THESIS

THE USE OF ON-LINE CONTINUING EDUCATION MODULES TO IMPROVE AWARENESS OF AFRICAN HORSE SICKNESS AMONG U.S. EQUINE VETERINARIANS

Submitted by

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ABSTRACT

THE USE OF ON-LINE CONTINUING EDUCATION MODULES TO IMPROVE AWARENESS OF AFRICAN HORSE SICKNESS AMONG U.S. EQUINE VETERINARIANS

U.S. equine veterinary practitioners will likely be responsible for the detection and reporting of a foreign animal disease (FAD) incursion, such as African horse sickness (AHS), into the U.S. On-line continuing education is one method of increasing awareness about FADs among equine veterinarians by providing a consistent message that can be conveniently accessed by most veterinarians. Two major types of on-line continuing education include webinar and text formatted modules.

An on-line educational assessment study for equine veterinarians was developed to determine baseline knowledge of AHS as well as the effectiveness of webinar versus text formatted education modules. The results from this study imply that the participants were not initially prepared to recognize and report a suspect case of AHS. Additionally, the webinar and text formatted modules were equally effective in educating the equine veterinarians about AHS.

The low voluntary participation rate in the study implies that on-line continuing education is not currently the best method for preparing equine veterinarians in the U.S. for an FAD outbreak. If equine veterinarians become more willing to participate in on-line education based on the new requirements for accreditation, or if incentives/penalties are

used to promote on-line continuing education participation, this continuing education method may become more accepted by U.S. equine veterinarians in the future.

ACKNOWLEDGEMENTS

The completion of my Master's thesis could not have been achieved without the exceptional guidance and commitment from my graduate committee. Each member brought a diversity of experience and knowledge in their instruction.

My sincerest gratitude goes to Dr. Traub-Dargatz, who not only encouraged my decision to go to graduate school, but provided constant mentoring and support throughout my program. I have been looking for a mentor my entire adult life, and I am forever grateful for her friendship. Dr. Salman was responsible for my first opportunity to work in the area of veterinary epidemiology prior to graduate school; I am very appreciative of the doors he opened for me. His in-depth knowledge about epidemiological studies and prioritizing the needs of his students despite his demanding schedule made this thesis a reality. Dr. Gillette's and Dr. O'Keefe's knowledge about communication was critical for the development of the educational assessment study in Chapter 2.

The quality of the AHS educational assessment study was also improved by non-committee members. Much thanks goes to Dr. Rao, who patiently guided me through the statistical procedures. Dr. Cordes assessed the AHS education module content and was instrumental to the design of the case scenario. Dr. White verified my AHS educational module content and contributed the graphic photographs of the AHSV infected equids.

Most importantly, I would like to thank my amazing husband and daughter. Not only did my husband assist with the technical aspects of the continuing education

module development, but he provided me with endless encouragement and support. Finally, my daughter graced me with much needed laughter and love every day.

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CHAPTER 1

Literature Review: African Horse Sickness and On-line Education for U.S. Veterinarians

Introduction

African horse sickness (AHS) is an infectious, non-contagious disease caused by the arbovirus African horse sickness virus (AHSV) (Van Regenmortel et al., 2000) and transmitted by the insect vector *Culicoides imicola* (Boorman et al., 1975). It is considered the most lethal disease of horses with a case fatality rate of up to 95% (Theiler, 1921; Coetzer and Guthrie, 2004; White and Cordes, 2008).

AHSV is considered endemic in parts of South Africa (S. Africa), and outbreaks have occurred throughout Africa and outside Africa in countries surrounding the Mediterranean Sea. AHS would be considered a foreign animal disease (FAD) if it occurred in the U.S. Drs. William White (Foreign Animal Disease Diagnostic Laboratory) and Timothy Cordes (Veterinary Services) recently identified contributing factors, such as the distribution of horses, climate, and the presence of a proven experimental insect vector in the U.S. that could potentially support a focal outbreak of the virus (White and Cordes, 2008).

The first section of this chapter will provide a detailed description of AHS, discuss possible implications of AHSV for the U.S., and review the following topics:

- AHS epidemiology,
- AHS pathogenesis, clinical signs, and pathologic findings.
- AHS distribution and control strategies, and
- Reporting of suspect case(s) of an FAD or emerging animal disease.

The second section will discuss the use of on-line education as a format for preparing veterinarians to detect and report an FAD in the U.S.

African Horse Sickness

AHS Epidemiology

Vertebrate hosts

AHSV infects all equids, with horses being the most susceptible to clinical disease that causes a severe morbidity and high case fatality rate of between 50 to 95%. Mules have a similar morbidity to horses, but with a lower case fatality rate of between 50-70% (Coetzer and Guthrie, 2004). Donkeys and zebras are very resistant to the disease, and usually just develop subclinical infection (Theiler, 1921; Barnard, 1993; Coetzer and Guthrie, 2004). Donkeys of the Middle East can have a case fatality rate of up to 10%, and may be more susceptible to clinical disease than the South African donkey (Alexander, 1948; Hamblin et al., 1998; Coetzer and Guthrie, 2004). Zebras only show mild fever when experimentally infected with the virus (Erasmus et al., 1978; Coetzer and Guthrie, 2004).

Zebras maintain year-round infections and are considered a reservoir host for the virus in endemic regions (Davies and Otieno, 1977; Barnard, 1993; White and Cordes, 2008). AHSV has also been isolated in blood samples 40 days post-infection in zebras. In comparison, in experimentally challenged horses, viremia usually lasts 4-8 days, but does not exceed 21 days (Barnard et al., 1994; Coetzer and Guthrie, 2004). Donkeys were considered potential reservoirs, but the absence of viral antigens after 14-19 days post-infection make donkeys unlikely long term hosts, although they may play a small role in spread of the virus (Hamblin et al., 1998).

Theiler demonstrated that AHSV can be transmitted to dogs, and causes a similar pathology as in horses (Theiler, 1906). Dogs are likely to be dead-end hosts for the virus (Braverman and Chizov-Ginzburg, 1996). The most common way for a dog to become infected with the virus is through the consumption of uncooked meat from an infected horse carcass, as was the case in Pretoria in 1980 (Van Rensburg et al., 1981).

Insect vector

In 1944, Du Toit proved that the wild-caught *Culicoides* midges were infected with AHSV (Du Toit, 1944), and in 1975, Boorman et al. demonstrated the midges' ability to replicate and transmit the virus (Boorman et al., 1975). There are over 1,400 *Culicoides* species (spp.) that can be found on most large land masses worldwide, with the exception of Antarctica and New Zealand (Meiswinkel et al., 2004; Mellor et al., 2000).

Culicoides imicola (C. imicola) is the principal insect responsible for AHSV transmission. The importance of *C. imicola* to AHSV transmission has been recognized for over 50 years (Meiswinkel et al., 2000; Mellor and Hamblin, 2004). *C. imicola* has historically been found in Africa and Southeast Asia (Meiswinkel et al., 2004; White and Cordes, 2008).

Recently, this midge has become more widespread in Europe, especially near the Mediterranean basin. *C. imicola* was first detected in southern Spain in 1982, and now is widespread in this area. This expansion of the primary AHSV insect vector's geographic range contributed to outbreaks of AHS in Spain (1987-1990), Portugal (1989), and Morocco (1989-1991) (Mellor et al., 1990; Mellor and Hamblin, 2004).

Culicoides bolitinos (C. bolitinos) has also been proven to be a competent natural vector of AHSV in S. Africa, and is considered an important insect vector in areas of Africa where *C. imicola* is less abundant (Meiswinkel et al., 2000).

There are three *Culicoides* spp. present in the U.S. each with different geographical distributions: *C. sonorensis, C. variipennis, and C. occidentalis* (Figure 1.1). In 1975, *C. sonorensis* was proven by Boorman et al. to transmit AHSV into embryonated hen eggs with exposed air sac membranes (Boorman et al., 1975). Therefore, *C. sonorensis* is the most likely potential vector if AHSV came into U.S. since it was proven to be a competent experimental vector. *C. sonorensis,* found in the southern and western U.S., is also believed to be the primary vector for the ruminant *Orbivirus*, bluetongue disease virus in the U.S. (Mullens et al., 1995; Tabachnick, 1996).

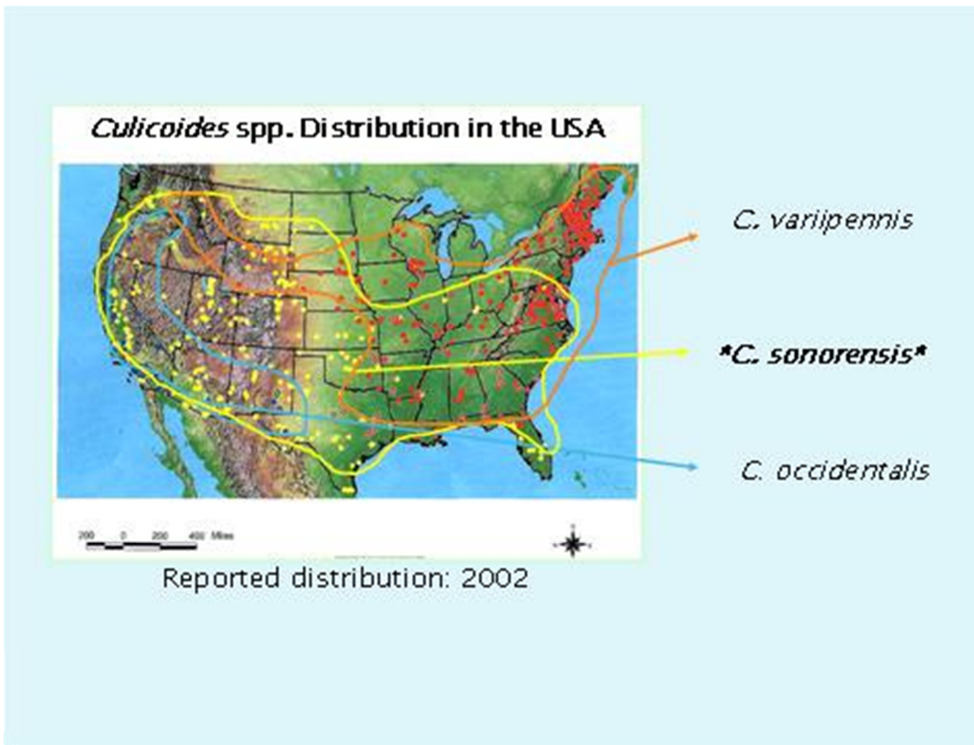

Figure 1.1. *Culicoides* spp. distribution in the U.S. (Drolet, 2010). This figure illustrates the location of three *Culicoides* species, *C. variipennis, C. sonorensis, and C. occidentalis*, found in the U.S. *C. sonorensis* is considered an experimental vector for AHSV.

Culicoides spp. life cycle

The transmission of AHSV by the vector *Culicoides* spp. leads to a seasonal incidence of the disease due to temperature and moisture requirements for different life cycle stages. The *Culicoides* spp. life cycle consists of the transformation of the *Culicoides* spp*.* from egg, larva, pupa, to adult (Kettle, 1984) (Figure 1.2). Adult females generally require a blood meal prior to the development of eggs (Mullen, 2009). The development of the eggs requires approximately seven to ten days, and the eggs are then laid in batches on moist substrates (Mullen, 2009). For *C. imicola*, an average of 69 eggs are laid per batch (Meiswinkel et al., 2004). The eggs turn from white to dark in color, and are small and elongated (250-500 μm) (Mullen, 2009). Eggs generally hatch in approximately three days under favorable conditions (temperatures between 21-24°C (70-75°F) for *C. imicola*) (Meiswinkel et al., 2004).

The larvae that hatch from the eggs consist of a well-sclerotized head, 11 slender, cylindrical body segments, and no appendages. Respiration is cutaneous and mobility is obtained by swimming using sinuous flexions of their body (Kettle, 1984). The larvae require a high moisture habitat, rich in organic matter; additional habitat requirements differ among the species (Braverman et al.,1974; Meiswinkel et al., 2004). The development of the larvae varies from two weeks to more than a year, depending on the species and ambient temperature (Kettle, 1984; Mullen, 2009).

There are four larval stages. Overwintering usually occurs during the fourth stage, allowing for pupation in spring or early winter (Mellor et al., 2000; Mullen, 2009). The pupae consist of a fused head attached to the thorax and a segmented abdomen (Kettle, 1984). Pupation generally occurs near the surface of the substrate, so respiration can be maintained by tubular prothoracic horns that penetrate the surface (Kettle, 1984; Mullen, 2009). Mobility is achieved by a pair of caudal spines (Kettle, 1984). Pupation is a short stage, and the pupae are transformed into winged adults generally after a few days (Kettle, 1984).

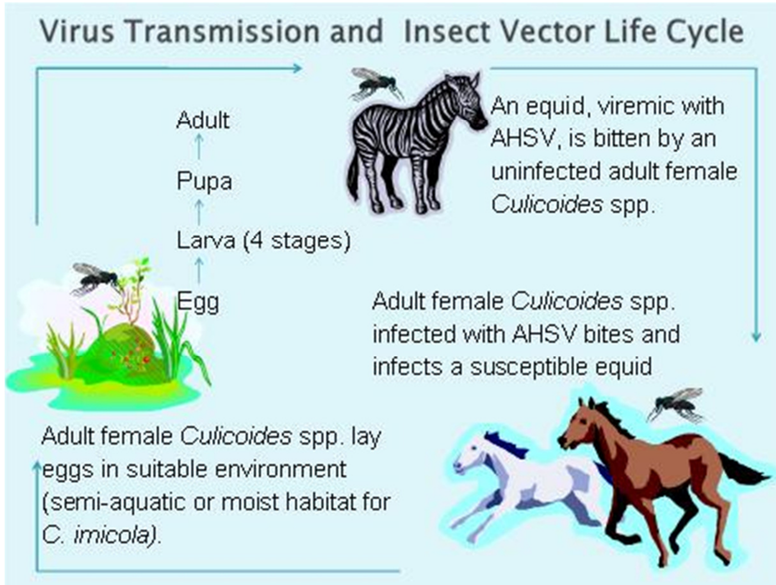

Figure 1.2. Virus transmission and insect vector life cycle. This figure illustrates the transmission of AHSV virus from an infected equid host, to an infected insect vector, finally to an AHSV susceptible equid. The *Culicoides* spp. life cycle consists of the transformation of the *Culicoides* spp. from egg, larva, pupa, to adult.

