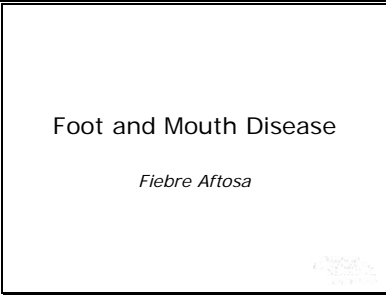


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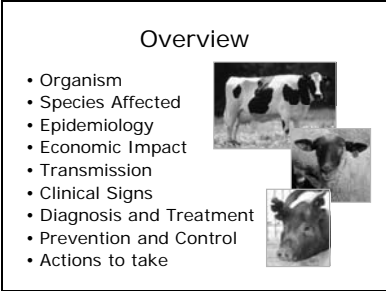


Foot and mouth disease (FMD) is a highly contagious viral disease that affects cloven-hooved livestock and wildlife. Outbreaks can severely disrupt livestock production, result in embargoes by trade partners, and require significant resources to control. Significant direct and indirect economic losses are not uncommon.

[Note to Presenter: Additional information to correspond with this presentation can be found in the CFSPH Technical Factsheet at <http://www.cfsph.iastate.edu/DiseaseInfo/factsheets.php>].

This presentation was last reviewed: December 2017

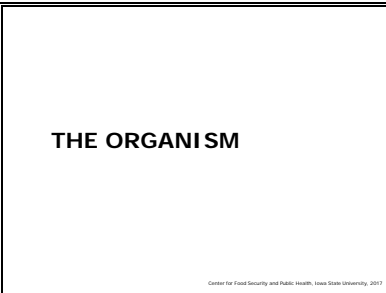
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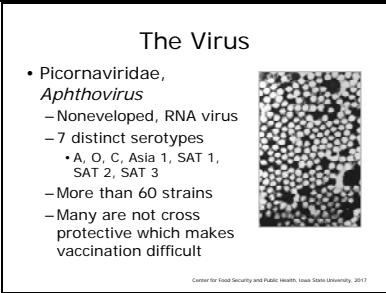
This presentation provides an overview of foot and mouth disease. It will describe the organism responsible for the disease, the epidemiology of the disease, and its impact on animal health. It will cover the species affected, how it is transmitted, prominent clinical and post mortem signs, and how the disease can be diagnosed and treated. Prevention and control measures for the disease will be discussed, as well as actions to take if foot and mouth disease is suspected.

[Photo sources: (Top) USDA ARS/Keith Weller; (Middle) Danelle Bickett-Weddle/CFSPH; (Bottom) Pam Zaabel/CFSPH]

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Foot and mouth disease is an ancient disease (described possibly as early as 350 BC) and has been recognized as one of the most significant epidemic diseases threatening livestock since the sixteenth century.¹ The causative agent (a virus) was not discovered until the late 19th century. FMDV is considered one of the first viruses of vertebrates to ever be discovered.¹ Since that time FMD has occurred in almost every part of the world, causing major losses in livestock.² Foot and mouth disease virus (FMDV), a small, nonenveloped RNA virus, that is a member of the genus *Aphthovirus* in the family Picornaviridae. There are seven major viral serotypes: A, O, C, Asia 1, and SAT (Southern African Territories) 1, SAT 2, and SAT 3. Serotype O is the most common serotype worldwide; other serotypes also cause serious outbreaks. Some FMDV serotypes are more variable than others, and collectively, there are more than 60 strains of the virus; new strains spontaneously develop. Immunity to one FMDV serotype may not protect an animal from other serotypes making effective vaccination difficult with new outbreaks. Protection from strains within a serotype varies with their antigenic similarity.

1. Mahy BW, Introduction and history of foot-and-mouth disease virus. *Curr Top Microbiol Immunol.* 2005;288:1-8
 2. Jamal SM, Belsham GJ. Foot-and-mouth disease: past, present and future. *Veterinary Research* 2013;44:116

[Photo: Electronmicrograph of the foot and mouth disease virus. Source: FBI Laboratory via Wikimedia Commons]

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The Virus

- Survival in the environment
 - Up to 3 months
 - Longer survival
 - In very cold climates
 - In the presence of organic matter
 - If protected from sunlight
- Inactivation at pH <6 and >9
 - Survives in bones, glands, milk, milk products

Center for Food Security and Public Health, Iowa State University, 2017

Information on the survival of FMDV in the environment is limited, but most studies suggest that it remains viable, on average, for three months or less. However, in very cold climates, longer survival – up to six months – may be possible. Additionally, the presence of organic matter, as well as protection from sunlight also promote longer survival times. The virus is sensitive to pH. It can be inactivated at pH below 6.0 or above 9.0. Due to this characteristic, the virus can persist in meat and other animal products when the pH remains above 6.0, but is inactivated by acidification of the muscles during rigor mortis. Since acidification does not occur to this extent in the bones and glands, FMDV may persist in these tissues. The virus can also survive in milk and milk products, with stability increasing at lower temperatures.

