATION OF HORSES

Commercial vaccines are available for only a small subset of the infectious diseases to which horses are susceptible. Despite this, vaccination plays an important role in reducing the incidence and severity of common viral and bacterial diseases. There is no such thing as a "one-size-fits-all" vaccination program that is appropriate for use in all horses!

Vaccination programs are tailored to the individual and the farm based on an assessment of:

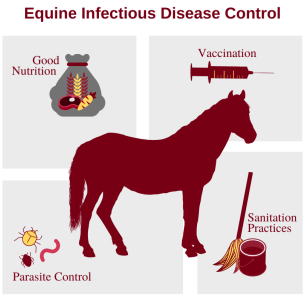
- Risk of infection and disease (geography, horse age, occupation, movement patterns)
- Medical, economic, and logistic consequences of disease should it occur
- Potential for spread of infection to other horses and/or humans
- Farm size and type
- Vaccine cost, availability, and efficacy
- Risk of adverse reactions to vaccination

Many equine vaccines are available for purchase "over-the-counter", but horse owners rarely have the knowledge and experience to conduct this type of analysis. Horse owners/managers should therefore make decisions about optimal vaccination programs for each individual horse with the guidance of an equine veterinarian that is familiar with their farm, animals, training/performance goals, and budget. That said, within a given geographical region there is typically a set of core vaccines that are promoted for use in all horses, similar to what was described for small animals. As an example, all horses are highly susceptible to tetanus, a devastating and often fatal disease caused by the bacterium *Clostridium tetani*. This bacterial organism is widespread in the soil and environment, and readily contaminates the minor wounds and punctures that horses tend to sustain on a frequent basis. Available vaccines are very safe and effective, so are recommended for use in all horses. If you had to identify the single most important core vaccine for horses, it would be tetanus toxoid!

For the remainder of commercial vaccine products, the benefit-risk-cost relationship is less clear and can vary widely between individual horses, different farms, and different geographical regions. These products are categorized as risk-based (non-core) vaccines**,** which are recommended for some horses and not others. Equine veterinarians use their knowledge and experience to identify horses and farms that may benefit from specific risk-based vaccines. For example, diarrhea caused by rotavirus affects young foals only. Adult horses often carry the virus within their gastrointestinal tracts, but only young foals in the first few months of life develop disease as a result of infection. Some breeding farms suffer high rates of disease caused by this pathogen year after year, while others experience no disease whatsoever. Farms with a

significant history of rotavirus enteritis are good candidates for use of the rotavirus vaccine, which is administered to pregnant mares late in gestation to stimulate high levels of anti-rotavirus antibodies in colostrum. These antibodies are consumed and absorbed by the foal in the first day of life, and help to reduce the subsequent risk of infection and disease. There is no reason for adult horses other than broodmares to be vaccinated with this product, nor do all broodmares require such vaccination.

Vaccination is only one element of an infectious disease control program. Horse owners and managers should be aware that farm management practices play just as important a role (for example, sanitation practices, good nutrition and parasite control, controlling horse traffic, quarantine of new arrivals, and quarantine of horses with known contagious disease). They should understand that vaccination does not provide a guarantee of protection at the individual animal level – it lowers the risk of infectious disease but cannot eliminate that risk entirely. Some vaccines are more effective than others, some horses respond to vaccination better than others, many vaccines require multiple doses before protective immunity is achieved, and protective immunity may not be achieved for days to weeks following vaccine administration. Owners who manage their own vaccines should be advised that improper storage, handling, and administration of vaccine products will undermine their effectiveness.



Immune protection of foals is generally achieved through vaccination of the dam in late gestation. Antibodies produced by the mare are concentrated in her colostrum, and then transferred to the foal as it suckles colostrum in the first hours of life. These antibodies provide protection for several months, after which levels gradually decline and the foal must be vaccinated to stimulate its own active immunity. For foals that received adequate amounts of colostrum from a properly vaccinated mare, first vaccines are administered at 4-6 months of age. If they are vaccinated earlier than this, maternal antibody will interfere with an effective immune response to vaccination. By contrast, foals of unvaccinated mares do not have significant concentrations of maternal antibody so vaccination should be initiated earlier. Since it is difficult to predict the precise timeframe during which maternal antibody concentrations wane, foals often receive more doses of vaccine in the initial series compared to adult horses being vaccinated for the first time. For example, a 2-dose initial series is recommended for first-time vaccination of adult horses against tetanus. By contrast, a 3-dose initial series is recommended for foals. This approach helps to ensure that all foals are adequately protected, even those in which maternal antibody may have persisted longer than usual.

The vast majority of equine vaccines are administered by intramuscular (IM) injection, and a few are administered intranasally. Adverse reactions to vaccination are common

but in most cases are limited to minor transient muscle swelling and tenderness at the injection site. Occasional horses develop hives, lethargy, fever, or inappetance that may be self-limiting or may require veterinary support. A very small percentage of horses experience serious, and potentially life-threatening, systemic reactions such as anaphylaxis, purpura hemorrhagica, endotoxemia, laminitis, or infection of muscle tissue with the anaerobic bacterium *Clostridium* sp. (clostridial myonecrosis). Owners should be aware that all vaccines carry an inherent risk of adverse effects, even when the product has been stored, handled, and administered correctly. Administration of vaccines by the veterinarian rather than the owner/manager ensures that an appropriate vaccine product has been chosen; the product has been properly stored, handled, and administered; and that peracute adverse reactions can be treated promptly while the veterinarian is still on the premises.

Serum antibody titers are not widely used to assess an individual horse's level of immunity to a given infectious disease, or to guide decisions about whether or not vaccination is warranted. Insufficient data are currently available to guide meaningful interpretation of such titers.