Most adult species are crepuscular and therefore are most active at twilight (Mellor et al., 2000; Mullen, 2009). Only adult females blood feed and they are responsible for the transmission of AHSV to the vertebrate host (Mellor et al., 2000). The life span for the adult midge is short, and under natural conditions, they typically only survive a few weeks (Mellor et al., 2000; Mullen, 2009). Adult midges can be found year-round in areas where freezing does not occur (Meiswinkel et al., 2004), but replication of the virus in the insect does not appear to occur below 15°C (59°F) (Mullens et al.,1995).

The basic breeding site requirements for *Culicoides* spp. include moist conditions and a medium containing organic material. These sites can range from areas almost strictly aquatic in nature, to areas where there is no free water but high humidity, depending on the species of *Culicoides*. Many *Culicoides* spp., including *C. imicola*, breed in moist organically enriched soil, however the *C. bolitinos* midge breeds in livestock dung, where the humidity is close to 100% (Meiswinkel et al., 2004). Four broadly defined breeding sites for *Culicoides* include surface water/soil interface situations, animal manure, tree-holes, and rotting vegetation (Meiswinkel et al., 2004). Adult midges generally do not actively migrate further than 500m from their breeding sites (Kettle, 1984). However, these insects can be passively transported over several hundred kilometers by wind currents (Gloster et al., 2007).

Pathogen

In the 1800s, S. African farmers believed AHS was a type of malaria that was contracted by eating dew laden grass. During this time, some scientists thought AHS was actually anthrax or caused by another type of bacterial spore. An experiment by M'Fadyean proved that the AHS was not anthrax by demonstrating that the pathogen was smaller than any known bacteria (M'Fadyean, 1900).

AHS is caused by African horse sickness virus (AHSV), a member of the genus *Orbivirus*, subfamily *Sedoreovirinae* and the family *Reoviridae* (ICTV, 2009; Van Regenmortel et al., 2000). The viron (Figure1.3) is approximately 70 nm in diameter (Polson and Deek, 1963), is non-enveloped and consists of a double-layered icosahedral capsid with 32 capsomeres (Van Regenmortel et al., 2000).

The double-capsid particles contain seven structural proteins (VP1-VP7), with the outer capsid made up of VP2 and VP5, and the inner capsid (the core) made up of VP3 and VP7 (major proteins) and VP1, VP4, and VP6 (minor proteins) (Roy et al., 1994). Among the capsid proteins, VP2 has been shown to be the most variable, responsible for most of the antigenic variation of the virus (Iwata et al., 1992; Mellor and Hamblin, 2004), and is the major target of the host's neutralizing antibodies response (Burrage et al., 1993; Roy et al., 1994).

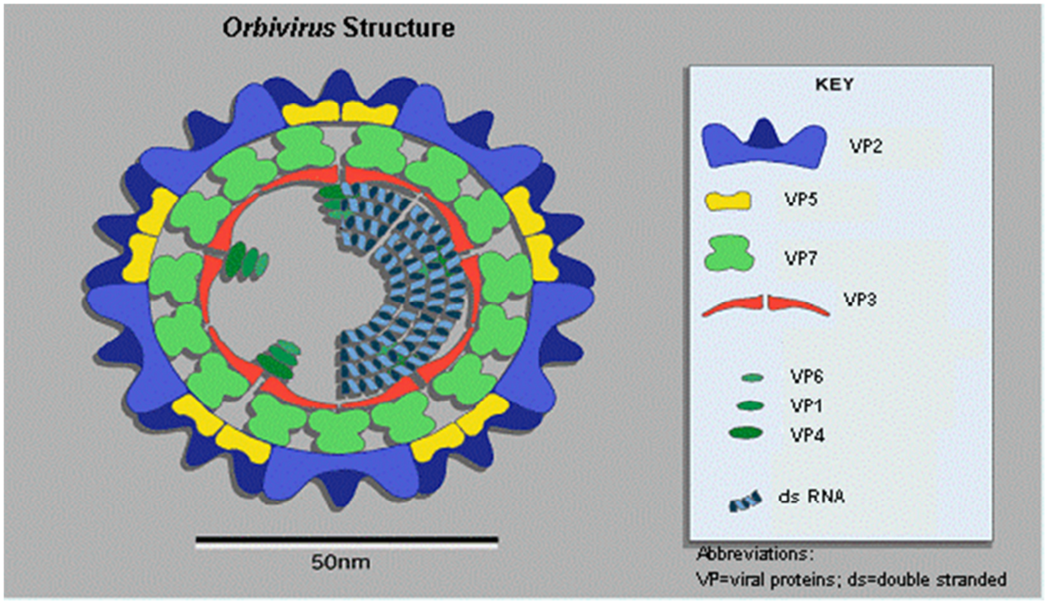

Figure 1.3. *Orbivirus* structure (Van Regenmortel, 2000). This figure illustrates the seven structural proteins (VP1-VP7), with the outer capsid made up of VP2 and VP5, and the inner capsid (the core) made up of VP3 and VP7 (major proteins) and VP1, VP4, and VP6 (minor proteins).

The capsid core surrounds the genome, and is composed of 10 double-stranded RNA segments. The genome encodes VP1-VP7 and four non-structural proteins, NS1-NS3, and NS3A (Roy et al.,1994; Coetzer and Guthrie, 2004).

In 1957, Mc Intosh established the existence of seven distinct immunological types of horse sickness virus (Mc Intosh, 1958), and experimentation by Howell in 1962 identified two additional new isolates (Howell, 1962). Today, these nine serotypes are found throughout East and S. Africa; serotypes 1 and 8 are usually found only in restricted areas of sub-Saharan Africa (Mellor and Hamblin, 2004).

Most recently, serotype 1 was isolated in non-wild equids in an AHS outbreak starting in February 2011 in the Mamre area of Western Cape Province, S. Africa. The final outbreak report in June 2011 listed 64 confirmed cases (60 deaths) and 14 suspect cases (five deaths) (Davey and Grewar, 2011; OIE, 2011). The Western Cape is usually free of the disease, although serotype 1 was isolated in a 2004 AHS outbreak (Sinclair, 2006).

Both AHSV 4 and AHSV 9 cause of the majority of the outbreaks outside the sub-Sahara (Wilson et al., 2009). AHSV 9 may not be particularly virulent among West African horses, but has proven to be virulent when introduced to a naïve horse population (Rawlings et al., 1998).

The virus infectivity is most stable at a pH between eight and nine, and decreases when the pH falls outside this range, especially at a more acidic pH due to the loss of outer coat proteins (Van Regenmortel et al., 2000; Coetzer and Guthrie, 2004).

The virus remains stable at 4℃ (39℉) and can be stored at this temperature for at least one year without loss of infectivity. Freezing the virus at -25℃ (-13℉; home freezer temperature) will decrease infectivity by up to 90% (Van Regenmortel et al., 2000; Coetzer and Guthrie, 2004). Because it is non-enveloped, AHSV is considered resistant to inactivation by detergents (Van Regenmortel et al., 2000; Coetzer and Guthrie, 2004).

AHSV is considered endemic in northeastern parts of S. Africa, primarily Mpumalanga Province (Lord et al., 2002; Coetzer and Guthrie, 2004) (Figure 1.4), but outbreaks regularly occur in other parts of S. Africa (Lord et al., 2002; Coetzer and Guthrie, 2004).

In addition, major outbreaks of the virus have recently occurred in regions with close proximity to the Mediterranean Sea, such as in the Middle East (1959-1961), North Africa (1965, 1989, 1991), Spain (1966,1987-1990) and Portugal (1989) (Rodriguez et al., 1992; Coetzer and Guthrie, 2004; Mellor and Hamblin, 2004; OIE, 2008) (Figure 1.5).

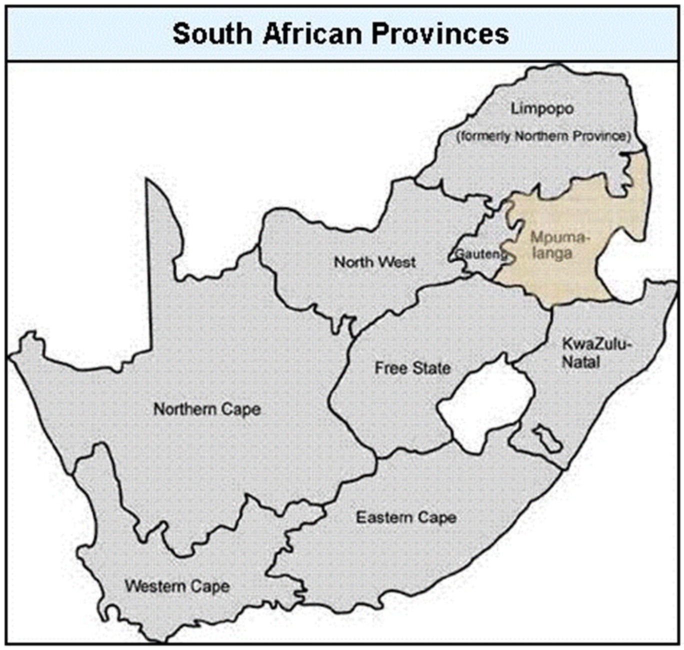

Figure 1.4. South African Provinces (Mercer, 2008). This map illustrates the AHSV endemic zones in northeastern part of S. Africa (indicated with brown shading).

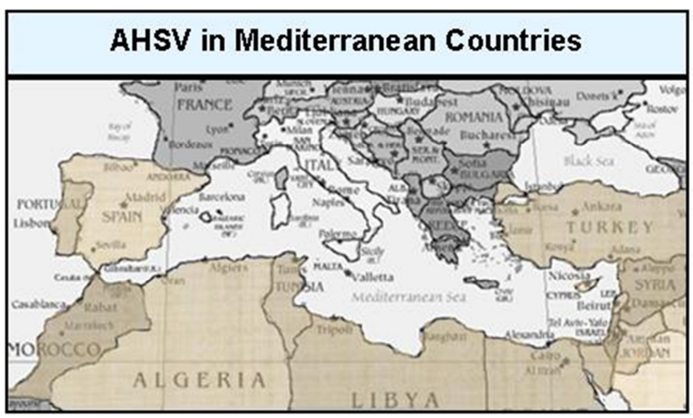

Figure 1.5. AHSV in Mediterranean Countries (Mediterranean Map, 2011).This map illustrates outbreaks of AHSV in regions surrounding the Mediterranean Sea (indicated with brown shading).

AHS Pathogenesis, Clinical Disease, and Pathologic Findings

Pathogenesis

Infection with AHSV in susceptible equids leads to virus multiplication in lymph nodes near the site of the insect bite. After viral replication in lymph nodes, a primary viremia follows and AHSV is disseminated into endothelial cells in vessels of target organs, primarily the lungs, heart, and spleen (Brown et al., 1994; Gomez-Villamandos et al., 1999; Coetzer and Guthrie, 2004). Virus multiplication at the target organs is followed by a secondary virema (Coetzer and Guthrie, 2004).

The pathology caused to endothelial cells includes, but is not limited to: hypertrophy, degenerative changes, changes in permeability of vessels, and loss of endothelium (Gomez-Villamandos et al., 1999).

Clinical disease develops in susceptible animals after an incubation of about five to seven days, depending on virulence and dose of virus (Theiler, 1921; Coetzer and Guthrie, 2004). While AHSV causes severe morbidity and mortality in the majority of infected horses, the pathogenesis and clinical disease that develop differ among cases. This difference is not completely understood, but is a function of both host factors (genetics and immune status) and virus factors (dose, route of infection in experimental inoculations, and virulence phenotype) (Burrage and Laegreid, 1994).

Clinical signs and pathology

The clinical signs of infection in horses are categorized into four clinicopathological forms (Theiler, 1921):

1. Pulmonary form,
2. Cardiac form,
3. Mixed form, and
4. Horse sickness fever form.

These categories are still relevant in describing the clinical disease (Coetzer and Guthrie, 2004), and enhance the understanding of AHS pathogenesis (Burrage and Laegreid, 1994).

1. Pulmonary form

The pulmonary form, also known as dunkop ('thin head'), occurs due to infection with a virulent type of AHSV, resulting in a short incubation time of three to five days (Theiler, 1921). This peracute form consists of a rapid rise in body temperature, peaking at approximately 41°C (105-106°F) within three days (Theiler, 1921; Coetzer and Guthrie, 2004). Characteristically, very few indicators of disease will be present until the temperature peak, but these may include lethargy or inactivity associated with the development of a fever (Laegreid et al., 1993).

After the body temperature peaks, sweat develops first on the muzzle and ears, then extends onto the body including the neck, flank, and inguinal region (Theiler, 1921). The horse becomes severely dyspneic and will stand with its head and neck extended, and front legs spread. Anorexia is not an indicator of disease and may not occur until the terminal stage of disease (Theiler, 1921; Mellor and Hamblin, 2004).

The respiratory rate will be between 40-60 bpm after the body temperature peaks, and will increase to 80-100 bpm in terminal stage of disease (Theiler, 1921). The horse's nostrils become distended and coughing often occurs, resulting in expulsion of a frothy yellow discharge that passes through the nostrils (Figure 1.6). The frothy fluid discharge, which occurs with the equid in lateral recumbency, is an indicator of the impending death, occurring minutes to hours later (Theiler, 1921; Laegreid et al., 1993).

Figure 1.6. Abundant frothy nasal discharge in a horse with AHS (White, 2010).

The case fatality rate for horses with the pulmonary form of the disease is approximately 95%, occurring around seven days post-infection (Theiler, 1921; Laegreid et al.,1993).

The characteristic pathology that accompanies this form includes pulmonary edema with hydrothorax (Figure 1.7). The edema will cause increased lung weight and will prevent the lungs from collapsing upon opening the thoracic cavity (Coetzer and Guthrie, 2004).

