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Review Article

Equine Bacterial and Viral Zoonosis: A Systematic Review

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Abstract

Zoonotic diseases are diseases of animals that can be transmitted to humans. An estimated 70 percent of infectious diseases of domestic and wildlife species has zoonotic potential and can, under certain circumstances, be transmissible to man. Regardless of the diversity of infectious agents involved, relatively few, however, are derived from horses or other members of the family *Equidae*. The number of diseases affecting the horse with zoonotic potential includes viral, bacterial, rickettsial, anaplasma, fungal and parasitic infections. A number of diseases bacterial and viral infections are discussed in this article. Occurrences of zoonotic diseases such as West Nile virus infection, Eastern Equine Encephalomyelitis and Venezuelan equine encephalomyelitis, are associated with severe disease in humans that can be fatal. The same would apply to certain multispecies diseases such as rabies and anthrax. Although Salmonellosis and Leptospirosis can be responsible for causing significant illness in man, are usually not considered of the same public health significance. Implication attributed to an equine Zoonosis is dependent on prevalence of that disease and its case-fatality rate in humans. Therefore, there is a need for greater collaboration between human and animal medical science to be effective in prevention and control of zoonotic diseases.

Keywords: *Bacterial zoonoses; Horse; Viral zoonoses; Zoonosis*

Abbreviations

EEEV: Eastern Equine Encephalomyelitis Virus; EMV: Equine Morbillivirus; MRSA: Methicillin-Resistant *Staphylococcus Aureus; S. typhimurium* DT 104: *Salmonella enterica subspecies enterica* Serotype Typhimurium Definitive Type 104; TB: Tuberculosis; VEE: Venezuelan Equine Encephalomyelitis; VEEV: Venezuelan Equine Encephalomyelitis Virus; WEEV: Western Equine Encephalomyelitis Virus; WNV: West Nile Fever is caused by West Nile virus

Introduction

It has been known since ancient times that human could contract certain diseases from animals, including horses [1]. Zoonotic diseases are diseases of animals that can be transmitted to humans. A number of zoonotic diseases can be further classified as direct zoonoses; diseases that are transmitted by make contact with or through an inanimate vehicle and that involve only one reservoir vertebrate to maintain the cycle of infection [1,2]. An estimated 70 percent of infectious diseases of domestic and wildlife species has zoonotic potential and can, under certain circumstances, be transmissible to man. Regardless of the diversity of infectious agents involved, somewhat few, however, are derived from horses or other members of the family *Equidae.* Zoonotic diseases are highly variable with respect to their transmissibility and seriousness of disease. A number of diseases may cause only mild transient disease, whereas others such as anthrax and *Burkholderia mallei* are so lethal and contagious that they have been used as biological warfare agents [2,3]. The range of diseases affecting the horse with zoonotic potential includes viral, bacterial, riketstseial, fungul, and parasitic infection: this review article provides an overview of some of the bacterial and viral Zoonosis of equine that human beings may acquire accidently by direct or indirect contact.

Bacterial Equine Zoonosis

Tuberculosis

Tuberculosis (TB) is a zoonotic disease caused by *Mycobacterium tuberculosis*, *M. bovis*, or other members of the *M. tuberculosis* complex in a wide variety of mammal hosts [4,5]. Horses are believed to be more resistant to mycobacterial infections compared to other livestock species [6].

The incidence of TB in horses is extremely low, especially in countries with established control programs [7]. On the other hand, equine cases of clinical disease due to *M. bovis, M. avium*, or *M. tuberculosis* have been described [8-10]. Among the tuberculous mycobacteria, *M. bovis* has historically been the principal causative agent, whereas *M. tuberculosis* is less commonly isolated from horses [7]. However, recently, an isolated case of TB due to *M. bovis* was reported by Keck *et al.* [11], in a horse living in close contact with infected cattle in the Camargue region of France, which is known for *M. bovis* infection in fighting bulls [12].

A research result that was reported by Konstantin *et al.* [10] showed a finding of a case of pulmonary tuberculosis that caused by *Mycobacterium tuberculosis* was diagnosed in a horse and the lung, multiple tuberculoid granulomas communicating with the bronchiolar lumen, pleural effusion, a granulomatous lymphadenitis involving mediastinal and tracheobronchial lymph nodes were found [10]. The findings suggest a possibility of interspecies transmission of *M. tuberculosis,* although the infection source remains unclear.