CORE VACCINATIONS

The AVMA defines core vaccines as those that "protect from diseases that are endemic to a region, those with potential public health significance, required by law, virulent/highly infectious, and/or those posing a risk of severe disease. Core vaccines have clearly demonstrated

efficacy and safety, and thus exhibit a high enough level of patient benefit and low enough level of risk to justify their use in the majority of patients." The following equine vaccines are considered to meet these criteria:

- Tetanus (tetanus toxoid)
- Western Equine Encephalitis (WEE) and Eastern Equine Encephalitis (EEE)
- West Nile Virus
- Rabies

Tetanus

This is a horrifying and often fatal disease caused by the bacterium *Clostridium tetani***.** Spores of the organism are ubiquitous and reside primarily in soil, from where they gain ready access to the body through lacerations, punctures, surgical incisions, and exposed tissue such as the umbilicus of neonatal foals. Bacteria multiply within devitalized tissues at the site of injury or invasion, then produce a neurotoxin that migrates along motor nerves to the spinal cord and central nervous system (CNS). Most mammals are susceptible to this neurotoxin, including humans, but horses are exquisitely sensitive to its effects. Within the CNS, tetanus toxin inhibits the release of inhibitory neurotransmitters, resulting in loss of normal balance and control of muscular contraction. Over 7-10 days, affected horses develop progressive localized and generalized muscle contraction, rigidity, and spasms that are aggravated by stimulation and excitement. Horses often exhibit a characteristic sawhorse stance, raised tail head, prolapse of the third eyelid, and difficulties prehending

and masticating feed due to excessive contraction of masticatory muscles ("lockjaw"). They suffer great pain and anxiety related to the muscle spasms and their inability to move or eat normally. Death is often the result of respiratory failure when the muscles of the larynx, intercostal muscles, and diaphragm become affected. Affected horses may be treated with a combination of tetanus antitoxin (antibodies targeting the neurotoxin), penicillin to kill the *C. tetani*, wound debridement and management to prevent further production of neurotoxin, sedatives, nutritional support, extensive nursing care, and a quiet environment. Whether or not a horse can survive depends upon how early the disease was diagnosed, the speed and severity of disease onset, and how aggressively it can be treated. The good news about tetanus is that it is easily prevented through vaccination! All available vaccines contain tetanus toxoid, a formalin-inactivated form of the tetanus neurotoxin that stimulates a strong humoral immune response following IM administration. The antibodies produced in response to vaccination bind and inactivate the neurotoxin before it can reach the CNS to wreak havoc. Many brands of tetanus toxoid are available and individual products may contain tetanus toxoid alone, or in combination with other antigens as part of a multivalent vaccine. Some products contain all of the core equine vaccines, and others also contain one or more risk-based vaccines. Initial vaccination of a previously unvaccinated adult horse consists of a 2-dose series administered by IM injection 4-6 weeks apart, after which horses are boostered with a single dose annually. Broodmares receive their annual vaccination 4-6 weeks prior to foaling to ensure that high levels of protective antibody may be transferred to the foal via colostrum. Foals then receive a 3-dose series beginning at 4-6 months

of age, followed by single annual booster doses as for adults. It is common for horses to receive supplemental boosters if they need surgery or sustain a wound/puncture more than 6 months following their previous vaccination. True protection probably lasts much longer than this, but we err on the side of caution given the horse's unique susceptibility to this devastating disease.

Western & Eastern Equine Encephalitis

This neurological disease is caused by the related Western (WEE) and Eastern Equine Encephalitis (EEE) alphaviruses, which are endemic in North America. Birds and rodents are the major reservoirs of these viruses, but they may be transmitted to horses and humans by mosquitoes. Following the bite of an infected mosquito, the virus replicates and moves through the bloodstream to the brain, where it causes inflammation and neurological dysfunction. Affected horses exhibit fever, incoordination and weakness, stupor (the common name of the disease is "sleeping sickness"), head-pressing, and terminal seizures and coma. No known antiviral agents are effective in the treatment of this disease, so treatment focuses on supportive care and reduction of CNS inflammation. Fatality rates are 50% for WEE and over 90% for EEE. Horses that survive typically exhibit permanent neurological injury and deficits. The viruses are not directly transmissible from infected horses to other horses or their human handlers, even through mosquitoes, but horses serve as sentinels for increased regional risk of human and equine exposure. The good news about WEE/EEE is that it is easily prevented through vaccination! All available vaccines contain formalin-inactivated WEE and

EEE viruses, and they are considered to be very safe and effective in preventing disease. Most vaccines are multivalent products containing WEE/EEE in combination with other core antigens such as tetanus toxoid and West Nile Virus, but versions containing additional antigens are also available. Initial vaccination of a previously unvaccinated adult horse consists of a 2-dose series administered by IM injection 4-6 weeks apart, after which horses are boostered with a single dose annually. Annual boosters are administered in early spring to ensure that horses are well-protected during the summer and fall vector seasons. Broodmares receive their annual vaccination 4-6 weeks prior to foaling to ensure that high levels of protective antibody may be transferred to the foal via colostrum. Foals then receive a 3-dose series beginning at 4-6 months of age, followed by single annual booster doses as for adults. In southeastern states where mosquitoes are active year-round, it is common practice to (1) use a 4-dose primary series for foals beginning at 3 months of age, and to (2) administer boosters every 6 months rather than on an annual basis to ensure that protective immunity is maintained year-round. Because horses are an important part of the surveillance network for arboviruses that also affect humans, WEE/EEE is a reportable disease in Minnesota. When you suspect or confirm this diagnosis you must notify your state veterinary regulatory authorities immediately. In Minnesota, this is the Board of Animal Health.

West Nile Virus Encephalitis

This neurological disease is caused by the West Nile Virus (WNV), a flavivirus for which birds throughout North

America are the major reservoir. The virus is transmitted to horses and humans by mosquitoes. After an incubation period of 7-10 days, affected horses develop inflammation of the brain and spinal cord that results in behavior changes, tremors, facial fasciculations, hyperesthesia, weakness, incoordination, and recumbency, seizures, and coma in severe cases. Approximately 30% of cases progress to recumbency and paralysis; these cases carry a poor prognosis and usually are euthanized. No known antiviral agents are effective in the treatment of this disease, so treatment focuses on supportive care and reduction of CNS inflammation. Horses that recover often exhibit neurological deficits that may or may not resolve over the next 6-12 months. The good news about West Nile Virus is that it is easily prevented through vaccination! Four commercial vaccine products are currently available: two contain inactivated virus, one is a live canary pox recombinant vector vaccine, and one is an inactivated flavivirus chimera vaccine. Some versions contain only WNV antigen, while others are multivalent products containing supplemental core or risk-based vaccines. These vaccines are considered to be safe and effective. Specific recommendations vary by product, and the manufacturer's instructions should be followed. For most of the commercial products, initial vaccination of a previously unvaccinated adult horse consists of a 2-dose series administered by IM injection 4-6 weeks apart, after which horses are boostered with a single dose annually. Annual boosters are administered in early spring to ensure that horses are well-protected during the summer and fall vector seasons. Broodmares receive their annual vaccination 4-6 weeks prior to foaling to ensure that high levels of protective antibody may be transferred to the foal via colostrum. Foals then receive a 3-dose series beginning at

4-6 months of age, followed by single annual booster doses as for adults. In southeastern states where mosquitoes are active year-round, it is common practice to (1) use a 4-dose primary series for foals beginning at 3 months of age, and to (2) administer boosters every 6 months rather than on an annual basis to ensure that protective immunity is maintained year-round. Many veterinarians also use a 6-month booster interval for geriatric and immunocompromised horses. Because horses are an important part of the surveillance network for human disease, WNV is a reportable disease in Minnesota.