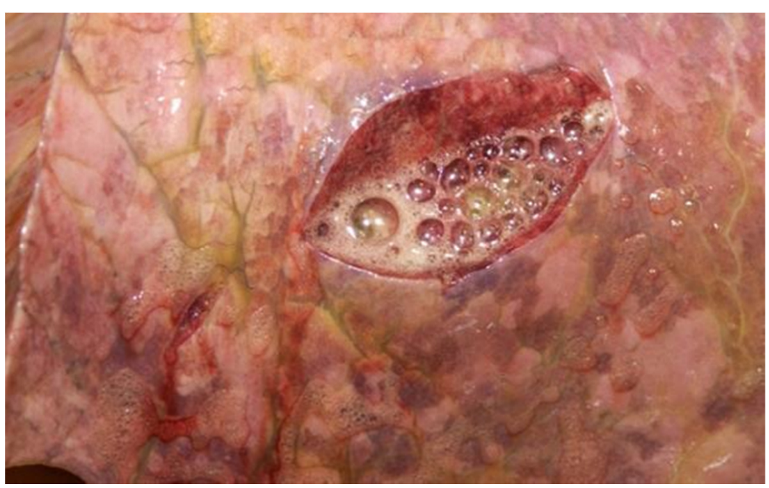

Figure 1.7. Severe pulmonary edema in a horse with AHS (White, 2010).

The thoracic cavity may be filled with several liters of pale yellow fluid that may coagulate when exposed to air (Theiler, 1921; Coetzer and Guthrie, 2004). The subpleural tissue and interlobular septa are usually distended with a serofibrinous yellow fluid, while the pharynx, trachea, and bronchi may be filled with a yellow froth (Theiler, 1921) (Figures 1.8 and 1.9).

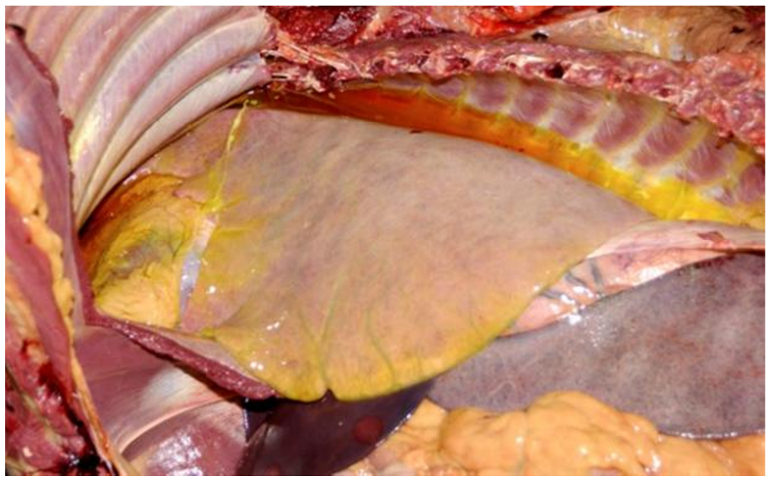

Figure 1.8. Severe pulmonary edema with hydrothorax; edema widening the interlobular septa and subpleural space in a horse with AHS (White, 2010).

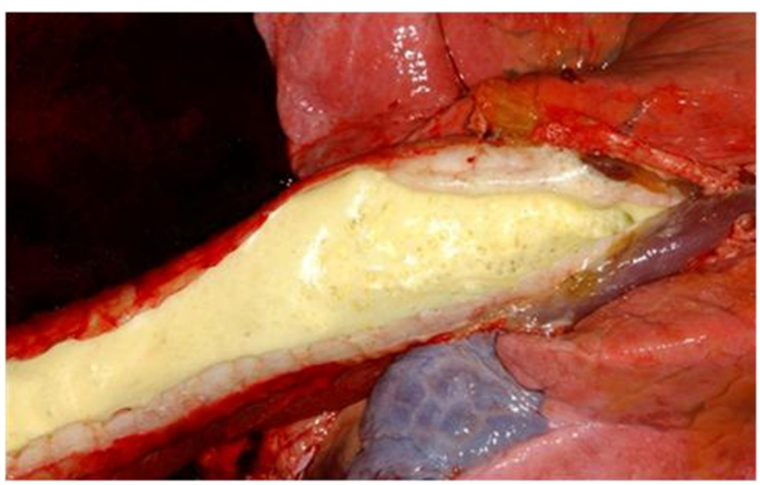

Figure 1.9 Abundant froth in the trachea of a horse with AHS (White, 2010).

Pulmonary edema of both the alveolar and interstitial tissues is composed of fibrin, eosinophils, and other inflammatory cells, resembling bronchopneumonia (Mauer and McCully,1963).

The mediastinal and bronchial lymph nodes are enlarged and edematous (Theiler, 1921), and epi- and endocardial hemorrhages may be present (Coetzer and Guthrie, 2004). In the abdominal cavity, ascites may be present in addition to hepatic and gastric congestion (Theiler, 1921; Mauer and McCully, 1963; Coetzer and Guthrie, 2004).

2. Cardiac form

The cardiac form, also known as dikkop ('thick head'), is the sub-acute form of AHS. It has a typical incubation of five to seven days followed by a febrile period that lasts eight to ten days (Theiler, 1921). The body temperature peaks at 39-40°C (102-104°F), approximately, 12 days post-infection (Theiler, 1921; Coetzer and Guthrie, 2004).

The clinical signs for this form of disease include subcutaneous edema of the head and neck, including swelling in the area of the supraorbital fossa, and severe heart disease (Theiler, 1921; Coetzer and Guthrie, 2004). These lesions usually occur at around 14 to 15 days post-infection, after the body temperature has begun to decline, but may occur earlier if the infection is more severe, often resulting in death (Theiler, 1921). Like the pulmonary form, anorexia is not a feature in the cardiac form of disease (Mauer and McCully, 1963). The case fatality rate for this form is approximately 50%, occurring four to eight days after the onset of fever (Coetzer and Guthrie, 2004).

The characteristic pathological changes seen in the cardiac form of AHS include gelatinous exudates found in the subcutaneous, subfascial, and intramuscular tissues (Mellor and Hamblin, 2004) (Figure 1.10). The parotid and submaxillary lymph nodes are also markedly increased in size (Theiler, 1921).

Figure 1.10. Intermuscular edema in the cervical area in a horse with AHS (White, 2010).

Primary cardiac changes include hydropericardium and hemorrhagic lesions on the epi- and endocardium (Theiler, 1921; Coetzer and Guthrie, 2004; Mellor and Hamblin, 2004) (Figures 1.11 and 1.12). Microscopic lesions of the heart can vary from focal myocardial hemorrhage to acute degeneration of myocardial fibers (Maurer and McCully, 1963; Guthrie, 2007).

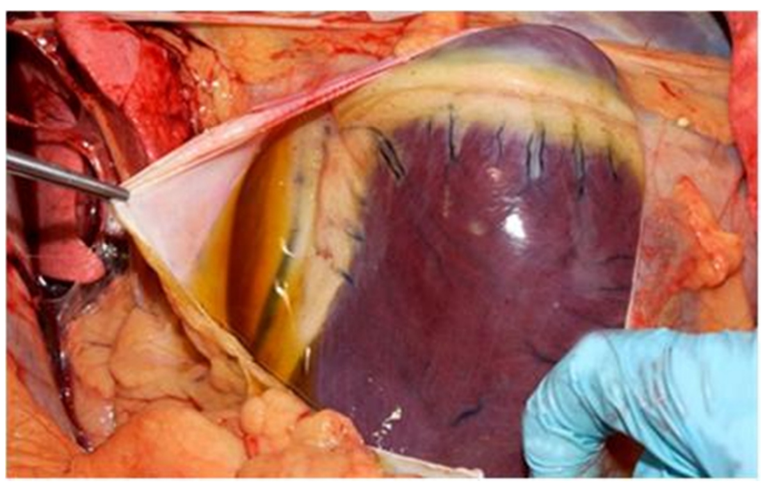

Figure 1.11. Moderate hydropericardium in a horse with AHS (White, 2010).

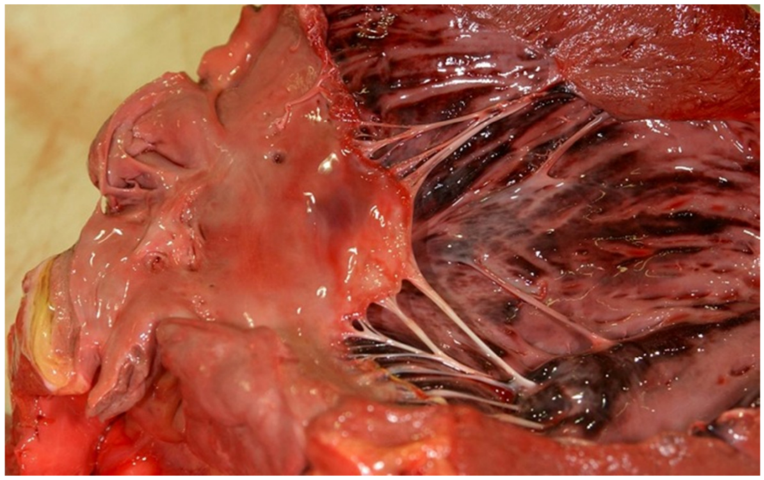

Figure 1.12. Marked endocardial hemorrhages in the left cardiac ventricle in a horse with AHS (White, 2010).

Lesion in the abdominal cavity may include hepatomegaly, splenomegaly, mild nephrosis, and ascites (Theiler, 1921; Coetzer and Guthrie, 2004; Mellor and Hamblin, 2004). Also, lesions the gastrointestinal tract are often most severe in the cardiac form and include edema and petechiation of the lower gastrointestinal tract (Coetzer and Guthrie, 2004) (Figure 1.13).

Figure 1.13. Serosal petechiation and congestion in the large colon of a horse with AHS (White, 2010).

3. Mixed form

The mixed form of AHS is characterized by clinical and pathological signs found in both pulmonary and cardiac forms of disease. Clinically, this form may be difficult to diagnose in the field because clinical signs of either the pulmonary or cardiac form may predominate and can occur concurrently (Coetzer and Guthrie, 2004). Both dsypnea with nasal discharge as well as swelling in the area of the supraorbital fossa may be present. Additionally, respiratory and heart rates are elevated (Mauer and McCully, 1963). Death occurs in approximately 70% of cases, three to six days after onset of fever (Coetzer and Guthrie, 2004).

Characterization of AHS is most often classified based on gross lesions at necropsy. The mixed form is considered the most common form of disease based on experimental challenge studies (Mauer and McCully, 1963), although this has not been proven in a field setting. This form may commonly occur because disease in the heart can lead to pathology in the lungs or vice versa (Mauer and McCully, 1963).

4. Horse sickness fever form

The horse sickness fever form of AHS is the least virulent form, and it typically occurs in zebras and donkeys who are more resistant to the disease than are horses. This form also occurs in horses with partial immunity (Coetzer and Guthrie, 2004).

The incubation period is five to seven days, which is followed by a slow rise in body temperature over five days. The body temperature peaks between 38-41°C (102-106°F) then gradually returns to normal over several days (Theiler, 1921). An elevated pulse of 40-44 bpm may be observed as well as mild lethargy, followed by recovery (Theiler, 1921).

No gross or microscopic changes are associated with the horse sickness fever form of the disease (Burrage and Laegreid, 1994).

Diagnosis:

AHS should be suspected based on the epidemiology, clinical signs, and macroscopic lesions, but definitive diagnosis is made through appropriate laboratory testing (Coetzer and Guthrie, 2004). AHS could be confused with other equine infectious diseases such as equine encephalosis, equine infectious anemia, equine morbillivirus pneumonia (Hendra virus), equine viral arteritis, equine piroplasmosis, and anthrax (OIE, 2008; CFSPH, 2011). It also shares similar clinical signs with an immune-mediated disease, purpura hemorrhagica (OIE, 2008). Other non-infectious diseases that result in pulmonary edema or sudden death could also be confused with AHS, such as various types of intoxication or accidental electrocution (CSFPH, 2011; Cordes, 2011). If AHSV entered the U.S., it would most likely cause a focal outbreak of disease (White and Cordes, 2008), and since AHSV is an arbovirus and not directly contagious, only a limited number of horses within a herd would be infected, although there may be a cluster of cases in a geographic region.

AHS is an OIE (World Organization for Animal Health)-listed disease (Class A in the old classification system) (OIE, 2010), suspected cases in the U.S. should immediately be reported to regulatory veterinary authority before diagnostic samples are acquired (Guthrie, 2007). The *OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* provides a detailed description of the diagnostic samples necessary for laboratory confirmation (OIE, 2008).

Virus isolation and neutralization

The intracerebral neutralization test in mice developed by Alexander in 1935 led to the original serotyping of the antigenic types of AHSV (Alexander, 1935). More commonly, virus isolation for identification and virus neutralization for serotyping (Hazrati and Ozawa, 1965; OIE, 2008) can be completed by the inoculation of cell cultures, such as baby hamster kidney-21 (BHK-21) (Mirchamsy and Taslimi, 1963), monkey stable

(MS) (Ozawa and Hazrati, 1964) or African green monkey kidney (Vero) (Ozawa, 1967) mammalian cell lines.

Diagnostic samples used for virus isolation include unclotted whole blood collected from febrile equids and two to four-gram tissue sections of equine spleen, lung, and lymph nodes collected during necropsy. All diagnostic samples should be kept at 4℃ (39℉) during transportation and storage (OIE, 2008).

Laboratory confirmation of AHSV using virus isolation takes two to ten days post inoculation of cell cultures, while serotyping using virus neutralization can take five or more days (OIE, 2008).

ELISA and RT PCR

In the U.S. and other countries where AHS is considered an FAD, a more rapid laboratory confirmation of disease is required in order to effectively implement control strategies in a timely manner. The advent of group specific enzyme-linked immunosorbent assay (ELISA) and reverse transcription polymerase chain reaction (RT-PCR) provides rapid confirmation of infection. Both tests have been described as highly sensitive and specific (Hamblin et al., 1992; Saileau et al., 2000).

The ELISA provides rapid result (within hours) to confirm or rule out the presence of AHSV antigens in a sample (Hamblin et al., 1992; OIE, 2008). Diagnostic samples used for the ELISA include undiluted spleen homogenates or inoculated cell culture supernatants (OIE, 2008).

