An Analytical Study of the Perceptions, Prevention Srategies, Treatment and Economic Impact of Equine West Nile Virus

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Abstract: Since the introduction of the West Nile Virus (WNV) in the United States in 1999, WNV has been the cause of disease and deaths in humans, wild birds, zoo birds, and horses. In 2002, more than 15,000 equines in 40 states were diagnosed with illness associated with WNV. Horses are infected with the WNV more often than humans or any other mammal. It is becoming one of the fastest growing health threats to horses nationwide. Positive reports for WNV were announced in 2002, which prompted an increase in public education and equine vaccination recommendations. Although much has been reported on the economic impact of WNV on human health and hospital care facilities, documentation is lacking on these issues in the equine population. In this study, we examine WNV cases in the equine population in Texas in order to better understand the distribution of clinical disease, signs, treatments and outcomes. The results of the survey suggest that there could be a need for WVN education among veterinarians in areas of prevention, control, and treatment. Values for lost horses were not solicited in the survey, thus, a total economic impact could not be completely estimated.

1. INTRODUCTION

With the introduction of the West Nile Virus (WNV) into the United States in 1999, WNV has been the cause of disease and deaths in humans, avian and equines. Since mosquitoes are the primary vector that transmits the virus and with wild birds as the reservoir of the virus, it has the enormous potential to affect livestock and poultry. In 2002, more than 15,000 equines in 40 States were diagnosed with causes of illness associated with WNV and approximately one third of these horses died or were euthanized (Campbell et al, 2002). While the virus may infect humans and horses, there is no documentation that infected horses can spread the virus to uninfected horses or other animals. Migrating birds appear to play a major role in spreading the WNV

infection and disease and it is becoming one of the fastest growing health threats to horses and equines nationwide.

Horses are infected with West Nile virus more often than humans or any other mammal resulting in one of the fastest-growing health threats to horses nationwide. Once a horse is infected, the virus multiplies, potentially causing the severe illness. This leads to a disruption of the central nervous system and swelling of the brain. The worst form of the disease is fatal encephalitis or inflammation of the brain.

While there is no specific treatment or cure for West Nile Virus, prevention is the key strategy in dealing with this life-threatening disease. Horses that are vaccinated and receive boosters at the designated intervals have the highest level of protection against the West Nile Virus. Millions of horses already have been safely vaccinated; however, millions more are still at risk. Many of the horses that do become infected will not show any symptoms at all and are able to shed the virus on their own within eight days.

Because the mosquitoes that infect horses are the same mosquitoes that infect humans, disease prevention and control efforts are essential. In addition, Public Health has always played a critical role in disease surveillance and control of both animal and human populations.

The virus was first isolated and identified in 1937 from an infected person in the West Nile district of Uganda (Campbell, Marfin, Lanciotti and Gubler, 2002). After it was first isolated, infrequent outbreaks in humans were reported in Israel and Africa, mostly in soldiers, children, and healthy adults. These outbreaks were associated mainly with low-grade fever, headache, myalgia and fatigue. An increase in the frequency of WNV outbreaks, as well as increased clinical severity of the disease with notable neurological involvement and increase in mortality were noted in the mid-1990's. Until 1999 the spread of the virus was limited to the Eastern Hemisphere with wide distribution in Africa, Asia, the Middle East, and Europe, and was not seen in the U.S. until the summer of 1999 (Campbell et al, 2002; Mostashari, Bunning, Kitsutani, Singer et al, 2001). During 1999-2001, WNV spread throughout much of the eastern half of the U.S. and Southern Ontario in Canada.

A broad range of mammalian species are susceptible to WNV. In the U.S. at least nine mammalian species including humans, horses, cats, rabbits, skunks, squirrels, chipmunks and two species of bats were found to be naturally infected with WNV. The outbreak of the disease in horses across a ten-state region in 2001, and experimental studies in horses, suggests that the dead-end host for the WNV is the equine population (Campbell, et al, 2002).

1.1 *Epidemiology of West Nile Virus in Equines*

Since the first case of WNV in the U.S. in 1999, the virus has been migrating across the country. By mid-June of 2002, the WNV had traveled to the eastern portion of Texas. Since then, it has been reported in mosquitoes, birds (such as blue jays and

crows), horses, and humans in Texas. There has also been a continued westward movement of the virus. (TDH, 2000).