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Salmonellosis

Salmonellosis is a relatively common enteric disease in horses and many other species caused by serotypes of *Salmonella enterica sp enterica*. This gram negative bacterium can cause disease in a wide range of species including humans and horses. Of special alarm is the emergence of virulent, multi-drug resistant strains of Salmonella. Multidrug-resistant *S. typhimurium* DT 104 (*Salmonella enterica subspecies enterica* serotype Typhimurium definitive type 104) initially emerged in cattle in 1988 in England and Wales [13]. Subsequently, the strain has been isolated from poultry, sheep, pigs, and horse. Infection with *S. typhimurium* DT104 was reported in a number of horses in Ontario [14]. This multi-drug resistant phage type carries a higher than-average mortality rate in people and has been reported to have an increased potential for zoonotic transmission [15]. Antimicrobial therapy is used extensively to combat *S. typhimurium* infection in animals. The progress of a strain resistant to the commonly used antibiotics has made infections *with S. typhimurium* DT 104 in food animals difficult to control and likely to remain a zoonotic problem [14].

Zoonotic transmission of salmonellosis is through the fecal-oral route. Typically, ingestion of a relatively high number of organisms is required to cause clinical disease in healthy adults; however, concurrent disease, antibiotic use, or immunosuppression can greatly lower the required number of organisms. Suspected or confirmed cases should be isolated and treated as highly infectious. Close attention to personal hygiene, barrier protection, and disinfection of contaminated instruments will reduce the likelihood of zoonotic transmission. Salmonella is susceptible to many disinfectants including bleach, iodines, phenolics, and aldehydes, but can survive for long periods of time in the environment [14].

Methicillin-resistant *staphylococcus aureus*

Methicillin-Resistant *Staphylococcus Aureus* (MRSA) is a Gram-positive bacterium that is commonly carried on the skin or in the nasal passages of approximately 25% to 40% of the healthy human population [16-19]. It is estimated that roughly 10% of all healthy and active horses also carry the pathogen in their nasal passages, intestinal tracts and on their skin [20]. MRSA is a resourceful and adaptable pathogen that is capable of both aerobic and anaerobic respiration [21-23]. The increasing prevalence of MRSA in human and animal populations is of greatest importance and most definitely a worldwide public health problem [16, 20-23]. Furthermore, infectious diseases and zoonotic pathogens like MRSA are continually emerging across the globe [24]. MRSA is a growing concern for both human and horse health. Colonized horses serve as MRSA reservoirs in the community and are capable of transmitting MRSA to humans [25,26].

Research has recognized that MRSA readily moves back and forth between horses and humans [20,21,26-28]. The transmission of MRSA from infected horses to humans is a significant concern, especially given the frequent international movement of horses in the equine industry [29]. MRSA has been identified in horses, both human-to-horse and horse-to-human transmission by veterinary professionals and researchers in numerous locations [29,30]. Furthermore, research suggests that MRSA may already be endemic in certain horse populations worldwide [2]. Given that people who handle horses for occupational and recreational purposes come in very close contact with the animals on a routine basis, there is potential that MRSA is already much more widespread than recognized in horses and their handlers [29,30]. For these reasons, MRSA transmission and infection control as it concerns to human and horse health in an equine situation deserves more consideration and research.

Anthrax

Anthrax is an often fatal infectious disease that can infect all warm-blooded animals, including horses and humans, caused by the spore forming bacterium *Bacillus anthracis* [31,32]. In most animals it results in a rapidly fatal septicaemia and 'sudden death'. Anthrax most commonly develops in domestic and wild herbivores, such as cattle, sheep, goats, antelope and deer [33]. Anthrax is of particular topical importance because of its bioterrorist potential [34].

Horses are considered to be less susceptible than ruminants, and horses may have a more protracted course of disease. Affected horses may present with marked pyrexia, colic, dyspnea, and subcutaneous edema, or may die suddenly [35]. Whereas cases of anthrax are reported worldwide, certain areas have higher rates of infection. In the United States, South Dakota, Arkansas, Missouri, Louisiana, Texas, and California have the highest rates of anthrax infection and outbreaks in horses in Minnesota and North Dakota have been reported [35].