RT-PCR assays have recently been developed that can provide serotyping within 24 hours (Sailleau et al., 2000). Sample types tested include cell culture supernatants, blood, serum, or tissue homogenates (OIE, 2008).

The OIE suggests that more than one diagnostic test be performed to detect the virus. Screening tests such as ELISA or RT-PCR provide rapid preliminary results, but these tests should be followed with virus isolation in tissue culture for confirmation (Hamblin et al., 1992; OIE, 2008).

Treatment

Supportive care is the only available treatment for equids infected with AHSV. Rest is critical for at least four weeks after infection. Development of secondary infections should be monitored and treated appropriately (Guthrie, 2007).

Lessons Learned from Previous *Orbivirus* Outbreaks

Reference to a clinical disease compatible with AHS in Africa occurred as early as 1569 (Theal, 1899; Theiler, 1921), according to a documentation of Franciso Baro's exploratory journey to East Africa. Horses brought from India to East Africa died after expelling "yellow matter," a characteristic clinical sign of horses infected with AHSV (Theal, 1899; Theiler, 1921). The virus causing AHS was not officially documented until 1719 when 1,700 imported naïve horses died of AHS at the Cape of Good Hope in S. Africa (Theiler, 1921).

Climate conditions affect the timing of S. African AHS outbreaks. Outbreaks tend to be cyclical and are associated with the warm (El Niño) phase of the El Niño/Southern Oscillation (ENSO). A drought followed by heavy rainfall, occurring approximately every 10-15 years (Baylis et al.,1999) in this region provides ideal *Culicoides* spp. breeding conditions. This cyclical pattern was first noticed during the late 18th and 19th century in districts that surround the Cape with an estimated 70,000 total equine deaths occurring during an 1854/55 epizootic (M'Fadyean, 1900; Theiler, 1921; Barnard, 1998). By 1913, AHS was no longer considered just an S. African disease as it could be found in the southwestern, the southern, and eastern portions of Africa (Theiler, 1921).

Outbreaks of AHSV outside the endemic areas of S. Africa have been associated with equine movement. A 1965 AHS outbreak in North Africa was believed to be due to movement of nomads and their equids across the Sahara from endemic areas (Pilo-Moron et al., 1969; Mellor and Hamblin, 2004). The 1987-1990 AHS outbreak in Spain can most likely be attributed to importation of infected zebras from Namibia into a safari park near Madrid, and AHSV may have spread to Portugal and Morocco through movement of the insect vector (Rodriguez et al., 1992).

Climate change has been a contributing factor in the expansion of the geographic distribution of *C. imicola* into Europe. Climatic conditions that result in high environmental temperatures and humidity impact the location of major AHS outbreaks due to their influence on *C. imicola's* breeding sites (Braverman, 1974; Calvete et al., 2008). Climate change, including high environmental temperatures and precipitation above average in regions of Europe (Purse et al., 2005), has resulted in the expansion of a suitable habitat for *C. imicola*, and could play a role in the northern spread of AHSV (Calvete et al., 2008). For example, the first reported outbreak of AHSV-2 recently occurred in the Northern Hemisphere (Fasina et al., 2008). Additional support that climatic conditions have allowed for an expansion of the *C. imicola* range is the occurrence of bluetongue virus (BTV) in Europe.

Like AHSV, BTV is also a member of the *Orbivirus* genus that shares the *C. imicola* as a primary insect vector (Van Regenmortel et al., 2000; Capela et al., 2003). Prior to 2006, BTV was limited to the latitudes of 40°N and 35°S due to the insect vector range (Purse et al., 2005) (Figure 1.14). However, a BTV epizootic in Western Europe in 2006 proved that *C. imicola* ranged as far as latitude 58°N (Calvo et al., 2009; Wilson and Mellor, 2009). The expansion of BTV into Western Europe has resulted in concern that AHSV could spread to this latitude as well. In 2008, at the United States Animal Health Association, Infectious Diseases of Horses Committee (IDOHC) meeting, the northern spread of African horse sickness was presented, as well as the potential spread of the virus to the U.S. (White and Cordes, 2008).

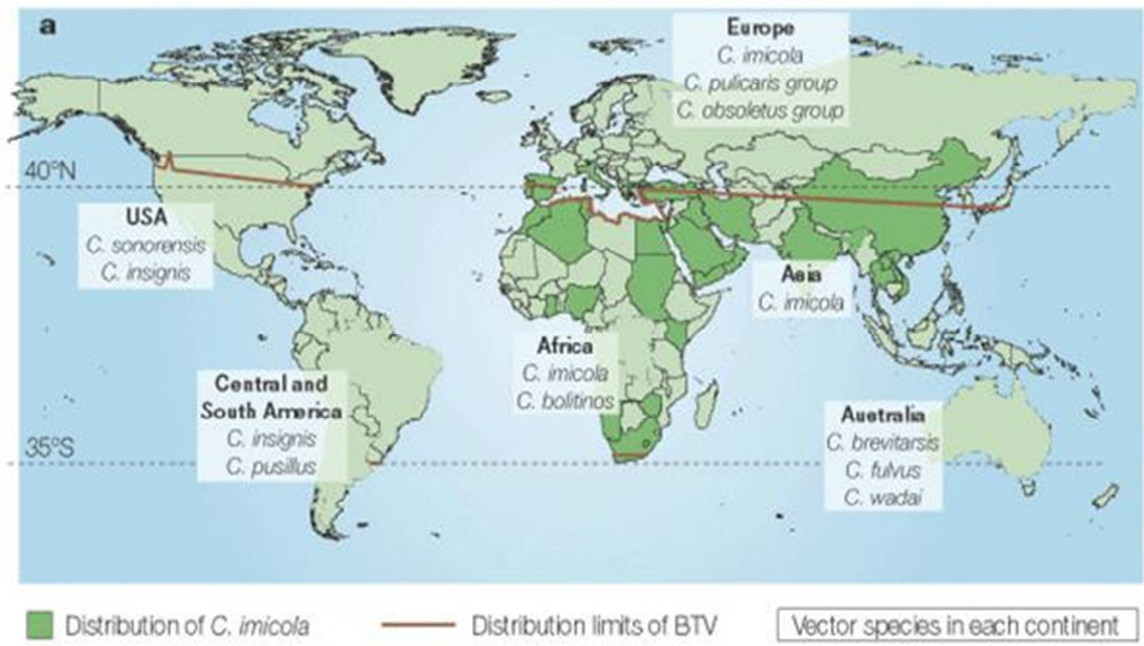

Figure 1.14. Distribution of BTV and *Culicoides* spp. prior to 2006. BTV was thought to be broadly contained between the latitudes 40°N and 35°S due to the range of the insect vector *C. imicola.* In 2006, a BTV outbreak in Europe was attributed to that *C. imicola* found as far north as 58° (Purse, 2005).

Predictions for future AHS outbreaks

There is a risk of future AHSV outbreaks outside of the endemic areas due to the previously described expanding distribution of *C. imicola.* In addition, the virus appears capable of replication in and being transmitted by other species of *Culicoides*. A 2009 study confirmed that the distribution of AHSV is widespread in insect vectors within the *Culicoides* genus in S. Africa (Venter et al., 2009).

The adaptability of AHSV to new environments has implications for outbreaks in the U.S. Although *C. imicola* is not present in the U.S., there are areas in the U.S. with suitable ecologic conditions to sustain this insect vector if introduced (White and Cordes, 2008). According to White and Cordes, “If a foreign midge vector were to successfully invade the *C. sonorensis* eco-niche and begin an African horse sickness virus epizootic, *C. sonorensis* would soon become infected, and become a primary vector” (White and Cordes, 2008).

Two possible routes of introduction of AHSV into the U.S. include the importation of an AHSV infected insect vector or animal (White and Cordes, 2008). First recognized in 1931, mechanically transported insects have been introduced to the U.S. (Griffitts and Griffitts, 1931). A recent paper by Kasari et al. describes the very real threat of transporting African insects into the U.S. via air or ship cargo (Kasari et al., 2008).

A less likely route of introduction of AHSV to the U.S. is through importation of equids. Equids imported from countries affected with AHS must undergo a 60-day quarantine on arrival in the U.S. (USDA: APHIS, 2010). Equids that enter the U.S. without complying with all import requirements could introduce AHSV (Cordes, 2010).

Prevention and control of future AHSV outbreaks

Prevention of future outbreaks of AHSV outside of the endemic regions in S. Africa and control of outbreaks within endemic areas requires understanding of the interrelationship between the vertebrate host, causative agent, insect vector, and environment (Calvo et al., 2009). Multifaceted control strategies address these relationships, and include:

- Equine movement restrictions,
- Insect vector control,
- Vaccination strategies, and
- Education of veterinarians so they promptly identify and report suspected cases.

Equine movement restrictions

Strict regulation of equine movement reduces risk of spread of AHSV from endemic areas to free areas through equine transport. Currently, OIE recommends a 40-day quarantine in a *Culicoides*-free environment and laboratory testing of equids from AHS areas to be sure they are free of AHSV (OIE, 2009).

The countries included in the U.S.'s 60-day mandatory quarantine for equids currently includes Oman, Saudi Arabia, the Yemen Arab Republic, and all countries in Africa except Morocco (USDA: APHIS, 2010). Additionally, zebras are not generally imported into the U.S. because of the associated expense, and it is now unnecessary because of the existence of successful zebra breeding programs within U.S. zoos (White and Cordes, 2008). Currently, the importation of AHSV infected equids into the U.S. is therefore unlikely.

Insect vector control

Controlling the movement of the AHSV insect vector is more difficult than regulating equine movement. Wind-borne vector movement poses a particularly high risk. It is unlikely that a *Culicoides* midge infected with AHSV could spread AHSV from Africa or Europe into the U.S. by wind currents (White and Cordes, 2008). However, if an outbreak of AHSV occurred in the U.S., and the *C. sonorensis* midge became infected with AHSV, wind-bone vector movement could spread the virus several hundred kilometers within the U.S. Vector control techniques to help reduce the viral spread include: 1) pesticide use, 2) management of breeding sites, and 3) animal husbandry practices.

While adulticides and larvicides do have their role in controlling *Culicoides* spp., their use must be carefully weighed against concerns about their environmental impact and possible development of resistant insect strains when developing risk based mitigation strategies (Carpenter et al., 2008).

Management of *Culicoides* spp. first requires the identification and subsequent elimination of their breeding sites (Mellor and Hamblin, 2004). Since different species of *Culicoides* have different breeding environmental preferences, it is essential to recognize the principal vector species for a given area. Breeding sites for *C. imicola* could be reduced, for example, by reducing water flow near livestock (Mellor and Hamblin, 2004).

The interaction between the host and the vector can also be disrupted by stabling horses during times of maximum vector activity. A study by Meiswinkel et al. showed that stabling horses in insect-proof stables prevented *C. imicola* and C. *bolitinos* from feeding on the horses, even though *C. bolitinos* is a more endophilic species of *Culicoides* (Meiswinkel et al., 2000).

Vaccines

Live-attenuated polyvalent and monovalent vaccines have been developed and successfully used to control outbreaks of AHS. Most areas in S. Africa are required to vaccinate all horses with a live-attenuated polyvalent vaccine (von Teichman and Smit, 2008). Disadvantages of using these live attenuated vaccines include failure to prevent viremia, variable immunogenicity, potential for reversion to virulence of the vaccine virus, and the inability to readily differentiate between vaccinated and naturally exposed horses (Burrage and Laegreid, 1994).

According to the OIE, inactivated monovalent vaccines and subunit vaccines have been developed, but are not currently commercially available (OIE, 2008). Additionally, there has been research on the development of a recombinant canarypox virus vectored vaccine (ALVAC-AHSV). This vaccine (ALVAC-AHSV) co-expresses the outer capsid proteins of AHSV-4 and appears to safely and effectively induce protective immunity to AHSV-4 in horses (Guthrie et al., 2009). The future development, characterization, and use of inactivated, subunit, and recombinant vectored vaccines will be necessary to successfully control outbreaks of AHSV with minimal adverse consequences (Burrage and Laegreid, 1994).

Veterinary preparedness

Veterinarians need to be able to promptly recognize and report FADs and emerging animal diseases (EADs). Many veterinarians outside the sub-Sahara have never seen a case of AHS, and thus may not respond promptly to an incursion of AHSV. Rapid diagnosis of the index case(s) is essential to effectively control infectious disease outbreaks.

Currently, the Colorado State Department of Agriculture, Division of Animal Industry and the Animal Population Health Institute of Colorado State University sponsor an annual, five-day training course on FADs, with the goal of preparing veterinarians to properly respond to an FAD event (APHI, 2010). In addition to classroom training as described above, FAD/EAD education should include the distribution of training materials (lessons and fact sheets) to equine veterinarians by electronic and other conventional routes.

Regulatory veterinarians are trained to conduct FAD investigations at the Foreign Animal Disease Diagnostic Laboratory (FADDL) in Plum Island, New York. FAD training is conducted five times a year. Regulatory veterinarians are trained in recognition of clinical signs, post mortem lesions, and sample collection from suspect FAD cases, including AHS (White, 2010).

In 2010, the United States Department of Agriculture's (USDA's) National Veterinary Accreditation Program was enhanced by regulation in order to meet demands of a global market and threats of emerging and exotic diseases of animals (EEDA). Equine practitioners must now regularly renew their accreditation with supplemental training, including sessions containing foreign equine disease information (USDA:

APHIS, 2011; Cordes, 2010). The USDA clearly recognizes accredited equine practitioner as first line of defense against diseases like AHS (Cordes, 2010).

Nearly all the veterinary schools in the U.S. offer web courses for their students (with an accompanying text book) in EEDA that were developed by the Center for Food Security and Public Health at Iowa State University. Students have a customized course that is accessed through the Association of American Veterinary Medical Colleges web site at http://aavmc.org. This course helps prepare these future veterinarians to recognize and respond appropriately to FADs/EADs. For those seeking veterinary accreditation for the first time, this course is accepted as part of the required training (AAVMC, 2010).

Areas in the U.S. where *Culicoides* midges are found and that have ports for air or ocean cargo entry hypothetically would be more at risk than other locations for localized outbreaks of AHSV. It is especially important for veterinarians in these areas to be prompted to identify and report a suspicious case of AHS to regulatory veterinary authorities.