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Species Affected

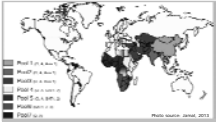
- Cattle, pigs, sheep, goats, yak, water buffalo
- Over 70 species of wild artiodactyls
 - Cervids: deer, elk, reindeer
 - African buffalo, bison, moose, wildebeest, giraffes, warthogs, others
- Experimentally: alpacas, llamas, Bactrian camels
- Other species: hedgehogs, bears, armadillos, kangaroos, nutrias, Asian elephants, capybaras
- Horses NOT susceptible

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FMDV primarily affects cloven-hooved (two-toed) mammals of the order Artiodactyla. Important livestock hosts include cattle, pigs, sheep, goats, water buffalo, and yaks. Other susceptible species include cervids such as deer, elk, and reindeer. Experimental infections in alpacas and llamas have been reported, but there have been no confirmed cases from the field. Experiments suggest Bactrian camels can develop FMD, but dromedary camels have little or no susceptibility. FMDV has been reported in at least 70 species of wild artiodactyls, including African buffalo, bison, giraffes, wildebeest, warthogs, several species of deer, antelopes and gazelles, and others. FMDV can also infect a few animals that are not members of Artiodactyla, such as hedgehogs, bears, armadillos, kangaroos, nutrias, and capybaras. Cases have been reported in captive Asian elephants, but there are few reports of FMDV in African elephants, and the latter species is not considered susceptible under natural conditions in southern Africa. Horses are not susceptible to FMDV.

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Geographic Distribution



Endemic in parts of Asia, Africa, the Middle East, and South America

Disease-free countries: North America, Iceland, Central America, New Zealand, Australia, western Europe

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FMD was once distributed worldwide. It has now been eradicated from many countries and regions. The disease is endemic in parts of Asia, Africa, the Middle East and South America. While serotypes O and A are widely distributed, SAT viruses occur mainly in Africa (and periodically in the Middle East) and Asia 1 is currently found only in Asia. North America has not had FMD reported for more than 60 years; Central America, New Zealand, Australia, Greenland, Iceland and western Europe are also free of FMDV. FMD outbreaks have occurred in Taiwan, South Korea, Japan, Mongolia, Britain, France, and the Netherlands. Recent outbreaks of FMD have occurred in Russia, Mongolia, and Korea. This map (from Jamal-open access article) shows a representation of the geographical distribution of various serotypes of the foot and mouth disease virus globally.

[Photo source: Jamal SM, Belsham GJ. Foot-and-mouth disease: past, present and future. Veterinary Research 2013;44:116. (open access article available at <https://veterinaryresearch.biomedcentral.com/articles/10.1186/1297-9716-44-116>)]

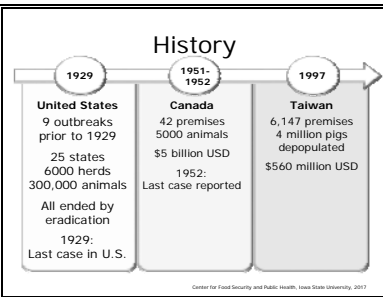
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Economic Impact	
<ul style="list-style-type: none"> • Direct costs <ul style="list-style-type: none"> – Loss of production – Loss of animals • Indirect costs <ul style="list-style-type: none"> – Eradication costs – Loss of trade/exports – Loss to affiliated industries – Consumer fear 	<ul style="list-style-type: none"> • Endemic countries <ul style="list-style-type: none"> – 6.5 to 21 billion USD per year • Previously FMD-free countries <ul style="list-style-type: none"> – Over 1.5 billion per year <p>Economically Devastating</p>

FMD is considered to be the most economically devastating livestock disease virus in the world. It results in direct losses due to the reduced production (e.g., decreased weight gains, decreased milk production), the loss of animals (e.g., increased mortality among young animals, abortions), as well as indirect costs such as loss of trade and eradication costs. Related industries, such as processing plants, feed suppliers, equipment manufacturers, food service and distribution, and textile industries that rely on agricultural products can also be impacted. Consumer loss of confidence could affect the cost of the food supply. Even though FMD is not a public health risk, consumption of red meat and dairy products could be reduced. It has been estimated that the costs associated with FMD in endemic areas ranges between 6.5 to 21 billion USD annually.^{1,2} Outbreaks in previously FMD-free countries are estimated to cost more than 1.5 billion USD per year.¹ Estimates of indirect costs due to lost exports for the U.S. have been estimated at \$6.3 billion in beef exports and about \$5.6 billion in pork exports each year.^{3,4}

- Paarlberg PL, Lee JG, Seitzinger AH. *Potential revenue impact of an outbreak of foot-and-mouth disease in the United States. JAVMA. 2002;220(7):988-992.*
- Knight-Jones TJD, Rushton J. *The economic impacts of foot and mouth disease - What are they, how big are they and where do they occur? Preventive Veterinary Medicine. 2013;112 (3-4): 161-173. Available at: <http://www.sciencedirect.com/science/article/pii/S0167587713002390?via%3Dihub>;*
- National Pork Board. *2016 U.S. pork exports show impressive progress. 2016. Available at: <http://www.pork.org/2016-u-s-pork-exports-show-impressive-progress/>.*
- U.S. Meat Export Federation. *Global beef exports held steady in 2016. Available at: <https://www.usmef.org/global-beef-exports-held-steady-in-2016/>.*