The prevalence of the WNV in horses in Texas has been declining since 2002. Below are annual summaries provided by the Texas Department of Health Zoonosis Control Division.

Table 1: West Nile Virus Statistics

Annual Summary of WNV Cases	2002	2003	2004
Bird	519	534	5
Human	202	437	0
Mosquito	260	1058	0
Horse	1699	717	3
Other	0	11	0
TOTAL	2680	2757	8

Source: Texas Department of Health Zoonosis Control Division (2004)

Horses are affected by WNV much more often than any other domestic animal. Forty percent (40%) of all cases of WNV in horses result in death, although most horses tend to recover ("West Nile Virus," 2003). Clinical signs of WNV in horses vary considerably, and may include ataxia (lack of coordination), circling, stumbling, falling, weakness or partial paralysis of limbs, muscle twitching (especially around the nose and lips), head drooping, lethargy, unresponsiveness, hypersensitivity to touch or sound, drooping lips, smacking, chewing, grinding teeth, falling asleep inappropriately, recumbency, and transient fever. Most horses continue to eat and drink normally, even when recumbent. Urination and defecation are usually normal. Many horses with WNV infection remain bright and alert and do not exhibit obvious signs (UC Davis CEH, 2004). However, it is important not to presume that horses with clinical signs of encephalitis have WNV.

A definitive diagnosis requires ruling out other important diseases with similar neurological signs. Rabies, botulism, Equine Protozoal Myeloencephalitis (EPM), and Eastern (EEE), Western (WEE), and Venezuelan (VEE) Equine Encephalitis are examples of other diseases with neurological signs that may be confused with WNV. A positive diagnosis of WNV can be made only by examining blood from infected horses (Fontaine, 2002).

1.2. *West Nile Virus in Texas*

Prompted by discovery of WNV in the New England area of the U.S. in 1999, the Texas Department of Health (TDH) announced expansion of their mosquito monitoring system. The TDH Laboratory tests over 200,000 mosquito specimens a year as part of the early warning system for encephalitis in an effort to prevent human outbreaks (TDH, 2001). The TDH Infectious Disease Epidemiology and Surveillance division initiated a plan to add WNV testing to seven counties with existing monitoring systems and expand monitoring to eight additional counties ("*Texas Department of Health*", 2000). Most of the areas collect and monitor mosquitoes during peak mosquito season, from May to November, but some do monitor every month. The targeted areas were within migration paths of birds traveling from the northeastern United States through the Gulf

Coast. The eastern one-third of the state receives concentrated surveillance. Infected birds, which serve as a reservoir for the virus, could be detected from samples sent to the TDH lab by county health departments, military installations, universities, and other mosquito control programs ("West Nile Virus", 2003).

Birds particularly affected by WNV are blue jays, crows and hawks. Blue jays in the Houston area first tested positive for the virus in June 2002 and one month later, two blue jays in Dallas County were found to carry WNV. In August, TDH reported that the Center for Disease Control and Prevention confirmed that seven persons living in Texas had tested positive for WNV. Four of those positives were from Harris County, two from Orange County and one from Jefferson County.

With horses identified as being most susceptible to contracting WNV, vaccination of the Texas equine population was encouraged by TDH early in 2003. TDH veterinarian, Joe Garrett noted that a vaccine that is approximately 95% effective in preventing WNV in horses was available (TDH, 2003). He added that horses should initially receive two injections 3-6 weeks apart with an annual booster thereafter. Protection against the disease would begin approximately 3-4 weeks following the second initial injection. WNV had not been shown to adversely affect other domestic animal populations.

1.3. *Economic Impact*

The economic impact of WNV on the equine industry is not an area that has received much research attention; however, in academic and public health circles, the issue has been of concern since the rapid spread of the disease was apparent. In looking specifically at the equine industry, very few studies have been published outlining the economic effect WNV has had on this industry. Knowing the increasing spread of the disease and potential health outcomes in humans and equines, the economic impact seems an important area to discuss. The most extensive study to date is one that was done in Colorado and Nebraska in the year 2002. This was a critical study in that it was the first time researchers had put a quantifying number on the cost of WNV to equines.