Reporting of Suspect Case(s) of an FAD/EAD in the U.S.

Equine practitioners are likely to play a critical role in control of equine FAD/EAD case(s). Veterinarians should be suspicious of an FAD/EAD when an unusual clinical case or laboratory results are encountered (McCluskey, 2002). Reporting of suspect equine FAD/EAD cases, such as AHS, can help expedite the initiation of the FAD investigation and help control the spread of disease. If a practitioner is suspicious of an FAD/EAD, appropriate biosecurity measures need to be implemented immediately, such as isolating the animal (ideally in a separate building from others), using barrier precautions when handling the animal, and using disinfectants to sanitize footwear and equipment that is not disposable.

In the U.S., once an FAD case is suspected, practitioners need to report to an Animal Health Official (AHO); either the State Animal Health Official (SAHO) or the USDA: Animal and Plant Health Inspection Service: Veterinary Services (USDA: APHIS: VS) Area Veterinarian in Charge (AVIC) (McCluskey, 2002) (Figure 1.15). The SAHO can be located in the American Veterinary Medical Association (AVMA) directory (www.avma.org) while the AVIC contact information can be found at the USDA: APHIS web site (www.aphis.usda.gov/animal_health/area_offices).

The SAHO and/or the AVIC assign a state employed foreign animal disease diagnostician (FADD) to complete a site visit or field investigation (USDA: APHIS: VS, 2010). The FADD directs the regulatory response, including collection of diagnostic samples. Nationwide distribution of FADDs make it possible for prompt investigation of a suspicious FAD outbreak and collection and submission of appropriate diagnostic samples, to either the National Veterinary Services Laboratory (NVSL) at Ames, IA or to the FADDL at Plum Island, NY. FAD investigations are done at no charge to the owner or private practitioner. Diagnostic testing is restricted to ruling out FADs/EADs agents (McCluskey, 2002).

Some components of the FADD investigation include obtaining a case history, performing a physical examination of animals, an epidemiologic analysis, and traceback/traceforward investigations of suspect animals. Information collected during the investigation includes clinical signs/duration of disease, lesions, case morbidity/fatality rates, vaccination history, premises' conditions, movement history, nutritional status, contact history, evidence of vector/pest, and zoonotic potential (USDA: APHIS: VS, 2010).

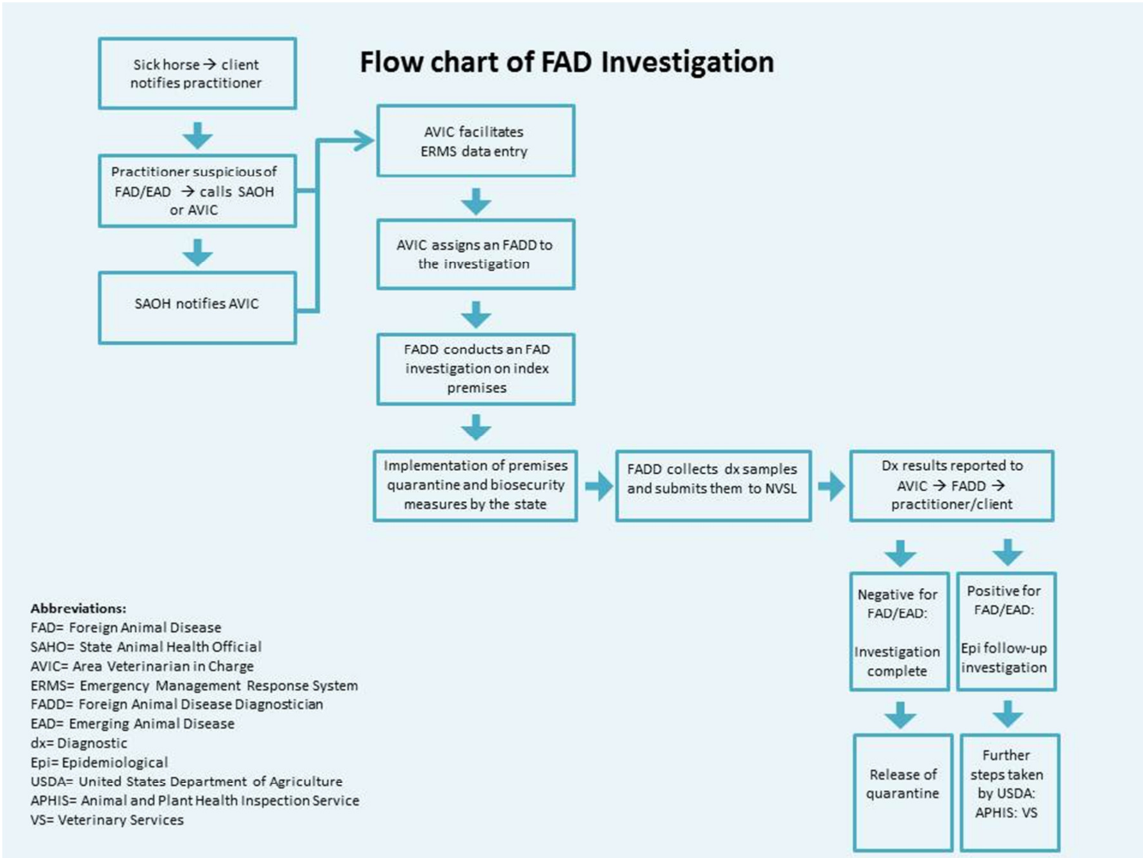

Figure 1.15. FAD investigation flow chart. Practitioners are required to notify an SAHO/AVIC if they suspect an FAD/EAD in order to initiate an FAD investigation by an FADD.

The FADD categorizes the situation as high, intermediate, or low suspicion of an FAD/EAD. The diagnostic samples are assigned a priority level, and appropriate biosecurity and quarantine protocols are activated (USDA: APHIS: VS, 2010).

Data collected during an FAD investigation is entered into the USDA: APHIS secure, web-accessible Emergency Management Response System Database (EMRS), which provides a real-time system for data collection, management, and analysis of the outbreak (USDA: APHIS, 2010).

The private practitioner is responsible for continuing medical care of the affected equid or equids while awaiting diagnostic results. The diagnostic results are sent to both the AVIC and the FADD, and then are relayed to the practitioner and the owner. If the results are negative for all suspected FADs/EADs, further diagnostic testing is the responsibility of the private practitioner. If positive, an epidemiological follow-up investigation is initiated and further steps taken by the USDA: APHIS: VS (McCluskey, 2002; USDA: APHIS: VS, 2010).

On-line Education for U.S. Veterinarians

Developing on-line continuing educational programs about FADs and EADs could help improve equine veterinary knowledge of FADs and EADs in the U.S. Practicing veterinarians are busy with their daily professional activities, but need to constantly expand their veterinary knowledge about animal diseases in order to be informative and effective animal health providers. Barriers to acquiring continuing education at an on-site event include travel to the venue, timing of the event, and personal demands (Moore et al., 2000). On-line education provides a convenient format that is not associated with the time and expense constraints that other continuing educational programs may have.

The requirements to maintain a veterinary license among the U.S. fifty states are not standardized, making development of new, nationally accepted continuing educational programs challenging. Most state licensing boards require veterinarians to acquire continuing education credits in order to maintain a license to practice, but the requirements (number of hours, type of education, and certification requirements) for continuing education vary by state. For example, in Colorado, licensed veterinarians must acquire at least 32 credit hours of continuing education biannually (DORA, 2011), whereas Kansas requires 20 credit hours annually (Kansas Board of Veterinary Examiners, 2011). Not all state veterinary licensing boards recognize on-line education as equivalent to on-site continuing educational programs and may restrict the number of allowable on-line continuing education credit hours. In South Carolina, for example, only

15 of the required 30 biannual credit hours can be obtained from distance learning programs (on-line), and follow-up testing must be a part of the on-line program (South Carolina Board of Veterinary Examiners, 2011).

Approval of the continuing education program may be required by the state veterinary licensing board. The registry of approved continuing education (RACE) is a program of the American Association of Veterinary State Boards that outlines specific requirements for continuing education. A complete list of requirements for RACE approval is at their web site (http://www.aavsb.org/race/). RACE approved courses are recognized by most state veterinary licensing boards; achieving RACE approval status can be challenging. The application process for RACE approval includes completion of a provider's application and payment of a processing fee, the program's application and processing fee, course fee, proof of organization, and three letters of reference stating the abilities of the provider to maintain RACE standards; all these must be submitted at least 45 days prior to the program start date (American Association of Veterinary State Boards, 2011).

Two common forms of on-line education include electronic pdf text files enhanced by illustrations, and narrated webinar modules, which may incorporate interaction with instructors and other students (Ferguson and Pion, 1996; Dhein and Memon, 2003; Ertmer and Nour, 2007). In a study where veterinarians were asked to evaluate text-based, on-line educational courses versus webinar-based, on-line courses, the authors found that the majority of participants classified both educational formats as "excellent" (Dhein and Memon, 2003). In an Italian, on-line veterinarian training course on avian influenza which incorporated virtual classes with on-line interaction among peers and instructors, participants all achieved passing quiz scores in the education. Evaluations by the participants showed that 96.2% thought the courses were "good or excellent" (Pozza et al., 2010). A United Kingdom veterinary continuing education model emphasizes on-line interaction among peers (Short et al., 2007). A survey by the American Association Equine Practitioners (AAEP) shows that over 88% of the respondents interested in on-line continuing education would prefer a non-interactive course, accessible anytime (AAEP, 2010).

Assessments for effectiveness in education of various on-line educational formats of equine veterinarians have not been done. There is evidence that suggests multimedia summaries with less text may enable students (college and elementary students) to learn more effectively than lengthy text passages (Mayer, 1990; Mousavi et al., 1995; Mayer, 1996; Mayer, 1999).

A case-scenario format is a technique that can be incorporated into on-line continuing educational programs. Case scenarios have been integrated into curriculum of medical and veterinary schools, as part of problem-based learning (PBL) instruction technique, in order to enhance learning (Barrows, 1996; Schoenfeld-Tacher et al., 2004; Dale et al., 2008). In the PBL technique, a small group of students work through a case scenario with the goal of identifying and diagnosing the problem as well as suggesting a course of treatment (Barrows, 1996; Schoenfeld-Tacher et al., 2004). On-line PBL has been shown to be as effective as face-to-face PBL (Schoenfeld-Tacher, et al, 2004).

On-line continuing educational veterinary courses are commonly hosted by universities (CSU, 2011) as well as veterinary professional organizations, such as the Veterinary Information Network (VIN) (VIN, 2011). Additionally, on-line training courses specifically on EADs/FADs can be found on the National Animal Health Emergency Response Corps web site (https://naherc.sws.iastate.edu/) (NAHERC, 2011) and the National Veterinary Accreditation Program web site (http://www.aphis.usda.gov/animal_health/vet_accreditation/) (USDA: APHIS, 2011).

There has been mixed acceptance of veterinarians for on-line continuing education the U.S. The AVMA launched its on-line continuing education program in

2008. This program was terminated in April of 2011, and the reason was not reported (Fiala, 2011). VIN has successfully offered on-line continuing education to veterinarians since 1991 (Ferguson and Pion, 1996). A complete analysis of the current growth trends of on-line veterinary continuing education in the U.S. has not been published. There were 6.9%-8.8% of continuing education hours obtained on-line by physicians in 2008, and 50% of the continuing education courses are speculated to be obtained on-line by physicians in the next ten years (Harris et al., 2010).

Developing and executing an on-line educational program that would attract participants and be accepted by all state veterinary boards is a daunting task. The time requirement (one hour per continuing education credit) for an on-line educational program may be potentially unattractive to busy veterinarians. The cost of developing and maintaining the on-line education includes hiring course designers/technicians to maintain the education and answer user questions, software costs to create and maintain the education, a web site to host the education, and fees and paperwork required for RACE approval status if desired. An additional cost would be promotion of on-line education to veterinarians to promote participation. A study of promotion costs for a continuing medical education program found that the promotion of a complimentary (no fee required to participate) on-line education course was $75 per participating physician acquired to participate (Harris et al., 2009).

On-line continuing education directly competes with other forms of continuing education such as annual on-site veterinary conventions. A 2008 survey of Alberta veterinarians showed that distance and workloads are barriers to attendance of an educational program, but on-site educational events were preferred over on-line education (Delver, 2008). An AAEP members' survey showed that 74% have limited or no interest in on-line continuing education, and their primary focus for continuing education credits was "traditional" offerings (AAEP, 2010).

Understanding the demographics of on-line continuing education as well as optimization of learning is necessary for success of an on-line FAD/EAD continuing educational program

Conclusion

This chapter includes detailed information on AHS, discussion of possible risk of incursion of AHSV into the U.S., and potential ways to heighten FAD/EAD awareness among U.S. equine veterinarians.

While AHSV can infect all equids, horses are most susceptible to disease and can have a case fatality rate of up to 95%. It is one of the most severe equine diseases, with no specific treatment currently available. Multiple outbreaks outside of sub-Saharan Africa demonstrate the virus's ability to expand beyond its historical geographic distribution. Although the principal insect vector, *Culicoides imicola,* is not present in the U.S., an experimentally competent vector, *Culicoides sonorensis,* is abundant. Regions in the U.S. with large populations of *C. sonorensis* and an equine population in proximity of international air or ocean-going cargo ships would be the most likely areas for a focal AHS outbreak.

Because this is a vector-borne disease, the prevention and spread of the virus is difficult to control as stopping equine movement will not prevent all transmission. Veterinarians should to be alerted when they examine a pyrexic horse with pulmonary edema or subcutaneous edema of the head and neck, or sudden equine death with pathologic findings consistent with AHS, especially when the *Culicoides spp*. are present in large numbers in the area. Veterinarians should take immediate action and report a suspicious FAD to regulatory veterinary authorities. This action is critical in avoiding spread of AHSV in the U.S.