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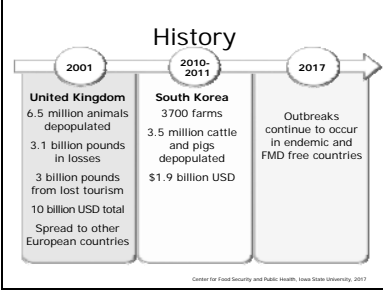


Let’s look at a few examples of some outbreaks. Prior to 1929, FMD was present in several U.S. states, generally due to the importation of infected animals or their products. The largest outbreak was in 1914 as the virus spread throughout a Chicago stockyard. In 1929, restrictions were imposed on imported animals and products from infected countries, reducing the number of outbreaks. All of the outbreaks were controlled by stop movement and eradication of affected herds. In all, the U.S. had 9 outbreaks of FMD, involving 25 states, nearly 6,000 herds, and more than 300,000 animals. The U.S. has remained FMD free since the last outbreak in 1929. Similarly, FMD outbreaks occurred in Canada and Mexico. From 1951–1952, Canada had an FMD outbreak that affected only 42 premises and led to the depopulation of fewer than 5,000 animals.¹ However, the outbreak still cost approximately \$722 million Canadian, plus one year’s loss of livestock and livestock product trade (nearly \$5 billion USD in 2015 dollars). This outbreak demonstrates that even a small outbreak can have substantial economic impacts. FMD has not been reported in Canada since 1952. Outbreaks have also occurred in Mexico; the last case of FMD occurred in 1953. A 1997 FMD epidemic in Taiwan resulted in the destruction of more than 4 million pigs on 6,147 premises. The epidemic cost the country roughly \$560 million USD when

indemnities, vaccines, carcass disposal, and loss of market value were considered.²

- *Sellers RF, Daggupaty SM. The epidemic of foot-and-mouth disease in Saskatchewan, Canada, 1951–1952. Can J Vet Res. 1990;54(4):457–64.*
- *Yang PC, Chu RM, Chung WB, et al. Epidemiological characteristics and financial costs of the 1997 foot-and-mouth disease epidemic in Taiwan. Vet Rec. 1999;145(25):731–4.*

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One of the largest foot and mouth disease outbreaks in recent history occurred in the United Kingdom in 2001. resulting in total estimated losses of approximately £3.1 billion (~\$6.3 billion USD dollars) from losses in agriculture and the food chain, plus an addition 2.7 to 3.2 billion pounds from lost tourism (roughly 10 billion U.S. dollars total).¹ The United Kingdom attempted FMD control and elimination through a ring depopulation and “stamping out” approach. All susceptible animals within a 3 kilometer radius, regardless of infection status, were depopulated. More than 4 million animals were destroyed to control this disease, and an additional 2.5 million were euthanized for welfare reasons. Despite all control and elimination efforts, the virus spread from the United Kingdom to Ireland and mainland Europe, including France and the Netherlands. A 2010-2011 outbreak in South Korea was the largest ever to be reported for that country, with about 3,700 farms affected. Both depopulation and emergency vaccination were implemented; nearly 3.5 million cattle and pigs were depopulated. This outbreak has caused estimated losses of nearly \$1.9 billion USD in 2015 dollars. Sporadic outbreaks continued to occur in South Korea during 2016 and 2017. These outbreaks have occurred despite vaccination efforts being used in the country since 2010. All of these outbreaks demonstrate that despite control efforts, the disease spreads quickly, affects large numbers of animals, and results in substantial economic impacts. Many countries had long periods of freedom from the disease prior to their outbreaks.

- *Thompson D, Muriel P, Russell D, et al. Economic costs of the foot and mouth disease outbreak in the United Kingdom in 2001. Rev Sci Tech. 2002;21(3):675–87.*
- *Carpenter TE, Kim H, Yoon H, et al. Direct costs of five foot-and-mouth disease epidemics in the Republic of Korea, from 2000 to 2011. Prev Vet Med. 2013;37(4):163–8.*
- *Park JH, Lee KN, Ko YJ, et al. Control of foot-and-mouth disease during the 2010–2011 epidemic, South Korea. Emerg Infect Dis. 2013;19(4):655–9.*

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TRANSMISSION




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Transmission	
• Virus in all secretions and excretions	– Enters body by inhalation, ingestion, skin abrasions, mucous membranes
• Respiratory aerosols	
• Direct contact	– Vesicular fluid
	– Ingestion of infected animal parts
• Indirect contact via fomites	– Boots, hands, clothing