For the study period of 2002, Nebraska had 1100 and Colorado had 378 reported and confirmed cases of equine WNV for a total of 1478. These numbers may be low due to the low prevalence of laboratory confirmation in this population. The estimated cost of lost revenue due to the horses not being able to be used during time of treatment and recovery is approximately $163,000(APHIS, 2002). "The cost attributed to death or euthanasia of 432 equines in Colorado and Nebraska was estimated at $600,660" (APHIS, 2002 p.2). The veterinarians surveyed were asked to estimate the cost for treatment in mild, moderate and severe cases. Their estimates were $200, $400 and $250 respectively. Factoring in the number of cases for Colorado and Nebraska, the total estimated cost for all treatments was $490,844. (APHIS, 2002, p.3)

Treatment and prevention in human and equine populations have been frequently debated in recent years. Cost analysis on the effectiveness of the vaccine

versus the costs is an issue that all states affected by WNV have questioned. For equines, the effectiveness of vaccines had previously been discussed. Concerning cost, an average vaccine treatment of two (2) shots costs $50 (Lavine, 2003). For the affected horse owners in Colorado and Nebraska, estimates are that they spent a combined $2.75 million dollars in 2002 on prevention (AVMA, 2003, p.1). This number assumes that a mere 25% of the equine population was vaccinated.

In Texas, there are over one million horses accounting for a value of $4.2 billion dollars. The impact of the horse industry on the Texas economy is over $11 billion dollars each year (Gibbs, Potter, Jones, 1998). These are important aspects to understand when one is dealing with a disease such as WNV.

2. METHODOLOGY

The objectives of this study are to: (1) provide information regarding the perceptions, knowledge, concerns, and treatment of the West Nile Virus by veterinarians in Texas; and (2) to determine the economic impact of the West Nile Virus on the equine population in Texas. This study was a collaborative effort of the Texas Veterinarian Medical Association (TVMA), the Texas Department of Health (TDH), and the University Of North Texas Health Science Center School Of Public Health. The TVMA licensure office provided the veterinarian contact information.

2.1. *Survey Design*

The survey instrument was developed by reviewing survey instruments that had been used in previous research. Two questionnaires were reviewed for relevance to the current study: the “2002 Veterinarian Survey” conducted by the Colorado State University Animal Population Institute in collaboration with the Colorado State Veterinarian Office; and the “West Nile Virus Survey” from the Harvard School of Public Health Project on Public and Biological Security. Questions from both studies were selected and modified for the current survey. Ease of response, brevity, and options for modes of responding (i.e. online and via mail) were considered in the content development of this tool. To preserve the confidentiality of the respondents, no identifying information was included in the survey instrument. The research study was granted Exempt Status by the University of North Texas Health Science Center’s Institutional Review Board.

The instrument consisted of 13 close-ended questions and 1 open-ended question. The one open-ended question was a component of the survey used to determine major West Nile Virus issues for Texas veterinarians. Several of the questions addressed knowledge and perceptions about the West Nile Virus, education and training, and the effectiveness of prevention methods (vaccination regimen). Other questions were specifically designed for veterinarians who had diagnosed cases of equine West Nile Virus during the previous year (2003).

The target population consisted of all licensed and practicing/non-retired veterinarians in the state of Texas (4,177) as of the year 2004. Veterinarians who were surveyed practice in the various urban, suburban and rural counties throughout the state and are

licensed by the Texas State Board of Veterinary Medical Examiners (TSBVME) who supplied the contact information and mailing list.

2.2. *Data Collection and Analysis*

Survey participants had the option to complete an on-line survey or to return a completed hard-copy survey to the University of North Texas Health Science Center by US mail. All of the surveys were mailed by February 25, 2004. The surveys were sent with a stamped business reply envelope in order to increase the response rate. Statistical analyses were performed by using SPSS version 11 (SPSS Inc, Chicago, IL). The methods used for analysis of WNV data were descriptive statistics including summations and frequencies and logistic regression analyses.

3. RESULTS

With 700 of 4,177 surveys returned, 73.4 % (514/691) veterinarians believed that they are knowledgeable about WNV (Table 2). Only 49.7 % (348/691) believed that they are receiving or have received enough training/education concerning WNV (Table 2). The vaccination regimen is believed to be effective and reliable by 56.1 % (393/691) of the veterinarians (Table 2).