Practicing equine veterinarians are critical in the identification of emerging and exotic diseases of equids and need to report suspicious case(s) of FADs/EADs. On-line continuing education is one method to help improve veterinary preparedness. While on-line veterinary continuing education has had mixed acceptance in the U.S., it provides one means by which a busy professional can achieve high-quality education without the time and distance restraints of on-site education. The use on-line continuing education in terms of the optimal FAD/EAD education module format for equine veterinarians needs further exploration.

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CHAPTER 2[1]

Knowledge Base and Effectiveness of On-line Education about African Horse Sickness of Equine Veterinary Participants

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[1] The formatting of this chapter is based on submission instructions for the Journal of the American Veterinary Medical Association. This chapter was written as an independent document for subsequent submission and consideration for publications, therefore some information in Chapter 1 is repeated in the introduction and the discussion of this document.

Project Summary

Objective: To describe the knowledge base of African horse sickness (AHS) among U.S. equine veterinarians, and to assess the effectiveness of two formats for on-line education.

Study Design: Cross-sectional study

Source Population: U.S. veterinary members of the American Association of Equine Practitioners (AAEP).

Procedures: An email was sent to U.S. veterinary AAEP members, inviting them to participate in a complimentary on-line educational opportunity. Baseline knowledge of AHS among participants was determined based on their responses in an AHS case scenario. After completion of the case scenario, participants were randomly assigned to either a webinar module or a text formatted module, that was then followed by an educational assessment quiz. The educational effectiveness was measured by taking the difference between the educational assessment quiz score and the baseline knowledge score.

Results: Of the 5,394 veterinarians invited, 309 started and 211 completed the entire study. The participants were significantly different from the AAEP non-respondents for gender, age, and region of primary residence. The median baseline knowledge score from the case scenario was 20/100 points. The median assessment quiz score for participants after completing education modules (90/100 points) was significantly higher than the baseline knowledge score (p=0.01). There was no significant difference in the educational effectiveness in the module formats (p=0.81).

Conclusions and Clinical Relevance: The participation in this study suggests that voluntary participation in on-line continuing education may not currently be the most effective way to educate veterinarians about equine foreign diseases. This study

demonstrates that the on-line education modules improved the knowledge of the participants.

Introduction

Based on the report of the 2002 Committee on Foreign and Emerging Diseases of the United States Animal Health Association (USAHA), inadequate veterinary education relating to foreign animal diseases (FADs) and emerging animal diseases (EADs) in the past decades has resulted in a lack of preparedness of U.S. veterinarians to identify and properly respond to an outbreak (Thurmond et al., 2003). More recently, conclusions of a cross-sectional study of U.S. veterinarians suggest that veterinary practitioners are not prepared to identify an FAD, and are aware of their limitation in knowledge about FADs (Merryman, 2008). Additionally, participants in a New York veterinary focus group lacked familiarity with FADs (Ablah et al., 2009). Equine veterinarians need to be knowledgeable about FADs, and be prepared to identify and report a suspect FAD to the proper veterinary authorities in order to help control an outbreak.

African horse sickness (AHS) is an infectious, insect vector borne disease. AHS is endemic in parts of Africa, and is considered an FAD to the U.S. Recent outbreaks of the virus have occurred outside of the endemic areas of Africa (Davey and Grewar, 2011; OIE, 2011) and the virus and primary insect vectors for the virus have spread north into parts of Europe (Mellor et al., 1990; Rodriguez et al., 1992; Coetzer and Guthrie, 2004; Mellor and Hamblin, 2004; OIE, 2008). During the 2008 USAHA-Infectious Diseases of Horses Committee meeting, the risks for AHS introduction into the U.S. were presented, such as the distribution of horses, suitable climatic conditions, and the presence of a proven experimental vector in the U.S. (White and Cordes, 2008).

Majority of veterinarians outside the sub-Sahara have never seen a case of AHS, and thus may not respond promptly to an incursion of AHSV.

Recommendations resulting from a 2004 report developed for the USDA: APHIS that described the lack of veterinary preparedness for FADs called for a broadening and renewal of veterinary FAD knowledge (Wenzel and Wright, 2007). The optimal educational format for imparting veterinary FAD knowledge has not been described in the literature. Findings of multiple studies suggest the use of multimedia formats with limited text may enable students (college and elementary) to learn more effectively than a lengthy textbook chapter format (Mayer, 1990; Mousavi et al., 1995; Mayer, 1996; Mayer, 1999). The objectives of this study were to determine the knowledge base of equine veterinarians on the FAD AHS, and to assess the effectiveness of two types of on-line education modules in educating equine veterinarians about equine FADs. AHS was used as a model to assess the effectiveness of on-line training for FADs in the U.S.

Materials and Methods

Study development

A cross-sectional study of 5,394 U.S. AAEP veterinary members with an email address listed in the 2010 AAEP directory were invited to participate in this study. An email containing a cover letter, explaining that the course content was about equine infectious diseases was sent to all potential participants. Further, potential participants were informed that the educational opportunity would take approximately one hour to complete, and they would receive a one hour continuing education credit for completing the study. An individualized hyperlink to the study was included in the cover letter. The study was considered exempt from an administrative review by the Colorado State University Human Subjects in Research Institutional Review Board. Two reminder emails to request participation in the course were sent to those who had not yet participated, with the inclusion of a lottery participation incentive for a $50 Amazon.com gift card.

This educational assessment study was hosted by Qualtrics™[2] software. Question branching was used in the case scenario so participants could choose their next course of action. In the case scenario, the order of listed differential diseases provided for the participants was randomized to encourage the participants to consider each disease on the list, thus preventing measurement bias due to the order the diseases were listed. Randomization was also applied to the distribution of the education modules.

The study consisted of between 34 and 46 questions, depending on the participants' responses through the case scenario. All questions were closed ended, and responses were required for all questions in order to proceed, although the participants could quit the study at any time.

The case scenario and FAD awareness section was created to determine the U.S. equine veterinarians' baseline knowledge of AHS and the requirement to report all equine FADs to regulatory authorities. The participants were provided with a case history of a horse with the initial stages of AHS. Throughout the scenario, the participants were given more prompts (or clinical indicators) in order to lead them to an AHS diagnosis.[3] After each prompt, the participants had the opportunity to create a differential list (28 disease options, including four FADs) and then chose their next course of action. A description of the clinical information provided by the five prompts and the differential list are included in Appendix I. Ideally, the participants would select AHS or another FAD on their differential list, and then decide to report the suspect FAD to a regulatory veterinary authority. This would result in the completion of the scenario. The participants were

[2] Qualtrics™ version 19973. Copyright (c) 2002-2008 by Qualtrics Lab Inc., Provo, UT, USA
[3] Case scenario prompts available upon request from AM Wiedenheft

provided with five opportunities to update their differential list, but only had an opportunity to notify a regulatory veterinary authority if an FAD was included on their differential list.

Baseline AHS knowledge was based on the number of prompts required for the respondent to suspect and report an FAD. The development of the case scenario, including the prompts and differential diagnoses were created based literature review and input from two subject experts on AHS.

Upon completion of the case scenario, the participants were again provided a disease differential list and asked to select all diseases that were reportable as FADs in the U.S.

The participants then proceeded to the AHS education module. The text formatted module was a 26-page text document, containing colored images. The webinar module was 26-minutes long and contained all same information and images as the text formatted module, but condensed. Narration was used, and two short videos illustrating the clinical findings of AHS were embedded into the webinar module.

The module opened for the participants and then closed when the participants proceeded to the assessment quiz. If the pop-up blocker feature was enabled by the participants' browser, the participants could click on a hyperlink to access the education module. The honor system was used to advise participants to close the education module before starting the assessment quiz if the pop-up feature was enabled. The amount of time spent on the education module was recorded, but there was no time limit for completion of the education module. The participants were instructed prior to beginning the module that they would subsequently be examined.

The educational assessment quiz consisted of 16 multiple-choice questions about AHS, and is included in Appendix II.[4] Two of the questions were in the form of a mini-case scenario about AHS. The format of the questions had been pre-reviewed by two Colorado State University faculty members, an instructional design specialist and an equine internal medicine specialist, for clarity and level of difficulty. The participants were instructed not to use any resources beyond what they learned in the module to answer the questions. Variable levels of question difficulty were included. Participants were provided results upon completion of the quiz.

Participant demographic questions included: location of primary residence (state), gender, age, primary type of veterinary employment, and year of graduation from veterinary school. The states (including the federal district Washington DC) were categorized to four regions[5] (USDA: APHIS: VS, 2005). The demographics of the participants in this study were compared to the AAEP's 2011 U.S. veterinary membership of the AAEP (Altwies, 2011) to determine if participants were statistically different from the AAEP non-respondents. Information regarding participants' familiarity with AHS and other equine FADs prior to beginning the study and their preferred method of continuing education and animal health related news was also collected.

Ten equine veterinarians were invited to pretest the survey and educational assessment, and the study was revised based on provided input.

Scoring

The case scenario was scored out of a total of 100 possible points. If, based on the first prompt, the participants selected AHS as a differential diagnosis and also

[4] Copies of the educational assessment quiz are available upon request from AM Wiedenheft
[5] Regions:
South: AL, AR, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV
Northeast: CT, DE, MA, ME, NH, NJ, NY, OH, PA, RI, VT
West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY
Central: IA, IL, IN, KS, MI, MN, MO, ND, NE, SD, WI

notified a regulatory veterinary authority, the score was 100 points. The score was reduced by twenty points after each prompt if the respondent did not recognize AHS and notify a regulatory veterinary authority. If, based on the first prompt, the participant selected an equine FAD other than AHS, and decided to notify a regulatory veterinary authority, the score was 50 points. Ten points were deducted for each additional prompt required for FAD recognition followed by regulatory veterinary notification.

The educational assessment quiz was scored out of a possible 100 points. The two mini-case scenario questions were worth a total of 30 points for correct responses. Each of the remaining 14 multiple-choice questions had only one correct response worth five points.

Statistical analysis

All calculations were performed using commercially available statistical software.[6] A chi-square statistical test was used to determine the if there was a difference of the participants in comparison to the non-respondent AAEP source population in terms of gender, age, region, and primary veterinary employment type. The non-respondents were considered to be all U.S. veterinary AAEP members who did not respond to the survey (n=6,622), although only veterinary AAEP members with an email address listed in the AAEP directory were included in the study (n=5,394).

A non-parametric statistical approach was used if the assumptions for a parametric approach were not met, and medians were reported. The non-parametric Wilcoxon signed-ranks test for independent samples was used to compare the non-linear baseline knowledge scores from the case scenario between the education modules (webinar versus text formatted module) and to compare the non-linear educational effectiveness outcome (the difference between the educational assessment

[6] SAS 9.2 Copyright (c) 2002-2008 by SAS Institute Inc., Cary, NC, USA.

quiz score and the baseline knowledge score) between the two education modules. The time spent on the education modules was transformed to meet the normality assumption of a parametric test and a t-test for independent samples was used to evaluate the difference. Significance was considered at $p<0.05$.

Results

Participation

Three pre-test results were used to revise the case scenario and education modules. There were 309 participants who started the study, and of these 293 completed the case scenario section of the survey, 290 completed the demographic section, 225 completed the familiarity section, and 211 completed the education module and assessment quiz.

Females made up 65.2% of the study population. Based on the four age groups used to categorize ages, the majority (31.4%) of the participants were between 25 to 34 years of age. The median year that the participants had graduated from veterinary school was 15 years with a time span of one year and 53 years. Of the four regions, the western region contained the majority of participants (34.1%) (Table 2.1). Private veterinary practitioners made up 79.7% of employment type. Approximately, 92% of veterinarians were currently practicing equine veterinary medicine that included care of patients, and 37.6% of practiced exclusively on equids.

The demographics of the 6,622 AAEP non-respondents differed from the 290 participants in the demographic section in this study in terms of gender ($p=0.01$), age ($p=0.04$), and region of primary residence ($p=0.01$). However, the current primary employment type did not differ between respondents and non-respondents ($p=0.43$) (Table 2.1). Additionally, Colorado veterinarians were over-represented in this study with 8.3% of the participants coming from Colorado compared to 4.0% of the AAEP members who are listed in Colorado.

Baseline knowledge and familiarity

Eighty-seven out of 293 participants (29.7%) chose an FAD differential and reported the case to a regulatory veterinary authority within the first three prompts of the case scenario, 134 participants (45.7%) recognized the case as an FAD and reported based on prompts four or five (Figure 2.1). For the participants who reported the FAD to regulatory veterinary authorities, 126 included AHS as one of their differentials. Approximately, a quarter of the participants failed to report the case to a regulatory authority; twenty-six participants (8.9%) recognized the case as an FAD but did not report it, and 46 participants (15.7%) did not recognize the case as an FAD. The scores for the case scenario ranged from 0 to 100 points and with a median score of 20 points.

When asked about diseases to be reported in the U.S. as an FAD, approximately 99.0% (n=289 out of 292) recognized that AHS was a reportable FAD, followed by equine piroplasmosis (87.3%), and equine morbillivirus pneumonia (Hendra virus) (86.3%). Only 20.2% of the participants knew that equine encephalosis was a reportable FAD. Participants incorrectly indicated that equine infectious anemia (60.3%), anthrax (59.6%), equine viral arteritis (49.0%), eastern equine encephalitis (44.2%) and West Nile virus (36.0%) were reportable FADs.

Approximately, 96% of the 225 participants who completed the familiarity section indicated that they were somewhat concerned or very concerned that an equine FAD could enter the U.S. and 90.7% were concerned about the entry of AHS into the U.S. (after completing the study). Prior to the study, only eight out of the 225 participants (3.6%) considered themselves knowledgeable about AHS, 39.6% (n=89) felt they knew some basics about AHS, and seven participants had actually seen a case of AHS. Approximately, 89% had less than six hours of continuing education on FADs in the previous five years, and 86.2% of the participants would prefer on-line FAD continuing education. Over 99% of the participants took continuing education courses to improve their knowledge of veterinary medicine (n=224), and only 42.2% participated in continuing education to meet other veterinarians in a social setting. Most participants kept up to date on animal-related news through e-newsletters (58.2%), followed by journal articles (23.1%).

Education participation and assessment

The Qualtrics™ timer option was used to validate that participants had opened the education module and viewed it for at least one minute, and only those participants were included in the analysis. The text formatted education module was randomly assigned to 110 participants, and 101 participants were randomly assigned to the webinar education module. Some participants had problems opening the webinar education module because Internet Explorer did not support streaming flash files. Once recognized, this issue was resolved by transforming the webinar flash format into a PDF file, with an embedded flash presentation.