FMDV is transmitted via direct or indirect contact with infected animals. The virus can be found in all secretions and excretions from acutely infected animals, including expired air, saliva, milk, urine, feces and semen, as well as in the fluid from FMD-associated vesicles, and in amniotic fluid and aborted fetuses in sheep. Transmission primarily occurs via respiratory aerosols and direct or indirect contact with infected animals and contaminated fomites. Aerosol transmission requires proper temperature and humidity; the virus may travel long distances. Virus is also found in large quantities in vesicle fluid; peak transmission usually occurs when vesicles rupture. Direct contact with vesicular fluid and contaminated animal parts can also spread the disease. Contact with contaminated fomites can also be a source of infection. People can act as mechanical vectors for FMDV, by carrying the virus on boots, hands, or clothing. Humans may rarely harbor FMD virus in their respiratory tract and may not be detected in nasal secretions following exposure after 12 hours.¹

- *Wright DV, Gloster J, et al. Short-lived carriage of foot-and-mouth disease virus in human nasal cavities after exposure to infected animals. Vet Rec. 2010 Dec 11;167(24):928-31.*

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Transmission		
		
Cattle	Swine	Sheep/Goats
Disease Indicators	Amplifying Host	Maintenance Host
Often first species to show signs	Produce large amounts of aerosolized virus	
Can carry the virus for up to 6 months Some animals may remain infected for up to 3-1/2 years	Rare, possibly carry the virus up to 28 days	Can carry/shed the virus for up to 4 months for goats and 12 months for sheep

Center for Food Security and Public Health, Iowa State University, 2017

FMDV carriers are defined as animals in which the virus can be found for more than 28 days after infection. Animals can become carriers whether or not they had clinical signs. How long an animal can remain a carrier of the virus varies with the species. Most cattle carry FMDV for six months or less, but some can remain persistently infected for up to 3.5 years. Cattle are considered indicator hosts because they are often the first species to demonstrate clinical signs. Pigs are not thought to become carriers; however, they are considered amplifying hosts, as they produce large amounts of aerosolized virus. The virus is shed for a short time and swine are not considered long-term carriers; there have been a few reports documenting the presence of viral nucleic acids after 28 days. Sheep and goats are considered maintenance hosts and may shed the virus for up to 12 months in sheep and up to 4 months in goats.

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DISEASE IN ANIMALS
<small>Center for Food Security and Public Health, Iowa State University, 2017</small>

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Morbidity/ Mortality
• Morbidity
– Up to 100% in naïve cattle and swine
• Mortality
– Adult livestock do not usually die
• 1-5% case fatality
– Deaths can occur in young animals
• Up to 94% lambs
• Up to 80% calves
• Up to 100% suckling piglets

Morbidity from FMD varies with the animal's species, breed and pre-existing immunity, as well as the dose of virus and other factors. The morbidity rate can approach 100% in naïve cattle or swine herds, but some FMD viruses can disappear from a sheep flock after infecting a relatively low percentage of the animals. Adult livestock do not usually die from FMD (the case fatality rate is approximately 1-5% for most strains), but deaths can occur in young animals. In lambs, reported mortality rates range from 5% to 94%. Mortality has also been reported to reach 80% in some groups of calves, and 100% in suckling piglets (with lower rates in older piglets).

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Clinical Signs

- Incubation period: 1-14 days
- Fever
- Vesicles
 - Feet, mouth, nares
 - muzzle, teats
- Lameness, reluctance to move, sloughing of hooves
- Abortion
- Death in young animals



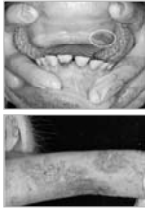
While there is some variability in the clinical signs between species, FMD is typically an acute febrile illness with vesicles (blisters) localized on the feet, in and around the mouth, and on the mammary gland. Vesicles (blisters) on the feet, mouth, nares, muzzle and teats are the characteristic lesions of FMD. The incubation period can vary with the species of animal, the dose of virus, the viral strain and the route of inoculation, but most infections usually appear in 2 days; some experiments report clinical signs in as little as 18-24 hours). Vesicles eventually progress to erosions which cause the affected animal to have clinical signs associated with the lesioned area. Pain and discomfort from the lesions leads to a variety of symptoms including depression, anorexia, excessive salivation, lameness and reluctance to move or rise. In severe cases, the hooves may be sloughed. Abortion can occur in adults and death in young animals without any other clinical signs. Animals generally recover in two weeks but secondary infections can lead to longer recovery time.

[Photo: Vesicles of hoof pad and ruptured vesicles of dewclaws of a pig. Source: USDA APHIS Foreign Animal Disease Diagnostic Laboratory and the U.S. Department of Homeland Security (DHS) Primus Visual Information Services at the Plum Island Animal Disease Center (PIADC)]

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Clinical Signs: Cattle

- Oral vesicles
 - Tongue, dental pad, gums, soft palate, nostrils, muzzle
 - Excess salivation, drooling, nasal discharge
- Reluctant to eat, loss of body condition




Cattle with FMD often have severe clinical signs. Clinical signs in cattle include oral lesions such as vesicles on the tongue, dental pad, gums, soft palate, nostrils or muzzle. This leads to excess salivation, drooling, and nasal discharge. Affected animals are typically reluctant to eat and may lose condition rapidly.