Rabies

Rabies is rare in horses, but it is given special consideration because of its public health significance and the fact that disease is almost always fatal. The rabies virus is transmitted in saliva through the bite of an infected wild or domestic animal. The most common vectors vary by geographical region, but in the United States are typically skunks, foxes, raccoons, and bats; in Minnesota, rabies usually is carried by skunks. Horses are typically bitten on the muzzle, face, or lower limbs, but bite wounds may not be visible at the time of diagnosis. Following the bite, the virus migrates along nerves to the spinal cord and brain, where is causes progressive encephalomyelitis that invariably proves fatal. The time period between the bite and onset of neurological symptoms is highly variable, and in other species can range from 1 week to 6 years! Clinical signs of equine rabies are highly variable, but most horses exhibit changes in behavior that are clearly recognized by their owners as uncharacteristic. These may include hyper-alertness, anxiety and mental distress, aggression,

hyperactivity such as persistent running, persistent abnormal vocalization, or simply profound depression/ somnolence. Affected horses can be extremely dangerous to their owners/handlers as a result of their altered mental status, even in the absence of overtly aggressive behavior. Animals that are not euthanized at this stage will progress to recumbency, paralysis, seizures, coma, and death. The time between first recognition of a problem and death is rarely more than 5-7 days. Definitive diagnosis of rabies requires laboratory testing on the brain. The good news about rabies is that it is easily prevented through vaccination! All commercial vaccines contain killed rabies virus, a potent antigen that triggers strong antibody responses; they are generally considered to be very safe and effective. Initial vaccination of a previously unvaccinated adult horse consists of a single dose of vaccine administered by IM injection, followed by annual booster doses to maintain protective immunity. Broodmares typically receive their annual vaccination 4-6 weeks prior to foaling to ensure that high levels of protective antibody may be transferred to the foal via colostrum, but available evidence regarding duration of immunity indicates that annual vaccination prior to breeding is also acceptable. Foals then receive a 2-dose series (4-6 weeks apart) beginning at 6 months of age, followed by single annual booster doses as for adults. At present, none of the rabies vaccines licensed for use in horses carry a 3-year label as is common for small animal products. Rabies vaccines are available over-the-counter in some states, while other states (including Minnesota) mandate that vaccines be administered by licensed veterinarians only. Because of its zoonotic potential, rabies is a reportable disease of great medical and legal concern.

Make a chart showing physical examination findings for the following diseases in adult horses: tetanus, Western / Eastern equine encephalitis, West Nile virus, rabies – the goal is to help you remember what body system(s) is/are most commonly affected with each disease so your chart may include history findings and clinical signs.

RISK-BASED (NON-CORE) VACCINATIONS

Risk-based vaccines are included in the vaccination program on the basis of risk-benefit-cost analysis. Their use varies regionally, between different horse populations within a region, and even between different horses on a single farm. The use of risk-based vaccines should be guided by an equine veterinarian, as horse owners and managers rarely have the knowledge and experience needed for optimum program design. The most commonly used risk-based vaccines in North America include:

- Equine herpesvirus (EHV; rhinopneumonitis or "rhino")
- Influenza
- Strangles
- Botulism
- Potomac Horse Fever (PHF)
- Equine viral arteritis (EVA)
- Rotavirus diarrhea
- Anthrax
- Leptospirosis

Equine Herpesvirus

Equine herpesviruses 1 and 4 (EHV-1 and EHV-4) are respiratory viruses that cause typical signs of upper respiratory disease: acute fever, lethargy, inappetance, serous nasal discharge, and cough, with full recovery within 2-3 weeks. Clinical disease is most likely to occur in young horses, especially those entering training at facilities in which extensive comingling occurs. EHV-1 is also an important cause of abortion in pregnant broodmares, however, and in rare cases it invades the CNS to cause weakness, incoordination, and inability to urinate and defecate. Epidemics of the neurological form of the disease occur with some regularity, especially among horses assembled at racing or show venues. The virus is spread via direct contact with nasal secretions, aerosolized virus from coughing and sneezing, and in the case of EHV-1 from contact with aborted fetuses, fetal fluids, and the infected placenta. The viruses are ubiquitous and most horses become infected early in life and remain so; the viruses have a complex biology that features a latency state, from which reactivation, viremia, and viral shedding can occur during periods of stress. These factors make infection virtually impossible to control, and explains why outbreaks of EHV can occur in closed populations of horses. Most adult horses develop some immunity as a result of repeated exposure to the viruses; these horses rarely develop significant respiratory disease when infected but can still contribute to spread of the virus within a population. This age- and exposure-related immunity does not protect horses from abortion or neurological involvement, unfortunately. Relegation of EHV vaccines to the risk-based category is the result of this complex virus biology, the high prevalence of latent infection, the fact that most

horses develop only mild respiratory disease as a consequence of active infection, and the fact that vaccines are only partially protective. The primary indications for use of EHV vaccines are:

- Prevention of EHV-1 induced abortion in pregnant mares
- Reduction of symptoms and spread of respiratory tract disease (rhinopneumonitis) in foals, weanlings, yearlings, and young performance/show horses that are at particularly high risk of exposure to EHV-1 and EHV-4

EHV-1/EHV-4 vaccines are licensed as aids in prevention of respiratory disease, while specific EHV-1 vaccines are licensed and labeled for prevention of abortion in broodmares. None of the current EHV vaccines are licensed for prevention of herpes myeloencephalitis, the CNS form of EHV-1 infection, nor have any available vaccines been shown to be effective in this regard. All except one vaccine contain formalin-inactivated EHV-1 and EHV-4 (respiratory vaccines) or EHV-1 only (abortion vaccines). Most of these are administered by IM administration only, while one product carries an option for intranasal use once an initial series of IM injections has been administered. Products licensed for prevention of abortion tend to contain larger amounts of viral antigen than those licensed for control of respiratory disease, and these products stimulate stronger immune responses. There is a single modified-live EHV-1 vaccine on the market that is licensed as an aid in preventing respiratory disease due to EHV-1. Initial vaccination of a previously unvaccinated adult horse with a killed virus respiratory vaccine consists of a 3-dose series administered by IM injection 4-6 weeks

apart, after which horses are boostered every 6-12 months depending on the stringency of immune protection desired. Horses under 5 years of age, those on breeding farms and in contact with pregnant mares, and performance/show horses are often boostered every 6 months. For abortion prevention, broodmares are vaccinated at 5, 7, and 9 months of gestation using a high-antigen EHV-1 product. This regimen also ensures that colostrum contains significant anti-EHV-1 antibody. Foals then receive a 3-dose series beginning at 4-6 months of age, followed by boosters every 6 months.