Case scenario scores were not significantly different between the participants in each of the education module groups (p=0.87). Scores of participants were excluded if they spent less than one minute on the education module. The median time spent on the webinar and text module was not significantly different (27.4 minutes and 26.8 minutes respectively; p=0.57).

In the educational assessment quiz, 209 (99.1%) selected AHS as a differential and 202 (95.7%) reported the FAD to a regulatory veterinary authority in the two mini-case scenario questions. Thirty-three (15.6%) participants answered all 16 questions correctly. The median quiz score was 90 points for both education module groups, ranging from 45 to 100 points. There was a significant improvement in quiz scores for both education module groups from the case scenario (p=0.01).

The educational effectiveness in both education module groups ranged from -30 to 100 points with, a median score of 60 points. There was no significant difference found between the groups in their educational effectiveness (p=0.81). When stratified by age groups, gender or region, the effectiveness of education did not significantly differ between the education module formats. The overall educational effectiveness (irrespective of the education module format) was significantly higher in males when compared to females (median effectiveness= 65 and 60, respectively; p=0.02). However, the overall educational effectiveness did not significantly differ among the age groups or regions.

Discussion

The first objective in this study was to determine the background knowledge of U.S. equine veterinarians regarding AHS. The U.S. AAEP veterinarians were considered the source population for U.S. veterinarians since over 5,000 members had email addresses published in the AAEP membership directory. In this study, a non-respondent bias may be present, since there are differences in gender, age, and region of participants compared to the non-respondent AAEP members. Therefore, the background knowledge results can only apply to only those with similar characteristics to those participants of this study.

The result of this study support previous reports suggesting U.S. veterinarians are unprepared for an FAD outbreak in the U.S. (Thurmond et al., 2003; Merryman, 2008; Ablah et al., 2009). Unlike previous studies, this study assessed equine veterinarian knowledge of equine FADs. Furthermore, this study included an education module and an educational assessment quiz.

After the first three prompts, the participants had been given numerous clinical indicators that should have led to placing AHS on the differential list, including the presence of a classical AHS clinical sign, marked frothy nasal discharge. Less than half of the participants (45.6%) reported the case in the first three prompts, suggesting that participants were not familiar with the clinical aspects of AHS. This lack of familiarity with

AHS was confirmed since only approximately 43% of the participants indicated that they at least knew basics of AHS.

An FAD has been defined as a disease which originates in another country and can, or does, enter the USA (Smith, 2001). In this study, 36% of the participants reported West Nile virus (WNV) as an FAD, even though it is endemic in the U.S. (DeHaven, 2002). It is possible participants chose to report because they misunderstood the distinction of an FAD or did not know WNV was considered endemic in the U.S.

Although almost all the participants recognized that AHS was a reportable FAD, approximately a quarter of the participants did not indicate they would report the case to a regulatory veterinary official by the end of the case scenario. Nine percent of participants did not report the case after at least one FAD was on their differential list. The results of this study would suggest there is a need to heighten FAD awareness and FAD reporting procedures among equine veterinarians.

The second objective of the study was to assess the effectiveness of two formats of on-line education. The equivalent effectiveness of the two formats contrasts with previous studies that suggested the use of multimedia summaries with less text may enable students to learn more effectively than lengthy textbook passages (Mayer, 1990; Mousavi et al., 1995; Mayer, 1996; Mayer, 1999). Participants in our study were highly educated professionals who use textbooks and scientific journal articles as a source of animal disease information, while students in the Mayer and Mousavi et al. studies had not completed higher education.

Integrating science with clinical content can help medical students learn (Abrahamson, 2007). The case scenario in this study required critical-thinking skills, similar to problem-based learning (PBL) (Barrows, 1996; Schoenfeld-Tacher et al., 2004; Dale et al., 2008), providing a “need to know,” and may have stimulated the participants’ interest in the education module.

Participation in this study may have been limited because it took at least one hour to complete. In another on-line veterinary education study in 2003, there were 144 participants in a two-week period (no denominator information) with open registration for North American veterinarians interested in small animal medicine (Dhein and Memon, 2003). The low participation in 2003 and in our study implies that on-line education is not popular among U.S. veterinarians, possibly due to the required time commitment on the computer.

Because our pretest participation was low and number of different browsers and the internet enabling options available to users, not all the technical issues were identified prior to the launching the study. This resulted in the loss of some potential participants.

Several participants provided voluntary feedback to the designer, for example, “an effective learning experience,” “a valuable way to learn, and “I wish there were more things like this available.” In another veterinary continuing education study in which a similar educational format was provided to the participants, 58.6% of the participants who were provided a webinar thought it was “excellent,” and 59.0% of the participants who took the text formatted education module thought it was “excellent” (Dhein and Memon, 2003).

In 2009, the United States Department of Agriculture’s National Veterinary Accreditation Program (NVAP) was enhanced. Veterinarians must now regularly renew accreditation through completion of supplemental training, including sessions that discuss equine FADs (USDA: AHPHIS: VS, 2011; Cordes, 2010). These changes in the accreditation program demonstrate the USDA’s understanding of the importance of FAD education for veterinarians. On-line continuing education is one potential method to reach equine veterinarians throughout the U.S. Participants of a veterinary focus group interview in California described that the timing, distance, money, solo practice, and family demands were barriers to participation in continuing education (Moore et al., 2000). On-line education does not have those same barriers. The use of incentives or penalties for on-line continuing education may increase the interest in this format in the future.

In this study, the majority of the participants did not know the basics of AHS, and we demonstrated that on-line education can be an effective and convenient way for veterinarians to learn, regardless of the education module format.

Table 2.1. Gender, age, region of primary residence, and primary veterinary employment type among participants in the study and AAEP non-respondents.

Variable		Participants No. (%)	AAEP Non-Respondents No. (%)
*Gender	Male (n)	101(34.8)	3502(52.9)
	Female (n)	189(65.2)	3120(47.1)
*Age	<35	91(31.4)	1834(29.5)
	35-44	58(20.0)	1413(22.7)
	45-54	70(24.1)	1159(18.6)
	>55	71(24.5)	1820(29.2)
*Region of Primary Residence	West	99(34.1)	1714(25.9)
	Central	53(18.3)	1130(17.1)
	South	77(26.6)	2617(39.5)
	North East	61(21.0)	1161(17.5)
Primary Veterinary Employment Type	Practice owner/Associate, Intern/Resident	241(83.1)	4877(85.0)
	Educator/Academic, Government/Regulatory, Industry relations	26(9.0)	518(9.0)
	Temporary, Retired, Other	23(7.9)	346 (6.0)
Total		290	†6622

*Study participants significantly differed ($p<0.05$) from AAEP non-respondents in at least one variable sub-category.
†Totals of AAEP non-respondents for age and current veterinary position are 6,226 and 5,741 respectively due to AAEP members without information available in these categories.

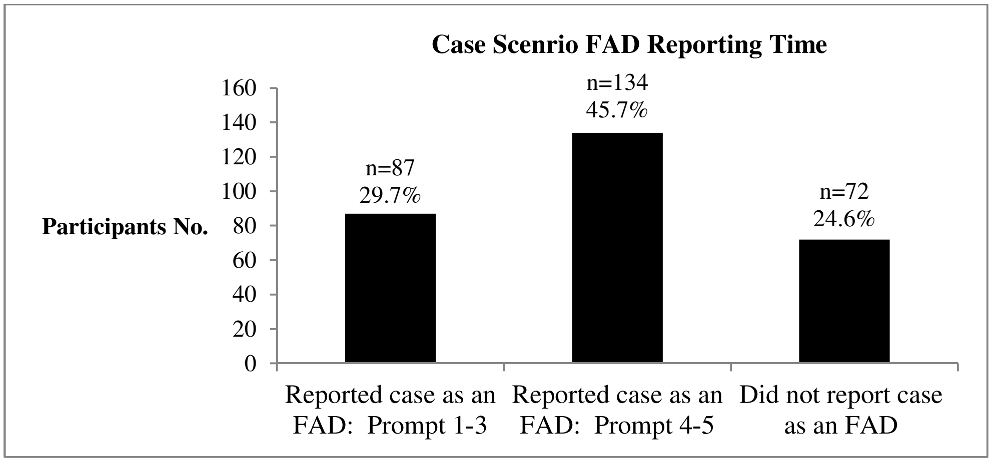

Figure 2.1. Case scenario prompt number when case was reported as an FAD.

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CHAPTER 3

Options for Improvement of Awareness Level of Veterinarians for Foreign Equine Diseases

Introduction

Equine veterinarians need to be aware of clinical signs and post mortem findings for equids with foreign animal diseases (FADs). Veterinarians also need to promptly report suspect cases to regulatory veterinary authorities in order to mitigate a potential outbreak of an FAD. Results of the study described in Chapter 2 clearly show the participants were not prepared to identify and report African horse sickness (AHS) prior to completion of the education module. They also lacked understanding of diseases reportable as FADs. But the low voluntary participation in this study demonstrates that on-line educational programs may not be the optimal way of improving awareness. Requirements for participation, such as standards for renewal of veterinary accreditation or licensure may be a way to enhance participation and expand FAD knowledge.

This chapter addresses options for enhancing FAD awareness among equine veterinarians. Review of the currently available educational courses to improve veterinary knowledge about FADs is presented in the first section. The challenges of on-line education, including enhancing participation and technical challenges of on-line education will then be discussed.

FAD Education

The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA: APHIS) has a primary role in educating U.S. veterinarians about FADs through the development of the National Veterinary Accreditation Program

(NVAP). This section will first describe the structure of this program and the educational training required for veterinarians. Additionally, the types of continuing education opportunities on FADs that are available for equine veterinarians, including annual veterinary conventions, hands on-training courses, and on-line continuing education, will be outlined.

National Veterinary Accreditation Program

The USDA established the veterinary accreditation program in 1921 because they understood the importance of the private practitioner's role in controlling the spread of animal disease. It became a national program in 1992 in order to standardize the accreditation requirements. In 2010, the new NVAP was created in order to "help meet the demands of a global market and threats of emerging diseases" (USDA: APHIS, 2011). The responsibilities of an accredited veterinarian are included in the *National Veterinary Accreditation Reference Guide,* and include 1) the control of animal movement, 2) disease surveillance, and 3) the control and eradication of animal diseases (USDA: APHIS, 2011).

With the new NVAP, accredited veterinarians must now renew their accreditation status every three years by taking supplemental training. The Center for Food Security and Public Health (CFSPH) at Iowa State University was granted a contract by the USDA: APHIS to develop APHIS-approved supplemental training (AAST) materials for the NVAP. The amount of AAST required for accreditation renewal is three units for Category I veterinarians, those veterinarians who are not accredited for food and fiber species, horses, birds, farm-raised aquatic animal, all other livestock species, and zoo animals that can transmit exotic animal diseases to livestock; Category II veterinarians, who are allowed to perform accredited duties on all animals, need six units. A unit is approximately an hour in length (USDA: APHIS: VS, 2011; USDA: APHIS, 2011). In March 2011, the first four AAST one unit modules became available, with five more modules to be released in September 2011 (USDA: APHIS, 2011). A module that is to be released in September 2011 is entitled *Foreign Animal Diseases, Program Diseases, and Reportable Diseases,* and it will contain a review of the clinical signs of FADs and reporting responsibilities for both Category I and Category II veterinarians (USDA: APHIS, 2011). While these new requirements for accreditation of veterinarians will provide an opportunity to improve their knowledge of FADs, the current courses offered do not focus specifically on equine FADs and will serve as a general overview. The use of equine-specific continuing education to improve FAD awareness among equine veterinarians will be needed.

The three formats for the AAST include web-based training (free of charge); attending presentations that are held by several state, regional, and national veterinary meetings (conference registration fees may apply); and printed manuals or CD-ROMs with the digital PDF files (nominal charge) (CFSPH, 2011). These options mimic traditional veterinary continuing education formats. As the program matures, it will be important for the NVAP to determine the popularity of different formats after veterinarians have been exposed to the free on-line AAST modules. Unfortunately, the success of the on-line education will only be measured by the NVAP staff based on frequency of access. The NVAP on-line education modules do not incorporate an outcome assessment. Some form of outcome assessment is necessary to determine if veterinarians taking on-line education are learning from the program and becoming more aware about FADs.

Continuing education programs

Annual conventions

Continuing education courses on equine FADs are available for equine veterinarians. An in-depth lecture session as well as a table topic discussion on an FAD, equine piroplasmosis was held at the 2010 AAEP annual convention (Traub-Dargatz, 2010). The 2011 convention in November will also include a two-hour table topic discussion on piroplasmosis (AAEP, 2011). While courses on FADs are available at veterinary conventions, these are often in direct competition with other educational opportunities that occur simultaneously on topics that practitioners may feel they need to know more about given their practice or their clients' demands for services. The lack of interest in FAD continuing education courses was illustrated in Chapter 2; almost 90% of the participants had taken less than six hours of continuing education about FADs in the previous five years. Perhaps the NVAP requirements will encourage equine veterinarians to learn about FADs by creating a "need to know," illustrating the potentially detrimental consequences of an FAD outbreak. This "need to know" may subsequently increase future participation in FAD continuing educational lectures at annual conventions or other continuing education opportunities.

Hands-on continuing education

Continuing education programs that are more focused on FADs and provide hands-on experience are also available in several states. In Colorado, for example, the Colorado State Department of Agriculture, Division of Animal Industry and the Animal Population Health Institute of Colorado State University have a five-day Foreign Animal Disease Training Course that not only provides a review of FADs that impact the livestock, poultry, and equine industries, but also include interactive case discussions and hands-on exercises as part of the training. Registration is free (FAD, 2011).

This weeklong in-depth FAD program prepares veterinarians to be effective responders in the event of an FAD. Participants learn about the clinical signs of FADs, and are taught to critically work through a suspect FAD case scenario in order to have a timely and operative intervention in an FAD incursion. Having participated in this course, I was provided with a general overview of FAD clinical signs and pathology in domestic animals. After working through a simulated FAD outbreak, I felt more confident that I was prepared to recognize a suspect case and notify the proper authorities in the event of an FAD outbreak.