[Photo: Top: Linear erosion on dental pad with fibrin; Bottom: Multifocal and coalescing erosions and ulcers with fibrin on dorsal surface of tongue. Source: USDA APHIS Foreign Animal Disease Diagnostic Laboratory and the U.S. Department of Homeland Security (DHS) Primus Visual Information Services at the Plum Island Animal Disease Center (PIADC)]

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Clinical Signs: Cattle

- Teat lesions
 - Decreased milk production
 - Mastitis
- Foot lesions
 - Interdigital space
 - Coronary band
 - Lameness
 - Reluctant to move



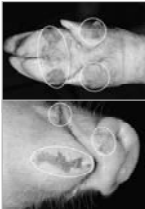
Teat lesions can occur and a decrease in milk production commonly results. Mastitis may also be a sequelae. Hoof lesions in the interdigital space and on the coronary band are also common- leading to lameness and a reluctance to move.

[Photos: Top: A ruptured vesicle on the end of the teat. Source: Plum Island Animal Disease Center/CFSPH; Bottom Extensive necrosis of interdigital skin with granulation tissue. Source: USDA APHIS Foreign Animal Disease Diagnostic Laboratory and the U.S. Department of Homeland Security (DHS) Primus Visual Information Services at the Plum Island Animal Disease Center (PIADC)]

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Clinical Signs: Pigs

- Hoof lesions
 - Coronary band, heel, interdigital space
 - Lameness
- Vesicles on snout
- Oral lesions less common
- Sudden death in young



Pigs usually develop the most severe lesions on their feet. In this species, initial signs may be lameness and blanching of the skin around the coronary bands. Vesicles then develop on the coronary band and heel, and in the interdigital space. The lesions may become so painful that pigs crawl rather than walk. The horns of the digits are sometimes sloughed. Vesicles are often seen on the snout. Mouth lesions are usually small and less apparent than in cattle; drooling is rare. Affected pigs may have a decreased appetite, become lethargic and huddle together. Young pigs (up to 14 weeks of age) may die suddenly from heart failure.

[Photos: Top: Multifocal deep ulcers, hoof pad, and dewclaws at the coronary band. Bottom: Ulcerative and erosive lesions of the skin on the lower jaw, lower snout, and the unilateral commissure. Source: USDA APHIS Foreign Animal Disease Diagnostic Laboratory and the U.S. Department of Homeland Security (DHS) Primus Visual Information Services at the Plum Island Animal Disease Center (PIADC)]

**Clinical Signs:
Sheep and Goats**

- Mild, if any
 - Fever
 - Lameness
 - Oral lesions
 - Decreased milk production
 - Abortion
 - Death of young



Although severe cases can occur, FMD tends to be mild in sheep and goats. Infected animals may be asymptomatic or have few lesions. Common signs in small ruminants are fever and mild to severe lameness of one or more legs. Vesicles occur on the feet but they may rupture and be hidden by foot lesions from other causes. Mouth lesions are often not noticeable and generally appear as shallow erosions. Vesicles may be noted on the teats, and rarely on the vulva or prepuce. Milk production may drop, and rams can be reluctant to mate. Significant numbers of ewes abort in some outbreaks. Young lambs and kids may die due to heart failure or from emaciation. The clinical signs in young animals can include fever, tachycardia and marked abdominal respiration, as well as collapse.

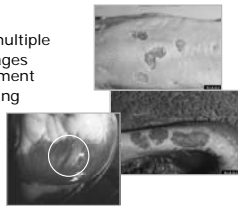
[Photo: Oral lesions on the tongue of a sheep. Source: Institute for Animal Health, UK at <http://www.bbsrc.ac.uk/news/food-security/2011/110505-pr-better-understanding-of-foot-and-mouth.aspx>]

	Cattle	Pigs	Sheep and Goats	Horses, Donkeys, Mules
All vesicular diseases produce a fever with vesicles that progress to erosions in the mouth, nares, muzzle, teats, and feet				
Foot and Mouth Disease	• Oral lesions, salivation, drooling, lameness, abortions, death in young animals	• Severe hoof lesions, hoof sloughing, lesions on snout (vesicles) • Less severe oral lesions	• Mild signs, if any	• Not affected
Vesicular Stomatitis	• Vesicles in oral cavity, mammary glands, coronary bands, interdigital space	• Same as cattle	• Rarely show signs	• Oral and coronary band vesicles • Draining cat mouths on objects • Lameness
Swine Vesicular Disease	• Not affected	• Lameness • Salivation • Neurological signs • More severe in young	• Not affected	• Not affected
Vesicular Exanthema of Swine	• Not affected	• Deeper lesions with granulation tissue formation on the feet	• Not affected	• Not affected
Senecavirus A	• Not affected	• Oral and feet lesions • Neurologic may be neurologic or nose diarrhea	• Not affected	• Not affected

Clinically, all vesicular diseases produce a fever with vesicles that progress to erosions in the mouth, nares, muzzle, teats and feet. Vesicular diseases are clinically indistinguishable from one-another, especially in swine as this chart shows. Any disease with vesicles and fever should be reported to a state or federal veterinarian.