A variety of clinical forms are reported in people, including cutaneous, pulmonary and gastrointestinal. Approximately 95% of human anthrax cases are the cutaneous form, and often there is a history of contact with animals or animal products [36].

Humans can become infected with anthrax by handling products from infected animals or by breathing in anthrax spores from infected animal products. There are three types of anthrax: cutaneous (skin), inhalation (lungs) and gastrointestinal (digestive). They symptoms of anthrax depend on the route of infection or type. Cutaneous anthrax presents with a small sore that becomes a blister [33]. Prompt and aggressive treatment of infected animals is necessary because of the rapidly progressive and often fatal nature of the disease [33].

Leptospirosis

Leptospirosis is a widely spread zoonosis of global concern [37,38]. It is caused by spirochetes belonging to the genus Leptospira, serovars of *Leptospira interrogans* [39]. *L. interrogans* is prevalent worldwide and is considered to be the most widespread zoonosis in the world [38]. Leptospirosis is a significant occupational hazard in the cattle and pig industries in certain areas. Horses, in the majority cases, are accidental hosts [39]. Most leptospiral infections in horses are asymptomatic; however, clinical syndromes such as fever, anorexia, jaundice and lethargy have been reported [40]. Uveitis is the most frequently encountered clinical manifestation of leptospirosis in horses [40-42].

Leptospirosis can be readily transmitted between species, including animals and humans through infected urine, contaminated soil or water, or other body fluids [38]. The disease is maintained in nature by chronic infection of the renal tubules of maintenance hosts. Other animals including human may become accidentally infected by contact with the maintenance host [38]. The threat of zoonotic transmission of leptospirosis from horses is not considered great; however, it would be practical to take basic precautions, principally

when evaluating abortions or stillbirths [40]. Prevention involves early identification of infected animals, reducing contact with affected animals like urine and other body fluids and the use of waterproof barrier clothing [43].

Brucellosis

Equine brucellosis is caused by *Brucella abortus* and most commonly manifests as fistulous withers in horses, which can be a source of exposure to humans [44]. Clinically, brucellosis may also be associated with poll evil, nonspecific lameness due to joint infection. Human brucellosis is dependent on the presence of *Brucella* spp., among other animals with which people have direct or indirect contact [45].

None of the *Brucella* species are adapted to the horse. Equine infections usually involve the cattle pathogen *B. abortus*, although infection with *B. suis* has been reported [44]. *B. abortus* infections in domestic animals have been reported worldwide, but have been effectively eradicated from several European countries, Japan and Israel [44]. Horses are relatively resistant to infection; however, disease can occur and brucellosis can be transmitted from horses to humans. The frequency of association of *B. abortus* with fistulous withers varies with geographic region [46].

Human brucellosis is considered to be an occupational disease that mainly affects slaughterhouse, workers, butchers, and veterinarians [2]. Transmission typically occurs through contact of infected animals or materials with skin abrasions. Human brucellosis can be highly variable, ranging from non-specific, flu-like symptoms (acute form) to undulant fever, arthritis, and orchiepididymitis in males [2].

Horses infected by *B. abortus may* represent a source of infection to man, although documented cases of this route of infection are rare [47]. The organism can enter the body through abraded skin and enter across intact mucous membranes, including the conjunctiva and respiratory mucosa. The number of human cases of brucellosis has declined dramatically over the past 30 years as a result of effective control measures to control the disease in domestic animals [48]. *B. abortus* infection is a reportable disease in many countries, and seropositive horses may require be quarantining or subjecting to euthanasia [48].

Viral Equine Zoonoses

Rabies

Rabies is a highly fatal neurotropic viral disease of all warm blooded animals including man, caused by a virus of the genus *Lyssavirus* of family *Rhabdoviridae* [49-52]. It is transmitted by a bite from a rabid animal (skunks, raccoons, foxes, dogs, cats, and other animals) [1,53]. Horses contract the virus from the saliva of an infected animal either through a bite or by the saliva contaminating an open wound [54]. The disease is mainly transmitted from rabies affected animal to man through close contact with infected saliva via bites or scratches and invariably results in death [1,51,55].