Influenza

Influenza is a common viral respiratory disease of horses. As with EHV-1/EHV-4, affected horses exhibit acute fever, lethargy, inappetance, serous nasal discharge, and cough, with full recovery within 2-3 weeks. The virus is spread via direct contact with nasal secretions, and as virus is aerosolized from coughing and sneezing. As with EHV, disease is most likely to occur in young horses, especially those in training at facilities in which extensive comingling occurs (training/show barns, racetracks). The virus does not circulate constantly within a population the way herpesviruses do, but triggers disease when an infected horse is introduced into a naïve population. Vaccination and 14-day quarantine of new arrivals is therefore more effective for control of influenza than for rhinopneumonitis. Since the influenza virus tends to change its genetic and structural makeup over time, vaccines tend to contain multiple strains of virus and are updated on a regular basis to ensure that horses remain protected against viruses in current circulation. Horses

under 6 years of age, show/performance horses, and horses boarded at stables with a high level of horse traffic are good candidates for vaccination against influenza. Older horses maintained in a closed herd are at comparatively low risk of infection and disease. There are 3 types of influenza vaccine on the market at present, most of which elicit at least 6 months of protective immunity:

- Many inactivated virus vaccines (IM administration, but for one product boosters may be administered intranasally). Often included in multivalent vaccines targeting EHV-1/EHV-4 or other infectious diseases
- One live canary pox recombinant vector vaccine (IM administration)
- One modified-live vaccine (intranasal administration)

Each of the vaccine types requires a different initial series. Initial vaccination of a previously unvaccinated adult horse with a killed virus vaccine consists of a 3-dose series administered by IM injection, after which horses are boostered every 6-12 months depending on the age of the horse, expected exposure level, and the stringency of immune protection desired. The canary pox recombinant vaccine requires a 2-dose initial series administered by IM injection 4-6 weeks apart, after which horses are boostered every 6-12 months. The modified-live intranasal vaccine requires only a single primary dose, followed by boosters every 6 or 12 months. Broodmares are vaccinated every 6 months, with one of those doses timed for administration 4-6 weeks prior to foaling. Foals are then vaccinated beginning at approximately 6 months of age; as for adults,

the primary protocol varies between vaccines but subsequent boosters are administered every 6 months.

Strangles

Strangles is a common and highly contagious respiratory disease of horses caused by the bacterium *Streptococcus equi equi*. Young horses are most susceptible but horses of any age can be affected. The organism is transmitted by direct contact with infected nasal secretions or purulent material from ruptured lymph node abscesses, and is easily spread on equipment, tack, feed and water buckets, grooming supplies, and human hands or clothing. Horses with active disease shed the highest levels of bacteria, but clinically normal carriers can also shed bacteria and trigger disease outbreaks. Classical signs of disease include fever, copious purulent nasal discharge, lethargy, inappetance, and progressive enlargement, abscessation, and rupture of submandibular, retropharyngeal, and parotid lymph nodes, with subsequent drainage of purulent material. Most horses make a full recovery within several weeks but occasional horses develop life-threatening complications such as upper airway obstruction, pneumonia, spread of infection beyond the respiratory tract ("bastard strangles"), abdominal abscessation, and purpura hemorrhagica, a dangerous immune-mediated disorder. Unless rigorous biosecurity precautions are taken, strangles can sweep through a large percentage of horses in a barn, interrupting the training and show schedule for weeks or months. Even once affected horses have made a full recovery, they may harbor bacteria in the pharynx and guttural pouch for months afterward, serving as a potential source of infection for additional horses. Routine cases of strangles are not

treated with antibiotics because they tend to slow progression and resolution of the disease. Treatment is primarily supportive with anti-inflammatory medications used to combat high fever and to encourage horses to eat and drink. Horses with life-threatening complications do receive antibiotic therapy, and horses with immune-mediated disease require concurrent immunosuppressive therapy with corticosteroids. Vaccination against strangles is recommended on premises where strangles is a persistent problem and for horses considered to be at high risk of exposure. Strangles cannot be completely controlled through vaccination, but it does reduce the incidence and severity of disease. Historical efforts to develop safe and effective strangles vaccines were ineffective due to the biology of the causative organism. Many of the vaccines that have been brought to market over the years have carried a high risk of adverse effects and elicited relatively poor levels of immune protection. At present, available vaccines are of two types: a single modified-live vaccine administered by intranasal inoculation, and subunit vaccines containing purified extracts of the *Streptococcus equi equi* M-protein virulence factor. The modified-live vaccine is considered to be more effective, but is more difficult to administer and carries a higher risk of adverse effects. Vaccination with either product can trigger development of purpura hemorrhagica. Initial vaccination of previously unvaccinated adult horses with the modified-live intranasal vaccine consists of a 2-dose series administered 3 weeks apart, after which horses are boostered every 6-12 months depending on the expected level of exposure and the stringency of immune protection desired. The subunit vaccine requires a 2- or 3-dose initial series administered 2-4 weeks apart, followed by boosters every 6 months. The intranasal modified-live vaccine is

not approved for use in broodmares, so when needed the subunit product is administered 4-6 weeks prior to foaling. Foals then receive a 3-dose series beginning at 4-6 months of age (subunit vaccine) or 6-9 months of age (intranasal vaccine), followed by boosters every 6 months if ongoing risk of exposure is anticipated. Horses that have recovered from strangles develop strong immune responses that provide protection for approximately 5 years. Subsequent vaccination should be done with caution, as vaccination in the face of existing immunity increases the risk of purpura hemorrhagica.