Post Mortem Lesions


- Vesicles
 - Single or multiple
 - Various stages of development
 - Fibrin coating
- Sloughed hooves
- Tiger heart




The characteristic lesions of foot and mouth disease are single or multiple, fluid-filled vesicles or bullae; however, these lesions are transient and may not be observed. The location and prominence of FMD lesions can differ with the species ; however, common sites for lesions include the oral cavity and snout/ muzzle; the heel, coronary band and feet; the teats or udder; pressure points of the legs; the ruminal pillars (in ruminants); and the prepuce or vulva. The earliest lesions can appear as small pale areas or vesicles, while ruptured vesicles become red, eroded areas or ulcers. Erosions may be covered with a gray fibrinous coating, and a demarcation line of newly developing epithelium may be noted. The rumen pillars may also have vesicular lesions. In young animals, cardiac degeneration and necrosis can result in irregular gray or yellow lesions, including streaking, in the myocardium; these lesions are sometimes called “tiger heart” lesions.


[Photo: Top: Multiple large mucosal erosions and ulcers on tongue. Bottom: Irregularly shaped erosions on the pillar of the rumen mucosa. Source: Plum Island Animal Disease Center/CFSPH]

<p>S I D E 2 3</p>	<p style="text-align: center;">Differential Diagnosis</p> <ul style="list-style-type: none"> • Swine <ul style="list-style-type: none"> – Vesicular stomatitis – Swine vesicular disease – Vesicular exanthema of swine – Seneca Valley virus in swine • Cattle <ul style="list-style-type: none"> – Rinderpest, IBR, BVD, MCF, bluetongue • Sheep <ul style="list-style-type: none"> – Bluetongue, contagious ecthyma 	<p>Differential diagnosis in swine includes Seneca Valley virus, vesicular stomatitis, swine vesicular disease, vesicular exanthema of swine, foot rot, and chemical and thermal burns. In cattle, oral lesions later in the disease can resemble rinderpest, infectious bovine rhinotracheitis (IBR), bovine virus diarrhea (BVD), malignant catarrhal fever (MCF), and bluetongue. In sheep, the lesions can be confused with bluetongue, contagious ecthyma, and lip and leg ulceration.</p>
<p>S I D E 2 4</p>	<p style="text-align: center;">Sampling</p> <ul style="list-style-type: none"> • Before collecting or sending any samples, the proper authorities should be contacted • Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease 	<p>Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease.</p>
<p>S I D E 2 5</p>	<p style="text-align: center;">Clinical Diagnosis</p> <ul style="list-style-type: none"> • Vesicular diseases are clinically indistinguishable! • Suspect animals with salivation or lameness and vesicles • Laboratory testing essential 	<p>Clinically, vesicular diseases are indistinguishable from one another. However, if salivation and lameness are present with vesicular lesions, FMD should be considered a differential. Fever is often the first clinical sign; that should prompt examination of the mouth and feet for early lesions. Laboratory confirmation is necessary, as all vesicular diseases have almost identical clinical signs.</p> <p>[Photo: Several healing vesicles on this bovine tongue have yellow-tan margins. Source: Dr. D. Gregg, Noah's Arkive, Plum Island Animal Disease Center/CFSPH]</p>
<p>S I D E 2 6</p>	<p style="text-align: center;">Laboratory Diagnosis</p> <ul style="list-style-type: none"> • If you suspect FMD, contact your state or federal veterinary authority • Initial diagnosis <ul style="list-style-type: none"> – Virus isolation – Virus identification <ul style="list-style-type: none"> • ELISA, RT-PCR, complement fixation • Serology <ul style="list-style-type: none"> – ELISA and virus neutralization – Nonstructural protein 	<p>If you suspect FMD, contact the state or federal veterinary authority prior to obtaining samples. Samples must be properly obtained, securely packaged, and sent to authorized laboratories for diagnosis. Testing for foot-and-mouth disease varies with the stage of the disease and purpose of the test. The virus is generally identified with ELISAs or RT-PCR; however, complement fixation is still in use in some countries or for some purposes. Some serological tests used include ELISAs and virus neutralization tests, and are serotype specific. Because FMDV vaccines also induce antibodies to structural proteins, these tests can only be used in unvaccinated animals. Nonstructural protein (NSP) tests are not serotype specific, and can be used in both vaccinated and unvaccinated animals if the vaccines used have been purified to have the NSPs removed. However, they are less sensitive and may not detect cases with limited virus replication, including some vaccinated animals that become infected. Due to such limitations, serological tests that detect antibodies to NSPs are generally used as herd tests rather than individual animal tests.</p>