Table 2. Response to Knowledge, Education, and Vaccination

Response	Q1 n (%)	Q2 n (%)	Q3 n (%)
Strongly agree	131 (19.0)	49(7.1)	80(11.6)
Agree	383 (55.4)	299(43.1)	313(45.3)
Neutral	75(10.9)	192(27.7)	277(40.1)
Disagree	84(12.2)	142(20.5)	15(2.2)
Strongly Disagree	18(2.6)	12(1.7)	6(0.9)
Total	691	694	691

Q1:I believe I am knowledgeable about West Nile Virus.
Q2: I believe veterinarians are receiving enough training/education concerning West Nile Virus.
Q3: I believe the vaccination regimen for the equine West Nile Virus is effective and reliable.

There were 1256 cases of equine WNV reported confirmed via laboratory testing. There were also 766 horses reported that were not confirmed via laboratory testing. Among the 2,022 diagnosed cases, 257 were vaccinated against WNV prior to illness and 159 cases were vaccinated after signs of illness.

A total of 441 horses died as either a direct cause of the disease or by owner or veterinarian elected euthanasia. In 301 horses the owners elected euthanasia; in 117 horses the veterinarians elected euthanasia. The most common criteria used to decide euthanasia in these horses was prolonged recumbency as reported by 44.2 % (87/197) of the veterinarians. Other criteria included prolonged course of disease without resolution of clinical signs (21.8 %), quality of life (13.7 %), perceived cost of treatment (13.2 %), and other (7.1 %).

Table 3: Response to Major Issues Concerning West Nile Virus

Concern					
Vaccination	n=227	Education	n=312	Vector Control	n=223
Vaccination Program	123(54)	Public Education	120(39)	Mosquito Control	123(55)
Horse Owner Compliance	39(17)	Client Education	63(20)	Human Risk	60(27)
Vaccine Efficacy	37(16)	Veterinarian Education	34(11)	Bird Migration	12(5)
Vaccine Cost	25(11)	Small Veterinarian Education/Non-Equine	41(13)	Zoonotic Potential	21(10)
Apathy	3(2)	General Education	41(13)	Wildlife	7(3)
		Economic Impact	13 (4)		

(%)

In questions to be answered only by veterinarians that diagnosed a case of WNV, 52% (233/448) of the veterinarians did not recommend prevention strategies to equine owners (Table 6). Of the 215 veterinarians that recommended prevention strategies, 94.8 % believed that they are knowledgeable about WNV. Of the 233 veterinarians that did not recommend prevention strategies, 50% did not believe they are knowledgeable about WNV. Also 61.2% (275/449) of the veterinarians did not provide any recommendations on mosquito mitigation or other control strategies to their clients. Among the 213 veterinarians that recommended mosquito mitigation or other control strategies, 76.1% believe that veterinarians are receiving enough training and/or education concerning WNV. However, of the 233 veterinarians that did not recommend control strategies, only 37.8% believe they were receiving enough education. Among veterinarians that recommended mosquito mitigation or other control strategies, 94.2% believe that they are knowledgeable about WNV. Also 70.8% (194) of veterinarians that did not recommend mosquito mitigation or other control strategies also believe that they are knowledgeable of WNV.

Table 4. Response to Prevention and Control Strategies “

Response	Q10 (n=176)	Q11 (n=176)
Yes	172 (97.7)	134(76.1)
No	4 (2.3)	42(23.9)

(%)

Q10: Have you recommended prevention strategies in the treatment of the equine population owned by your clients?” among veterinarians that treated equine cases

Q11: Have you provided any recommendations on Mosquito mitigation or other control strategies?” among veterinarians that treated equine cases

According to the survey results 97.2% (171/176) of veterinarians that treated WNV in 2003 agree that they are knowledgeable about WNV. However, the percentage drops to 65.5% (343/524) of veterinarians that have not treated WNV. Among these veterinarians, 78.4% (138/176) believe that veterinarians are receiving enough training and/or education concerning WNV. In veterinarians that did not treat WNV only 40.1%

(210/524) believe that they are receiving enough education. Also 81.8 % (144/176) of veterinarians that treated WNV believe that the vaccination regimen is effective. Only 47.5 % (249/524) of veterinarians that did not treat WNV believed that the vaccination regimen is effective.