Botulism

This is a serious and life-threatening disease caused by a toxin produced by the bacterium *Clostridium botulinum***.** Bacterial spores gain access to the body either through ingestion or wound contamination, after which the spores vegetate and toxin is produced. Alternatively, preformed botulinum toxin may be consumed when horses eat decaying or improperly preserved hay, haylage, or silage, or feed contaminated with rotting remnants of animal carcasses (a decomposing dead rabbit incorporated during round bale production, for example). Horses are exquisitely sensitive to the biological effects of botulinum toxin, which blocks acetylcholine release at the neuromuscular junction to cause profound flaccid paralysis of muscle. Clinical signs in horses include generalized weakness progressing rapidly to recumbency, tremors, inability to prehend and swallow feed (dysphagia), secondary injury related to falls, and death by respiratory paralysis. There are 8 distinct toxins produced by different subtypes of *Cl. botulinum*; types B (90% of cases) and C

(10% of cases) are responsible for most cases of equine botulism. Type B botulism occurs most often in the Mid-Atlantic states and Kentucky, while Type C botulism is most common in Florida. Affected horses may be treated with a combination of antitoxin (antibodies targeting the neurotoxin), antibiotics to kill the *C. botulinum* organism, laxatives to encourage passage of any toxin within the gut, nutritional support, extensive nursing care, and mechanical respiratory ventilation for horses in respiratory failure. Prognosis for life depends upon how early the disease was diagnosed, the speed and severity of disease onset, how aggressively it can be treated, and whether the horse remains standing. Horses that survive can take weeks to recover fully. Vaccination is recommended for horses in endemic regions, or horses scheduled for transport to endemic regions. Minnesota horses are not routinely vaccinated against botulism, as the disease is rare here. By contrast, Minnesota broodmares that will be transported to Kentucky in the spring for foaling and breeding are typically vaccinated to optimize protection for the mare and her foal in that environment. Available vaccines contain inactivated Type B botulinum toxin (toxoid). There are no licensed vaccines containing Type C or any other toxin sub-type. Initial vaccination of previously unvaccinated adult horses with botulinum toxoid consists of a 3-dose series administered by IM injection 4 weeks apart, after which horses receive annual boosters. Broodmares typically receive their annual vaccination 4-6 weeks prior to foaling to ensure high levels of antibody in colostrum. Foals then receive a 3-dose series (4 weeks apart) beginning at 2-3 months of age, then boostered at 12 months of age, and annually thereafter. This vaccine may be administered earlier than others because maternal antibody shows little interference with vaccination.

Potomac Horse Fever

Potomac Horse Fever (PHF) is caused by *Neorickettsia risticii*, a bacterial organism that is transferred to horses when they inadvertently ingest aquatic insects near rivers, streams, ponds, or marshland. Most infections are subclinical, but some horses develop fever, diarrhea, endotoxemia, and laminitis. Severe cases may be fatal or result in euthanasia of the case due to cost of management and/or occurrence of severe laminitis. In Minnesota most cases are seen from July to September. Young foals are less susceptible to this disease than adults. Commercial killed bacterin products are available but efficacy is questionable; clients should not expect prevention of disease in endemic regions. Not only is there little scientific evidence that vaccination induces protective immunity, but vaccines contain a single strain of *Neorickettsia risticii* while natural disease has been attributed to multiple field strains. Anecdotally, veterinarians in endemic regions believe that vaccination may reduce the incidence and severity of disease. Vaccinations should be timed to precede the peak period of exposure during summer/fall months. PHF is available as both a standalone vaccine and as a combination PHF-rabies vaccine. Initial vaccination of a previously unvaccinated adult horse with the killed bacterin consists of a 2-dose series administered by IM injection 3-4 weeks apart, after which the horse is boostered every 6-12 months depending on the regional level of exposure and risk of disease. Broodmares typically receive their annual vaccination 4-6 weeks prior to foaling. Foals then receive a 2-dose series (3-4 weeks apart) beginning at 5 months of age, and are then boostered at 12 months of age, and every 6-12 months thereafter.

Equine Viral Arteritis

Equine viral arteritis (EVA) is a viral disease of particular significance to the equine breeding industry. Infection is rarely life-threatening, but the virus can establish a long-term carrier state in breeding stallions and cause abortion in pregnant broodmares. The virus is transmitted in respiratory secretions and also in the semen from infected stallions. Most horses that become infected show no signs of disease, but clinical signs that do occur include fever, edema of the lower limbs and ventral abdomen, hives, serous nasal and ocular discharge, and abortion. Infection of intact males can result in a life-long carrier state within the reproductive tract, and these horses are the key reservoirs of infection within the population. A modified-live EVA vaccine is commercially available, and is considered safe and effective in stallions and non-pregnant mares. It is not widely used, but is reserved for use in specific circumstances. Reasons for vaccination include:

- To protect stallions against infection and subsequent development of a carrier state
- To immunize seronegative mares before being bred with known-positive semen
- To stop outbreaks in non-breeding populations

EVA is a reportable disease because of its significance to the breeding industry. When planning a vaccination program against EVA veterinarians should consult with state veterinary officials. Since is not possible to differentiate serological responses to vaccination from those induced by natural infection, horses being vaccinated for the first time are tested first to confirm that they are

seronegative. Vaccination status may also influence the ability to export a horse in future; vaccinated horses become seropositive and this can bar them from export to certain countries. Initial vaccination of a previously unvaccinated seronegative adult horse with the modified-live EVA vaccine consists of a single dose administered by IM injection, followed by annual boosters. Broodmares are vaccinated prior to breeding, and stallions are vaccinated approximately 4 weeks prior to the breeding season.

Rotavirus Diarrhea

Rotavirus is a major cause of infectious and contagious diarrhea in young foals. Adults can become infected and shed rotavirus in manure, but do not develop clinical disease. The virus is transmitted by the fecal-oral route and destroys small intestinal villi, leading to maldigestion, malabsorption, and profuse diarrhea. The manure from affected foals contains high levels of virus that cause widespread contamination of barns and paddocks. Fatality rates are low as long as foals receive adequate supportive therapy including fluids, electrolytes, and nutritional support. Although vaccination is a useful aid in reducing the incidence and severity of rotaviral enteritis, biosecurity procedures play an even more important role. An inactivated vaccine containing Group A rotavirus is commercially available, and is used on breeding farms with a history of significant rotaviral disease. This vaccine is not administered to foals, but to pregnant broodmares in late gestation with the goal of eliciting high levels of anti-rotavirus antibody in the colostrum. The vaccine is considered to be safe and effective. Pregnant mares receive a 3-dose series of IM vaccinations at 8, 9, and 10 months of

gestation. In order for colostral antibody to protect the foal, the foal must consume an adequate volume of colostrum and absorb the antibody it contains.

Anthrax

This is a rapidly fatal type of septicemia caused by the bacterium *Bacillus anthracis*. Horses and other species (including humans) become infected through ingestion, inhalation, or wound contamination by bacterial spores within the soil. Survival of spores is enhanced by alkaline soil conditions, so the disease tends to occur only in specific geographical regions, including pockets of North and South Dakota. Vaccination is warranted only for horses that are pastured in endemic regions. A single vaccine product is licensed for use in horses. It contains live non-encapsulated bacterial spores administered by subcutaneous injection. Vaccination of pregnant mares is not recommended. Initial vaccination of a previously unvaccinated adult horse consists of a 2-dose series (2-3 weeks apart) administered by subcutaneous injection, followed by annual boosters. If broodmares are vaccinated, this should be done when they are open (non-pregnant) prior to the breeding season. There is little information to guide vaccination programs in foals, and foals are more likely to experience adverse effects following vaccination compared to adult horses.