<p>S l i d e 2 7</p>	<p style="text-align: center;">Treatment</p> <ul style="list-style-type: none"> • No treatment available • Supportive care  <ul style="list-style-type: none"> • Quarantine • Movement controls 	<p>There is no specific treatment for FMD, other than supportive care. Due to the grave economic impact, infected or exposed animals may be destroyed or will be quarantined and animal movement controls placed to reduce risk of transmission.</p> <p>[Graphic: Do Not Enter sign. Source: Center for Food Security and Public Health]</p>
<p>S l i d e 2 8</p>	<p style="text-align: center;">DISEASE IN HUMANS</p>	
<p>S l i d e 2 9</p>	<p style="text-align: center;">Disease in Humans</p> <ul style="list-style-type: none"> • Not a public health concern • Clinical disease very rare <ul style="list-style-type: none"> – 40 cases since 1921 – Mild, short-lived and self-limiting – Flu-like signs and vesicular lesions – Entry through broken skin 	<p>Foot and mouth disease is not considered to be a public health problem, as infections seem to be very rare and their consequences mild. In the past, people who worked with FMDV in vaccine laboratories developed antibodies to this virus, but there were few clinical cases. One laboratory reported only 2 cases in more than 50 years. It may be that exposure to extremely large amounts of virus or a predisposing condition is necessary for infections. Only 40 cases of human FMD have been reported since 1921. Many of those were not confirmed with laboratory testing. Symptoms included vesicular lesions and influenza like symptoms and the disease was generally mild, short-lived, and self-limiting. Broken skin was a recognized route of entry for some human cases. Person-to-person transmission has never been reported.</p>
<p>S l i d e 3 0</p>	<p style="text-align: center;">PREVENTION AND CONTROL</p>	
<p>S l i d e 3 1</p>	<p style="text-align: center;">Prevention</p> <ul style="list-style-type: none"> • Strict import restrictions <ul style="list-style-type: none"> – Prohibit infected animals or contaminated foodstuffs fed to animals from FMD-affected countries • Heat-treatment of swill (garbage) • Travelers and belongings monitored at ports of entry 	<p>Import regulations help prevent FMDV from being introduced from endemic regions in infected animals or contaminated foodstuffs fed to animals. Waste food (swill) fed to swine is a particular concern. Heat-treatment can kill FMDV in swill; some countries have completely banned swill feeding due to difficulty in ensuring adequate heat-treatment protocols are followed. Global FMD control programs have recently been established to reduce virus circulation and the incidence of this disease. Government officials at ports of entry continue to monitor travelers and their belongings that have returned from an FMD area.</p>

S I d e 3 2	<p style="text-align: center;">Prevention: U.S.</p> <ul style="list-style-type: none"> • Federal response plans - FAD PReP – www.aphis.usda.gov/fadprep • State planning exercises • Suspicious lesions investigated • Biosecurity protocols for livestock facilities 	<p>The U.S. Department of Agriculture has upgraded the safeguarding measures in place to prevent introduction of FMDV into the United States. APHIS has developed federal response plans and strategies should FMD occur on U.S. soil. There are approximately 450 foreign animal disease diagnosticians (FADD) trained to investigate suspicious lesions and other unusual symptoms that private veterinary practitioners alert them to. Numerous states have also been involved in training exercises regarding actions to take if FMD is introduced. Producers should implement and follow strict, complete biosecurity protocols on U.S. livestock production facilities as their best means of prevention.</p>
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[Photo: Cover of the USDA Foreign Animal Disease Preparedness and Response Plan (FAD PReP) Foot-and-Mouth Disease Response Plan. Source: USDA]

S I d e 3 3	<p style="text-align: center;">Control</p> <ul style="list-style-type: none"> • Quarantines and movement restrictions • Depopulation • Cleaning and disinfection • Vector control • Vaccination • Combination of actions 	<p>Measures taken to control an FMD outbreak include quarantines and movement restrictions, euthanasia of affected and exposed animals, and cleaning and disinfection of affected premises, equipment and vehicles. Additional actions may include euthanasia of animals at risk of being infected and/or vaccination. Infected carcasses must be disposed of safely by incineration, rendering, burial, or other techniques. Proper disinfection of all contact premises and infected materials is also required. Various disinfectants including sodium hydroxide, sodium carbonate, citric acid, Virkon-S® are effective against FMDV. Iodophores, quaternary ammonium compounds, hypochlorite and phenols are reported to be less effective, especially in the presence of organic matter. Rodents and other vectors may be killed to prevent them from mechanically disseminating the virus. People who have been exposed to FMDV may be asked to avoid contact with susceptible animals for a period of time, in addition to decontaminating clothing and other fomites. Good biosecurity measures should be practiced on uninfected farms to prevent entry of the virus. A combination of response strategies may also be utilized.</p>
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[Photo: Top: The quarantine process is important to prevent the further spread of the disease. Source: Don Rush/USDA; Bottom: A burning pyre of animal carcasses. Source: www.bbc.co.uk]