Human exposure to rabies is less likely in equine than small animal or wildlife but there is opportunity since there were 82 reported cases of equine rabies in the United States in 1998, 65 reported cases in 1999, and 52 reported cases in 2000 [54,56]. Once more, in Florida, 128 animals were killed by the rabies virus in 2010 [53]. The vast majority of affected species were wildlife such as raccoons and foxes, but one horse and 15 cats were also lost [53].

Rabid horse may bite or strike viciously and, because of their size and strength, become unmanageable in few hours: some people have been killed outright by these horses [57]. These animals frequently suffer self-inflicted wounds [57]. Rabies can be prevented by vaccination and rabies virus is susceptible to bleach, aldehydes, ethanol, lipid solvents, ultraviolet radiation, and heat (1 hr at 50°C) [50,57].

Hendravirus (morbillivirus)

Equine Morbillivirus (EMV) was isolated in September 1994 in Queensland, Australia, involving two outbreaks that caused the deaths of 15 horses and 2 people [58]. The viral agent is commonly found in specific species of fruit bats and close contact among horses and these bats is suspected to have caused transfer of the virus to horses [59].

In 2008, one more multiple horse outbreak was reported in a veterinary hospital in Brisbane [60]. In this outbreak, all horses were in residence at the veterinary hospital at the commencement of the outbreak and affected horses presented with signs of central nervous system disease, rather than the previously reported signs of respiratory disease. Five horses were affected, out of a population of more than 30 horses [60]. In this outbreak a veterinarian and a veterinary nurse became infected, both were admitted to hospital and the veterinarian subsequently died from viral encephalitis. It was likely that both affected people were exposed to the virus prior to the infected horses showing any obvious clinical signs of disease [60].

In horses, the clinical course is very acute with the time from onset of signs to death, being only 1–3 days. Pyrexia, anorexia, and depression are the initial signs after an incubation period of 8–11 days [61]. The virus produced severe damage to the lungs with the accumulation of massive amounts of fluid [58].

In human, serious influenza-like signs predominate. Of the two deaths that were reported, one was caused by severe respiratory disease whereas the other was caused by meningoencephalitis [58]. People are at risk if they have had close contact with a horse that has the Hendra virus. They can contract the virus through inhaling respiratory secretions or if they get bodily fluids from the horse on their eyes, nose, and mouth or on their skin - especially if they have small cuts or abrasions [58,61]. Under experimental conditions, the virus did not appear to be highly contagious between animal species, and urine is the most likely source of excretion and infection [59].

Venezuelan equine encephalitis

Venezuelan Equine Encephalomyelitis (VEE) has been recognized as an important human and equine disease in northern South America since the 1920 [62,63]. The aetiologic agent, VEE virus, is a mosquito-borne virus in the family *Togaviridae*, genus *alphavirus* [64]. Venezuelan Equine Encephalitis Virus (VEEV) is the most important human and equine pathogen. It is an emerging infectious disease in Latin America [65].

The epizootic and enzootic strains of the VEE virus range from northern Argentina to Florida and parts of the Rocky Mountains;

however, it is most prevalent in northern South America [65,66]. A 1995 outbreak of Venezuelan equine encephalitis in Colombia and Venezuela affected an estimated 75,000 humans; 3000 people developed neurologic complications, and 300 fatalities occurred. Of the estimated 50,000 equines infected, 8% died of the disease. The extensive transmission of the virus was probably due to a combination of unvaccinated horses and a record high level of rainfall leading to an increase in the mosquito population [65,67].

Horses and humans are the most common hosts; however, a variety of other animals have been shown to be susceptible to infection [68]. These include mammals such as cats, dogs, cattle, goats, pigs, rodents, and birds [68].

The VEE virus is most often transmitted by infected mosquito bites, although, it is also very contagious through aerosols [68,69]. Subcutaneous injection, nasal instillation, and contact with broken skin or contaminated animal bedding are other ways to spread the virus [69]. This virus is spread between horses and humans via mosquitoes [70]. Instances person-to-person transmission has not been reported for the VEE virus, although an infected individual can transmit the virus to mosquitoes [65]. Generally, humans and equines become infected by mosquitoes of the *Psorophora* and *Ochlerotatus* genuses. Equines can spread the virus to each other through aerosols and to mosquitoes via bites [70].