Leptospirosis

Leptospirosis is a zoonotic disease, caused by bacteria of the genus *Leptospira*. There are many different serotypes of disease and prevalence varies with geographic location.

Healthy horses may carry multiple serovars and clinical disease occurs sporadically. The serovar most commonly associated with disease in horses is pomona. Infection is acquired through exposure to the organism via the mucous membranes or abraded skin. The leptospiral organisms are shed in the urine of infected horses (additionally the placenta, fetal fluids, and urine of the mare in abortion cases) and a number of wildlife hosts can shed *Leptospira spp*. in the urine as well. Clinical manifestations of disease include inflammation within the eye (uveitis), late-term abortion, and acute renal failure. There is one vaccine approved for use in horses in the United States. It is a killed vaccine and is labeled for use in healthy horses 6 months of age or older. Duration of immunity of this product has not been determined. Vaccination will prevent animals from shedding leptospiral organisms in urine. Horses 6 months of age or older should receive two initial doses, 3-4 weeks apart with annual revaccination. The product can safely be used in mares up through the second trimester of pregnancy.

List your five (5) take-home points – What are things you want to remember from this chapter as you progress through the curriculum and into your career?

EXTRA RESOURCES

- AAEP Vaccine guidelines and vaccine charts, adults and foals: https://aaep.org/guidelines/vaccination-guidelines
- 2017 AAHA Vaccine guidelines: https://www.aaha.org/guidelines/canine_vaccination_guidelines.aspx
- 2015 WSAVA Vaccination guidelines for dogs and cats: https://www.wsava.org/guidelines/vaccination-guidelines
- Purpura hemorrhagica: https://ker.com/equinews/purpura-hemorrhagica-horses/
- Laminitis: https://www.merckvetmanual.com/musculoskeletal-system/lameness-in-horses/laminitis-in-horses

4.

Vaccines and Vaccinations: Production Animals

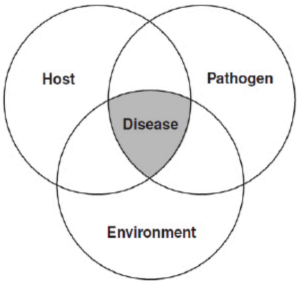
Learning Objectives

- Describe risks and management factors to consider when vaccinating cattle, small ruminants, and swine
- Describe cause and clinical manifestations of conditions for which we vaccinate cattle, small ruminants, and swine
- Explain where and how to vaccinate production animals
- Define what is meant by commercial, autogenous, and on-farm vaccine production
- Create appropriate vaccine protocols for cattle, small ruminants, and swine

DAIRY CATTLE

Dairy and beef cattle generally always live in a herd. Management practices will therefore affect multiple animals. Likewise, from an infectious disease standpoint, it has to be kept in mind that not one, but multiple animals will be exposed to a particular pathogen. As a result, the prevention of disease on dairy farms needs to be targeted towards groups of animals and the entire herd rather than individual animals. Disease prevention is crucial to allow the economic survival of the farm and to ensure animal welfare. Specific brands of vaccines will not be discussed for beef or dairy cattle because there is tremendous variability in vaccines used. Examples of diseases for which cattle may be vaccinated include bovine viral diarrhea (BVD), infectious bovine rhinotracheitis (IBR), parainfluenza (PI3), bovine respiratory syncytial virus (BRSV), leptospirosis, *Pasteurella*, *Histophilus* (*Hemophilus*), *Campylobacter* (*Vibrio*), and clostridial diseases. Specifics of vaccines and their use will be covered in species-specific coursework later in the curriculum. An example of which vaccines are used at which life stage is included in the section on beef cattle as are descriptions of the diseases we protect against with vaccination in cattle.

Risks and Management Factors



"The Epidemiological Triad", https://www.nap.edu/read/13147/chapter/1#xviii

Factors to Consider in Disease Prevention
Diseases occur due to multiple factors. Their relationship is sometimes called the infection triangle.All three factors (environment (e.g. management practices), host, and pathogen) are important for the development or prevention of disease and all three need to be considered during disease prevention.

The host has various defense mechanisms to prevent or to deal with infections. A given species or animal might not be susceptible to a certain disease. For example, *E. coli* O157:H7, a potentially fatal bacterium for humans, is a normal gut commensal for cattle. Cattle do not have the receptors for the toxins of this bacterium in their kidneys and so they cannot develop the hemolytic uremia syndrome that affects humans. Other defense mechanisms, specific and non-specific, are part of the immune system. These defense mechanisms may be impaired due to the animal's

age, inadequate nutrition, and other stressors from within the animal, or may be impaired due to management practices. Stress due to heat, weaning, malnutrition, infection pressure (amount of exposure to a given pathogen), transport, and other factors will negatively impact how the immune system can react to a "pathogen attack".

Furthermore, an infectious disease can only spread through a population if the pathogen 'finds' susceptible animals to infect. Some animals might get sick, but if a population (herd) has many resistant animals, the probability of new infections can be so low that the disease 'dies out' even if not all animals are resistant to the disease. This is called "herd immunity". In human medicine this principle is used every year as we receive flu shots. The aim is to reduce the number of susceptible humans through flu vaccinations and so reduce the likelihood of new infections, particularly in children and immunocompromised people.

So for obvious reasons, the environment and management practices play a crucial role in disease prevention on farm by influencing the animal and the pathogen. Any management practices that decrease the infection pressure on animals (for example, hygiene or biosecurity) will support animals in coping with infection pressure and will reduce the likelihood that animals will even get exposed to the pathogens.

Vaccination is only part of this puzzle and cannot be used as a standalone practice to prevent disease or infection on farm. Vaccination is not a miracle intervention. It does not result in immediate immunity or resistance against diseases in all vaccinated animals. First, it takes time for the immune system of the animal to react to the vaccine and second, just because an animal is vaccinated, it does

not automatically mean that the animal cannot be infected or develop the disease. However, vaccination can be used as one of many management practices to help animals cope with potential infection threats.