On-line continuing education

On-line continuing education is another format that is available for improving equine veterinary FAD awareness. On-line continuing education cannot replace hands-on training provided by the Foreign Animal Disease Training course held in Colorado and other states because hands-on training helps veterinarians visualize responding to an FAD outbreak and allows them to network with other participants and the instructors. However, on-line continuing education could provide veterinarians with an opportunity to regularly renew their FAD knowledge on a more regular basis through a convenient and affordable means. The education can be started and stopped on demand and taken during free time throughout the day, with no incurred travel or lodging expenses.

One of the American Veterinary Medical Association's goals for 2020 is to "advance the use of technology to achieve efficiency" (King et al., 2011). The use of on-line continuing education is consistent with that goal. An on-line course would allow for an unlimited number of veterinarians to access FAD training. On-line education provides a consistent message to a broad audience. In comparison, the message in annual convention lectures could vary depending on the lecturer. To reach a large number of veterinarians, there would need to be an incentive or penalty-based stimulus to participate. Providing free on-line continuing education on equine FADs and requiring a specific amount of continuing education credits about FADs would be two changes that could be made.

As utilized in Chapter 2, on-line continuing education can also incorporate case scenarios. The use of a case scenario prior to the in-depth education module created a "need to know" for the participants. Thus, regardless if the education module is a multimedia rich webinar or a text formatted, case scenarios can enhance learning for the participants. Case scenarios are also beneficial to veterinary learning as they make the participants think beyond their classic role, to an evolving role of dealing with emerging diseases.

Challenges of On-line Continuing Education Programs

While on-line continuing education does provide quality education that is convenient for its users, there are challenges that must be addressed for a program to be successful. This section is first going to discuss issues with participation in on-line continuing education with an emphasis placed on the strategies used in Chapter 2, and then discuss technical challenges that the on-line format creates.

Participation in on-line continuing education

Chapter 2 demonstrates that the participation in on-line continuing education for equine veterinarians was low. In Dillman's tailored design method for survey development, making the questionnaire short and easy to complete, and using incentives to increase the perceived benefits of participation are important factors to consider when designing a survey (Dillman, 2009). The same principles may apply to on-line continuing education.

AHS study length

The required time commitment that a study requires reflects the perceived cost of responding for the participant. Equine veterinarians are busy professionals, and to acquire participation in an on-line continuing educational program that required approximately one hour of their time per continuing education unit was potential a barrier to participation. The low participation in Chapter 2 implies that the study length may have influenced the participation of veterinary professionals.

The participation in Chapter 2 differed from the participation a 2009 Colorado State University on-line research needs survey, which was also emailed to AAEP members. The research needs survey received over 800 responses (compared to approximately 300 who started Chapter 2), although the source population in the research needs survey was larger than Chapter 2 (6,100 compared to 5,394) because the research needs survey study included international and student members. In both studies, AAEP members received an email with a link to the study, with two reminder emails sent in subsequent weeks. The marked difference between the two studies was the time required to complete the study. In the 2009 research needs survey cover letter, participants were told that the survey would take approximately 15 minutes to complete (Ferris, 2011). By comparison, Chapter 2's cover letter stated that participation would take approximately one hour. We can only speculate that one hour on the computer may have been more time than a busy veterinary professional was willing to commit.

Incentives

Dillman suggests incentives can be used to improve response rates by increasing the perceived benefits of participation, while demonstrating respect for the participant (Dillman, 2009). According to a meta-analysis on the use of material incentives (primarily pre-paid incentives) in on-line studies, material incentives motivate people to start web surveys (Goritz, 2006). A study looking at the impact of lottery incentives found that monetary lotteries only minimally impacted the response rate: out of the four monetary cash prizes ranging from $50 to $200, only the $100 prize differed significantly from the no-reward control group (Porter and Whitcomb, 2003). According to Dillman, a reason why lottery offers have such a little effect on the response rate is that unlike prepaid material incentives, the potential respondent has less motivation to reciprocate a generous gesture in a lottery, since they have not actually received a gift up-front (Dillman, 2009).

AHS study incentives

Incentives to enhance participation were used for the study described in Chapter 2. In the first week of the study (February 15th to February 23rd), the incentive for participation was the awarding of one hour of complimentary continuing education credit from Colorado State University,120 participants opened the link to the study. In the second week (February 24th to March 2nd), a lottery for $25 Amazon.com gift card was added to the continuing education incentive, and 94 opened the study link. In the third week of the study (March 3rd to March 8th), in addition to the continuing education credit, the lottery for the gift card was increased to $50, which generated 112 responses to the study link. Chapter 2 was not designed to test the effectiveness of incentives or reminders and responses, but it is interesting to note that more people responded to the final reminder email in which the lottery prize had been increased to $50 gift card than the second reminder email when the lottery prize was $25 gift card, although the initial incentive of a continuing education credit generated the most responses to the study link.

While on-line continuing education was used as an incentive for participation, the approval from the Registry of Approve Continuing Education (RACE) was not pursued due to the financial and time requirement necessary for achieving RACE approval. Colorado State University Department of Clinical Sciences continuing education programs no longer have RACE provider status because the leadership within the department does not believe that RACE approval is imperative (Banfield, 2011). The continuing education courses offered by the AAEP are currently RACE approved (Kleine, 2011). The use of a continuing education credit as an incentive may not have been as effective as it could have been due to lack of RACE approval since AAEP members may expect this from a continuing education provider.

Technical challenges

Veterinarians have different computer technical skills, and an on-line education program needs to meet all veterinarians' skill levels. For instance, veterinarians that have recently graduated from veterinary school have more experience with the on-line course format due to on-line courses that are now traditionally a part of veterinary curriculum than those veterinarians who graduated prior to the 1990s (when the internet became mainstream at universities). In the study described in Chapter 2, participants graduated between 2010 and 1962. Thus, the experience of veterinary school curriculum computer-based courses varied widely among participants. On-line education must be user-friendly for all participants, with technical support staff readily available for questions. As more veterinarians become more internet proficient, there could be a large gain in FAD awareness due to on-line education.

Another obstacle with multimedia based on-line learning is the diversity of technology, platforms, browsers, and versions used by each participant. Although access to high-speed internet has become more common, rural veterinarians may still use dial-up internet connections, which may make downloading and viewing multimedia rich webinar courses challenging. Respondents with dial-up connections may be less likely to participate in a study or complete the study due to slower internet connections.

There are five major web browsers[7], and even standard components like Adobe flash may function differently in each browser. In the AHS survey, users of Internet Explorer (IE) were not initially able to open the webinar module because the browser did not support the webinar flash-based formatting. While modification to the webinar formatting allowed for IE users to view the webinar module, similar obstacles would likely occur with other new on-line educational programs, which may result in participant frustration. This also means that extensive browser compatibility testing

[7] Internet Explorer, Firefox, Google Chrome, Safari, Opera

should be done prior to releasing multimedia webinar education. Additionally, as technology continues to change, the on-line educational programs will have to make technological modifications to stay current.

Conclusion

The results of the study presented in Chapter 2 indicate that the equine veterinary participants lacked FAD awareness. Continuing education about FADs is one method to improve their FAD awareness. In comparison to the other continuing education formats available such as annual conventions and hands-on FAD training courses, on-line continuing education has the benefits of convenience and affordability for the participants, and the ability to provide consistent education to veterinarians throughout the country. Although Chapter 2 demonstrated the format of on-line education does not appear to affect its educational effectiveness, the use of case scenarios may enhance learning.

The recent requirements by NVAP for periodic training on topics of importance to accredited veterinarians may improve future on-line education participation. On-line training is the only free option for accredited veterinarians to obtain the required AAST, and therefore, it could become the preferred option for some veterinarians, especially solo practitioners who may find it more difficult to leave their practice with no coverage for emergencies while away. Veterinarians may consequently become more comfortable with technology and on-line education. The implementation of the AAST as well as the receptiveness of veterinarians to the on-line training courses will most likely set the tone for on-line continuing education in the future. The NVAP requirements may also create a "need to know" for equine veterinarians about FADs, and stimulate future interest in FAD continuing education courses.

The use of on-line continuing education to improve the knowledge base of equine veterinarians on FADs does not currently appear to be a popular option for continuing education. But, perhaps the use of the on-line AAST modules as well as emphasizing the importance of FAD knowledge to equine veterinarians may make this option more appealing to equine veterinarians soon.

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APPENDIX I

Case Scenario Information

Table A.1. Summary of clinical information provided in the five case scenario prompts. Participants updated their disease differential list after they received the prompt information.

Prompts	Clinical information
1	History: International exposure, pyrexia, lethargy Physical exam: Pyrexia, lethargy, insects around eyes Blood work: Leukopenia, thrombocytopenia
2	Physical exam: Pyrexia not responsive to empirical therapy, pulmonary crackles and wheezes Thoracic ultrasound: Findings suggestive of bilateral pulmonary edema
3	Physical exam: Lateral recumbency, respiratory distress, muffled heart sounds, frothy nasal discharge, pyrexia Additional information: Similar case occurred last week in same region
4	Physical exam: Coughing, pale yellow, frothy fluid expelled from nostrils (image included), supraorbital fossa area swollen Additional information: Horse dies
5	Pathology report: Supraorbital fossae filled with yellow edematous fluid, pulmonary edema, hydropericardium

Table A.2. Case scenario differential list. Participants could select as many differentials as they wanted to include on their list. The list was presented in a randomized order.

Differential list
Acute selenium toxicity
African horse sickness*
Anhydrosis
Anthrax
Bacterial pneumonia
Blister beetle toxicosis
Botulism
Choke: esophageal obstruction
Colic
Eastern equine encephalitis
Equine encephalosis*
Equine herpes virus
Equine infectious anemia
Equine influenza
Equine morbillivirus pneumonia (equine Hendra virus)*
Equine piroplasmosis (babesiosis)*
Equine rhinitis virus
Equine viral arteritis
Exercised induced pyrexia
Feed allergy
Fever of unknown origin
Pleuropneumonia
Purpura hemorrhagica
Red maple toxicosis
Recurrent airway obstruction (RAO)
Rhabdomyolysis (tying up)
Strangles
West Nile virus

*Disease reportable as an FAD

APPENDIX II

Educational Assessment Quiz

1. You have been called to a farm to examine a 2 year old female Quarter horse who, according to the farm manager, is lying down on her side and breathing "hard." You arrive at the farm 20 minutes later, and the horse is dead, with copious amounts of frothy, yellow fluid coming out of her nose. Which of the following should be on your differential list? (Select ALL that apply)

    Dourine
    Equine encephalosis
    African horse sickness (AHS)
    Equine morbillivirus pneumonia (equine Hendra virus)
    Rift Valley fever

2. In addition to the frothy, yellow nasal discharge, further physical evaluation of the horse reveals swelling in the area of the supraorbital fossa. Based on the horse's history and physical findings, you are concerned that this horse may have a foreign animal disease. Assuming disposal of the carcass after an on-farm necropsy and cost are not issues, as the attending veterinarian, what would you do next? (Select 1)

    Perform a field necropsy and take diagnostic samples to confirm diagnosis
    Contact a regulatory veterinary authority to discuss the case
    Place a 10 mile quarantine around the premises
    Transfer the horse to a diagnostic laboratory for necropsy

3. Where in South Africa is AHSV considered endemic? (Select 1)

    Northeastern region
    Eastern Cape
    Central region
    Western Cape

4. What serotypes have caused the majority of AHSV outbreaks outside sub-Saharan Africa? (Select 1)

    AHSV 3 and AHSV 9
    AHSV 4 and AHSV 9
    AHSV 5 and AHSV 9
    AHSV 6 and AHSV 9

5. Worldwide, which of the following insects is considered the primary vector for AHSV? (Select 1)

   Culicoides variipennis
   Tabanus lineolu
   Culicoides imicola
   Tabanus nigrovittatus

6. Which of the following *Culicoides* species found in the U.S. has been proven to be a competent experimental insect vector for AHSV? (Select 1)

   C. cajennese
   C. sonorensis
   C. variipennis
   C. occidentalis

7. What type of equid is most susceptible to clinical disease when infected with AHSV? (Select 1)

   Donkey
   Zebra
   Mule
   Horse

8. Anorexia prior to the peak in the body temperature is a common clinical sign in a horse infected with the pulmonary form of disease?

   True
   False

9. Which of the following is considered the most common form of AHS in AHSV naïve horses based on experimental trials? (Select 1)

   Pulmonary form
   Cardiac form
   Mixed form
   Horse sickness fever form

10. Which of the following is a common clinical sign in a horse with the cardiac form of AHS? (Select 1)

    Expulsion of foamy, yellow nasal discharge
    Central blindness
    Head pressing
    Anorexia prior to the peak in body temperature
    Swelling in the area of the supraorbital fossa

11. The adult female C. *imicola* midge is primarily responsible for the transmission of AHSV?

    True
    False

12. Which of following vaccines has been undergoing active field based research to determine its efficacy in the prevention of AHS in South Africa? (Select 1)

    Recombinant herpesvirus vectored vaccine
    Recombinant canarypox virus vectored vaccine
    Recombinant sindbis virus vectored vaccine
    Recombinant rinderpest virus vectored vaccine

13. Which of the following viruses is transmitted by *Culicoides imicola*? (Select 1)

    West Nile virus
    Rift Valley fever
    Bluetongue virus
    Eastern equine encephalitis virus

14. What is the quarantine period required by the U.S. for importation of horses from South Africa? (Select 1)

    3 day quarantine
    7 day quarantine
    60 day quarantine
    80 day quarantine

15. What is the definition of an FADD? (Select 1)

    A database used to track FADs
    A set of diagnostic tests used to rule out FADs
    A diagnostic protocol designed to help veterinarians respond to an FAD event
    Federal or state employed veterinarian who is specifically trained to investigate FADs

16. Which of the following is a correct statement about African horse sickness? (Select 1)

    A horse with AHS poses a zoonotic risk to its care takers
    A horse with AHS is infectious, but not contagious
    A horse with AHS is contagious to other horses through nose-to-nose contact
    A horse with AHS is not a source of AHSV to other horses