Eastern equine encephalomyelitis

Eastern Equine Encephalomyelitis Virus (EEEV) is a mosquito-borne virus in the family *Togaviridae*, genus *Alphavirus*. EEEV, Western Equine Encephalomyelitis Virus (WEEV), and Venezuelan equine encephalomyelitis virus (VEEV) are related but genetically distinct *alphaviruses* [71]. EEEV and VEEV are lethal in up to 90% of recognized equine cases, whereas WEEV is least virulent in horses, which have a mortality rate of approximately 40% [72].

EEEV may also cause fatal encephalitis in humans (mortality rate 50%-75%) [73], in the United States, enzootic EEEV occurs mainly from New England to Florida, California and along the Gulf Coast, with rare reports of foci as far inland as Michigan and South Dakota [73,74]. In North America, sylvatic populations and the mosquito *Culiseta melanura* maintain the virus in hardwood, salt-water swamp habitats. Large populations of this mosquito allow amplification of the virus by transmission among wild birds [75]. Mosquitoes become infected when they feed on infected birds, which may circulate the virus in their blood for a few days. Infected mosquitoes can then transmit EEE to humans and animals when they bite and the best way to prevent EEE is to avoid mosquitoes and prevent mosquitoes from breeding [76].

West nile fever

West Nile Fever is caused by West Nile virus (WNV), a member of the Japanese encephalitis virus complex within the genus *Flavivirus*, family *Flaviviridae* [1,77]. WNV was first isolated in 1937 from the blood of a febrile adult human in the West Nile District of Uganda [78]. The virus is transmitted in natural cycles mainly between mosquitoes and birds, with humans and horses serving as incidental hosts [1,79,80]. This virus has since been reported in Africa, the Middle East, Asia, southern Europe, Australia, and, North America [81-83].

There are 30,000 human cases and 1172 deaths in USA since it was first reported in New York in 1999 [84]. The virus can cause death rates up to 100 % among avian species [84]. The main route of human infection is through the bite of an infected mosquito [1].

Approximately, 90% of WNV infections in humans are asymptomatic but, if it occurs, the clinical manifestation ranges from mild febrile and flu-like syndrome, termed West Nile fever to the neuro-invasive disease known as West Nile meningitis or West Nile encephalitis [85]. People over the age of 50 and some immunocompromised persons such as transplant patients are at the highest risk for getting severely illness [85].

Approximately 90 % of symptomatic cases in horses result in neurological disease with case fatality rates of 30-40% [86]. In the absence of a human vaccine, certain measures such as application of repellent cream on exposed skin, wearing of protective clothing when handling sick animal and clinical samples, drainage of standing water from pit, spraying of insecticides in buildings, regular testing of blood and organ donors and health education will certainly reduce the risk of infection to people [1,87,88].

Conclusion

An estimated 70 percent of infectious diseases of domestic and wildlife species has zoonotic potential and can be transmissible to man. Most of the more frequently encountered zoonoses are contracted through direct or indirect human contact with other domestic/wildlife species. From the numerous infectious diseases of domestic species and wildlife, few are specifically equine diseases. The range of diseases affecting the horse with zoonotic potential includes viral, bacterial, rickettsial, anaplasma, fungal and parasitic infections. Certain of these (Bacterial and viral infections) are discussed in this article. Among the group of viral infections, Venezuelean Equine Encephalomyelitis, Eastern Equine Encephalomyelitis, West Nile Fever and Equine morbillivirus are associated with severe disease in humans that can be fatal. The same would apply to certain multispecies diseases such as rabies and anthrax. The etiologic agents of other diseases like Salmonellosis and Leptospirosis though they can be responsible for causing significant illness in man are usually not considered of equivalent public health importance. Implication attributed to an equine zoonosis is dependent on prevalence of that disease and its case-fatality rate in humans. Thus, there is a need for greater cooperation between human and animal medical science, if more successful prevention and control of these diseases is to be accomplished.

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