Vaccinating Production Animals

When thinking about vaccinating a dairy herd, you have to understand the production system and the diseases that are of importance for that particular dairy farm. You need to ask several questions:

- What management practices are already in use on this dairy farm and where could improvements possibly be made to decrease infection pressure? Examples include improving hygiene, not bringing in animals from unknown sources, and limiting foot traffic between age groups.
- Which pathogens are of concern for their impact on the health and production of animals? If an animal is unlikely to ever encounter a pathogen, it is probably not necessary (and is possibly too costly) to vaccinate against it. Do not over-vaccinate animals, and tailor the vaccine program toward each herd individually.
- Do benefits of a possible vaccination outweigh the costs of the disease or could vaccination be economically detrimental? For example, Foot-and-Mouth-Disease (FMD) has not been diagnosed in the United States since the 1920s and the detection of positive antibody titers in animals would result in serious trade

restrictions. Therefore, routine vaccination against FMD is probably not economically sound.

- When is the best time to vaccinate the animals? On farms, it is always groups of animals, not individuals, that are vaccinated with a given vaccine. The timing of the vaccination has to take into account which age groups are at the highest risk for diseases, how long it takes for an animal to build up immunity, when the animals are going to be handled for any reason, and when the potential stressors occur in an animal's life. For example, when is the best time to vaccinate a dairy cow against pathogens associated with calfhood diarrhea? Calves desperately need to ingest the antibodies in the colostrum of its dam (passive immunization) to allow them to handle infections until they were able to build their own immune response. The cow needs several weeks after vaccination to develop significant antibody concentrations that can be deposited into colostrum. So, keeping biology and management practices in mind, in this example, it is best to vaccinate the dam in the weeks before calving so the dam can deliver these antibodies through the colostrum to the calf to prepare the calf's immune system for a potential exposure in the first week of life.
- Read the label of the vaccines! What is the dosage and route for vaccine administration? How long will the immunity last? Some vaccines are for heifers only and some must not be given during pregnancy. Other vaccines (in

particular those against zoonotic pathogens) are to be administered by the veterinarian only. Additionally, you have to remember that you are administering a biological drug to a food production animal. Therefore, you need to consider withdrawal times to ensure safety of meat and milk from that animal as products from that animal may enter the human food chain. Withdrawal times may be based on the organism itself or on other components of the vaccine (for example, preservatives or adjuvants).

A producer tells you that he learned at an extension meeting that there are not withdrawal times for vaccines, only for drugs. What is your response?

BEEF CATTLE

The role of vaccines in a preventative health program for beef cattle is to prevent or eliminate clinical disease in an individual or a population of cattle. This is accomplished by decreasing the incidence and severity of disease through increased level of immunity as part of a preventive health program. No vaccine is 100% effective. Vaccines are part of a preventive health program that should include management procedures and handling, parasite control,

and nutritional considerations that reflect an in-depth understanding of not only the beef production system but also farm-specific issues and goals.

Factors to Consider in Developing a Vaccination Strategy

When developing a vaccination strategy, several factors must be considered. Some of these factors are:

- Class of cattle (age)
    - Nursing calves, weaned calves, yearling cattle, replacement heifers, pregnant cows, open cows, breeding bulls
- Production system the cattle are in
    - Cow-Calf, Stocker/Backgrounder, Feedlot
    - Open system (purchasing and bringing in cattle) vs. Closed system
- What to vaccinate for
    - Reproductive Diseases
    - Respiratory Diseases
    - Systemic Diseases
- Goals of the producer / history
    - Future plans, direction, etc.
    - Previous challenges/approaches
- Risk tolerance of the producer

    - High vs. Low
    - Expectations
- Facility availability / husbandry skills
    - Ease of handling, stress of handling
    - Labor needed/available
    - Compliance ability

Vaccination does not equal immunization, so designing the vaccine program also requires consideration of factors affecting immune response. These factors can include:

- Age of calf
    - The bovine's immune system begins to develop prior to birth but does not reach maximum responsiveness until later in life.
    - In addition there is thought to be "maternal interference" where passive immunity obtained through colostrum consumption may interfere with ability for young calves to respond to some vaccines.
- Nutritional Status
    - Current and previous nutritional status should be considered. Cattle that have been deficient in key components (protein, energy, vitamins, and minerals) may have a decreased ability to mount an immune response.
- Stressors

- Vaccines should be administered at times of low or minimized stress and, if possible, prior to expected stressors. Common stressors include environmental temperature, disease status, parasite load, transport, weaning, nutritional changes, handling, management practices (castration, dehorning, etc), and comingling.

- Timing of vaccination
  - The time between vaccination and challenge by infectious agents is important. If using a killed vaccine, you need adequate time for a booster dose when first administering.
  - Additional considerations such as time following parturition or prior to breeding, colostrum production, pregnancy status, and avoiding stressors are important as well.
  - Try to incorporate vaccination with other herd management procedures when possible to take full advantage of handling efficiencies; your goal is to minimize frequency of handling, which is a stressor.

Regarding vaccination of calves, describe stressors and timing to minimize those stresses and ensure an appropriate immune response.

Recommended Vaccination Schedules

Preventive health programs for beef cattle in the upper Midwest provide recommendations for vaccines at specific lifestages.

Calves

LIFESTAGE	RECOMMENDED VACCINE
Birth	• +/- Oral Scours vaccine • +/-IBR, PI3, BRSV(intranasal)
Branding (mid summer) or Prebreeding	• IBR, PI3, BRSV, BVD I & II • 7/8 way Clostridia (+/- tetanus) • +/- *Mannheimia-Pasteurella* • +/- Pinkeye (*Moraxella bovis*)
Preweaning	• IBR, PI3, BRSV, BVD I & II • *Mannheimia-Pasteurella* • 7/8 way Clostridia (+/- tetanus) • +/- *Histophilus (Hemophilus)*

Weaning	• IBR, PI3, BRSV, BVD I & II • +/- 7/8 way Clostridia (+/- tetanus)
At entry to feedlot (Variable; based on vaccine history and risk class)	• IBR, PI3, BRSV, BVD I & II • *Mannheimia-Pasteurella* • 7/8 way Clostridia (+/- tetanus) • +/- *Histophilus (Hemophilus)*
Revaccination (Variable; based on vaccine history and risk class)	• +/-IBR, PI3, BRSV, BVD I & II • +/-*Mannheimia-Pasteurella* • +/-7/8 way Clostridia (+/- tetanus) booster • +/- *Histophilus (Hemophilus)* booster

Beef Replacement Heifers

LIFESTAGE	RECOMMENDED VACCINES
Prebreeding 1 (8-10 months)	• IBR, PI3, BRSV, BVD I & II • 5 way Lepto • +/- *Lepto hardjo-bovis* • +/- Vibrio (*Campylobacter fetus*) • *Brucellosis*
Prebreeding 2 (30 days before breeding)	• IBR, PI3, BRSV, BVD I & II • 5 way Lepto booster • +/- *Lepto hardjo-bovis* booster • +/- Vibrio (*Campylobacter fetus*) booster • +/- 7/8 way Clostridia booster