S I d e 3 4	<p style="text-align: center;">Recommended Actions</p> <ul style="list-style-type: none"> • IMMEDIATELY notify authorities • Federal – Assistant Director (AD) www.aphis.usda.gov/animal_health/area_offices/ • State – State veterinarian www.usaha.org/menu_item/StateAnimalHealthOfficials.pdf 	<p>A quick response is vital for containing outbreaks in FMD-free regions. Veterinarians who encounter or suspect this disease should follow their national and/or local guidelines for disease reporting. In the U.S., state or federal veterinary authorities should be informed immediately. Animals suspected with FMD should be isolated, and the farm quarantined until definitive diagnosis is determined.</p>
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[Photo: Quarantined farm that was FMD positive in the UK in 2001. Source: Katie Steneroden/CFSPH]

S I d e 3 5	<p style="text-align: center;">Vaccination</p> <ul style="list-style-type: none"> • Vaccine may be used in an outbreak • May be used in endemic regions • Vaccination issues <ul style="list-style-type: none"> – serotype specific – Re-vaccination required <ul style="list-style-type: none"> • Costly, time consuming – Does not protect against infection, but prevents or lessens clinical signs <ul style="list-style-type: none"> • Spread infection to other animals 	<p>Vaccination may be used during an outbreak to reduce the spread of FMDV or protect specific animals (e.g. those in zoological collections) during some outbreaks. The decision to use vaccination is complex, and varies with the availability of vaccine, scientific, economic, political and societal factors specific to the outbreak. Vaccines are also used in endemic regions to protect animals from illness. FMDV vaccines only protect animals from the serotype(s) contained in the vaccine. Semi-annual or annual re-vaccination may be required to maintain immunity; this is very costly and time consuming. The FMD vaccine does not protect against infection, but it prevents or lessens the severity of clinical manifestations.</p>
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Vaccination

- Killed vaccine, serotype specific
- North American Foot-and-Mouth Vaccine Bank
- Monitor disease outbreaks worldwide
- Stock active serotypes and strains
- Essential to isolate virus and identify the serotype to select correct vaccine

In the U.S., a decision to vaccinate during an outbreak would be made by USDA officials in consultation with state, and local officials. Limited quantities of FMD vaccines (killed, serotype specific preparations) are available to members (U.S., Mexico, Canada) of the North American Foot and Mouth Vaccine Bank (NAFMDVB). The NAFMDVB is housed at the USDA Foreign Animal Disease Diagnostic Laboratory (FADDL). The scientists at this biosafety-3 level lab monitor outbreaks worldwide to stock the NAFMDVB with the FMD antigens from the most active serotype or strains of the virus. Since FMD has 7 different serotypes and more than 60 subtypes and there is no universal vaccine. It is essential to isolate the virus and identify the serotype to select the correct vaccine.

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The OIE classifies countries and regions as FMD-free without vaccination, FMD-free with vaccination, suspended FMD-free status with or without vaccination, and unrecognized. This map shows OIE Member countries recognized as free from FMD. Those shaded in dark green are free from FMD without vaccination, those in lighter green are free from FMD with vaccination. Countries in red had their FMD free status suspended in October 2017 due to a recent outbreak.

[Photo: Map showing the FMD status of OIE Member countries worldwide-some of which implement routine vaccination. Source: World Organization for Animal Health. <http://www.oie.int/en/animal-health-in-the-world/official-disease-status/fmd/en-fmd-carte/>. October 2017]

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Additional Resources

- World Organization for Animal Health (OIE)
 - www.oie.int
- USDA FAD PRoP Materials and References
 - www.aphis.usda.gov/fadprep
- The USDA FMD Response Plan: the "Red Book"
 - www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf
- Center for Food Security and Public Health
 - www.cfsph.iastate.edu
- USAHA Foreign Animal Diseases ("The Gray Book")
 - http://www.aphis.usda.gov/emergency_response/downloads/naheims/fad.pdf

Additional resources on FMD may be found at the following sites.

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Additional Resources

- Secure Beef Supply
 - www.securebeef.org
- Secure Milk Supply
 - www.securemilksupply.org
- Secure Pork Supply
 - www.securepork.org
- FMD Pocket Guide for Domestic and Feral Swine
 - <http://www.cfsph.iastate.edu/products/>
- FMD Pocket Guide for Cattle
 - <http://www.cfsph.iastate.edu/products/>

Center for Food Security and Public Health, Iowa State University, 2017

USDA APHIS has developed the Foreign Animal Disease Preparedness and Response Plan (FAD PRoP) materials to raise awareness, develop capabilities, and enhance the coordinated response to an animal disease outbreak. The materials present a comprehensive U.S. preparedness and response strategy for FAD threats, both zoonotic and non-zoonotic. The USDA also has a resource, termed the Red Book, which details management of infected premises. Finally, a suite of materials, termed Secure Beef Supply, Secure Pork Supply, and Secure Milk Supply, that focus on maintaining a safe and wholesome supply of beef, pork, and milk products to consumers should an FMD outbreak occur in the U.S. [Photos: Covers of the FMD Pocket Guides. Source: Center for Food Security and Public Health]

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