Precalving 1 if on a fall (pregnant cow) vaccine schedule	• IBR, PI3, BRSV, BVD I & II (May use MLV if vaccinated prebreeding with MLV) • 5 way Lepto • +/- *Lepto hardjo-bovis* • +/- Vibrio (*Campylobacter fetus*) • +/-Scours vaccine	
Precalving 2 (5-7 weeks precalving)	• +/-Scours vaccine booster	
Move to cow schedule		

Adult Cows and Bulls

LIFESTAGE	RECOMMENDED VACCINES	
Fall Pregnancy Check or Prebreeding	• IBR, PI3, BRSV, BVD I & II • 5 way Lepto • +/- *Lepto hardjo-bovis* • +/- Vibrio (*Campylobacter fetus*) • +/- 7/8 way Clostridia booster	
Precalving (3-7 weeks precalving)	• +/- Scours vaccine booster	

Vaccination Risks and Methods

As in small animals, side-effects can occur with

vaccination in cattle. These include soreness/swelling/knots at the injection site, fever, off-feed, and potentially anaphylaxis (allergic reactions). “Endotoxin stacking,” the act of giving multiple killed bacterin vaccines (often Gram negative or Gram negative-like) vaccines together, has been associated with higher incidence of adverse reactions, failed immune response, and death.To minimize vaccine risks:

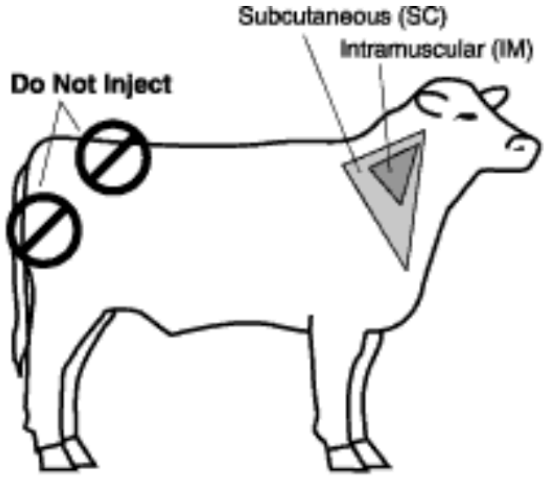
- Avoid the administration of more than two killed bacterin vaccines at the same time
- Do not shake killed bacterial vaccine such as clostridial (black-leg) products
- Never vaccinate on days where cattle are heat stressed
- Store vaccines properly
    - 35-45^{o}F, DO NOT FREEZE, and avoid sunlight
- Administer with proper care
- Only use licensed, quality vaccines

Beef Quality Assurance Vaccination Administration Guidelines

Any injection has the ability to cause a detectable lesion at slaughter. Beef Quality Assurance programs offer guidelines in proper administration of injectable products with the goal of maintaining

and increasing the quality of the end product.Some general recommendations include:

- Use vaccines labeled for subcutaneous route of administration whenever possible.
- Administer all vaccines in the neck region.
- Inject in a clean site.
- Replace needles frequently or use single use needles.
- Use an appropriately sized needle for the intended injection route.
- Use good sanitation when withdrawing vaccines.
- Use properly cleaned and maintained syringes.



"Injection sites", *https://www.ag.ndsu.edu/bqa/documents/injections*

Route of Vaccine Administration in Cattle

	Subcutaneous (SC) (1/2 to 3/4 inch needle*)			**Intravenous (IV)** (1 1/2 inch needle*)			**Int** (1 to 1
Cattle Weight (lbs)	<300	300-700	>700	<300	300-700	>700	<300
Gauge needle required for thin injectable viscosity (ex: saline)	18	18-16	16	18-16	16	16-14	20-18
Gauge needle required for thick injectable viscosity (ex: oxytetracycline)	18-16	18-16	16	16	16-14	16-14	18

*Select the needle to fit the cattle size (the smallest practical size without bending)

—*"Recommended needle size"*, *https://bqa.unl.edu/bqanebr-article-3*

Diseases to Vaccinate Against in Beef and Dairy Cattle

Diseases in beef and dairy cattle to vaccinate against, include:

- Bovine viral diarrhea (BVD)
- Infectious bovine rhinotracheitis (IBR)
- Parainfluenza (PI3)
- Bovine respiratory disease complex
- Leptospirosis
- Campylobacter
- Clostridial diseases
- Brucellosis

Bovine Viral Diarrhea

BVD is a common cause of respiratory and reproductive issues in the herd. It is an economically important disease in many countries. The disease is caused by the bovine viral diarrhea virus, which may cause primary disease or be part of a large complex of infections. Cows infected during pregnancy may abort, give birth to a stillborn calf, or give birth to a live calf. Calves can be infected *in utero* or after birth. Calves born carrying BVD virus will never clear the infection and will shed the virus continuously into the farm environment. Signs of BVD in adults are highly variable and include fever, lethargy, loss of appetite, ocular discharge, nasal discharge, diarrhea, and decreased milk production. Infected calves may have cerebellar hypoplasia; signs of this are ataxia, tremors, a wide stance, and failure to nurse.

Infectious Bovine Rhinotracheitis

IBR is a highly contagious, infectious respiratory disease that is caused by bovine herpesvirus I. It can affect young and older cattle. IBR causes acute inflammation of the respiratory tract; clinical signs include those of respiratory disease (mucosal hyperemia, erosive mucosal lesions, nasal discharge, coughing), and also conjunctivitis, abortion, and encephalitis. After the first infection, the virus is sequestered in neurons in the brain as a latent infection. At times of stress, the virus undergoes recrudescence and can be shed from the eyes and nose. Because an infected animal never clears the virus, animals that are seropositive for bovine herpesvirus 1 cannot be shipped into countries that are free of the disease and cannot be housed in artificial insemination (AI) centers. Carrier cattle should be identified and removed from the herd.

Parainfluenza

The PI3 virus infects the upper respiratory mucosa, where it is shed in aerosols (sneezing and coughing) and by direct contact. PI3 causes only respiratory disease. In mature cattle, infection is mild. The most important consequence of PI3 infection in bovine respiratory disease is that it predisposes animals to concurrent infection with IBR or bacterial respiratory pathogens.

Bovine Respiratory Disease Complex

Bovine respiratory disease complex is caused by a variety of pathogens, including the three above. Other organisms against which cattle may be vaccinated to minimize this disease complex are bovine respiratory syncytial virus (BRSV) and bacteria including *Pasteurella multocida, Mannheimia haemolytica,* and *Histophilus (*formerly *Hemophilus) somnus*. These pathogens interact with each other to cause disease. Disease is worsened in the