Table 5. Logistic Regression Analysis

	Question	OR	95% CI
Did Not Treat WNV/Treated WNV	I believe I am knowledgeable about West Nile Virus.	0.06	(0.02, 0.14)*
Did Not Treat WNV/Treated WNV	I believe veterinarians are receiving enough training/education concerning West Nile Virus	0.18	(0.12, 0.28)*
Did Not Treat WNV/Treated WNV	I believe the vaccination regimen for the equine West Nile Virus is effective and reliable	0.20	(0.13, 0.31)*

* p< .05, OR: Odds Ratio, CI: Confidence Interval

Logistic regression analyses were conducted to determine the magnitude of the difference between veterinarians that did not treat WNV as compared to those that did with respect to the first three survey questions (Table 5)**.** All three analyses were statistically significant at the p<.05 level. Veterinarians that did not treat WNV for approximately 95% less likely to agree that they were knowledgeable about WNV. It was also observed that those that did not treat WNV were 82% less likely to agree that veterinarians are receiving enough training. In addition, 80% of the practicing veterinarians that did not treat horses for WNV did not agree that the treatment regimen for WNV was effective and reliable.

The cost of the vaccination regiment for the equine WNV was reported by 62% (269/434) of the veterinarians to be $25 or less. Only 1.4% (6/434) reported that the average cost of the vaccination was $101 or greater. In questions pertaining to cost of treatment, 59.9% (109/182) of the veterinarians reported that treating a mild case of WNV cost less than $200, 70.6%(127/180) of the veterinarians reported that treating a moderate case of WNV cost less than $600, and 59.9%(100/167) of the veterinarians reported that the cost of treating a severe case of WNV is more than $701

Anti-inflammatory products were used in 63.47% (146/230) of mild WNV cases treated by veterinarians. Other treatments included antibiotics (13.04%), fluids (5.65%), steroids (2.17%), and other (15.65%). Anti-inflammatories were used in 57.76% (160/277) of moderate cases. Other treatments included fluids (9.03 %), antibiotics (7.8%), steroids (5.77%), and other (19.86%). Anti-inflammatories were used in 44.2% (156/353) of severe cases. Other treatments included fluids (13.3%), antibiotics (7.9%), steroids (6.0%), and other (28.6%).

In 1998, Texas A&M University estimated the horse population in the State of Texas to be over 1 million, with an estimated value of approximately $4.2 Billion or $4,200 per horse. It is estimated that the State has over 280,000 horse owners with a total investment in the horse industry of $13 Billion. Additionally, it is estimated that the horse industry has an economic impact of over $11 Billion dollars to the Texas economy (Texas A&M University, Animal Science, 1998). Utilizing these figures, tables 15 and 16 provide a conservative estimate of the economic impact to the horse owners and the horse industry on two parameters: vaccination and mortality.

Utilizing a conservative estimate of one million horses in the State of Texas, tables 15 and 16 reflects a conservative twenty five percent (25%) vaccination rate at a cost of twenty five dollars ($25) per vaccination regime. Based on this estimate, the economic impact to horse owners for these two years (2002-2003) was $12.5 million. Based on data in table 1, the number of WNV cases in Texas for 2002 and 2003 was 1,699 and 717, respectively (Texas Department of Health Zoonosis Control Division 2004). With an estimated forty percent (40%) mortality rate (Johnson, 2002), the number of horses that died or were euthanized in Texas in 2002 and 2003 as a result of the WNV was estimated at 680 and 287, respectively. With an estimated cost of $4,200 per horse, the economic impact from WNV to horse owners in 2002 and 2003 was $2,856,000 and $1,205,400, respectively, for a total of $4,061,400. Based on these same figures, the total estimated economic impact associated with WNV in Texas specifically resulting from costs related to vaccination and mortality was $16,561,400. This estimate does not take into account animal replacement and training costs. Based on the estimation, It is recommended that additional studies are warranted to grasp the full economic impact of WNV on the equine industry and the Texas economy.

Table 6. Estimated Economic Impact of WNV – 2002 and 2003*

	Estimate per Horse	Number of Horses		Total Estimated Impact	
		2002	2003	2002	2003
Vaccination	$25	250,000	250,000	$6,250,000	6,250,000
Mortality	$4200	680	287	$2,856,000	$1,205,400
Total				$9,106,000	$7,455,400

*Source: Texas Department of Health

4. DISCUSSION

The objectives of the study were to gain understanding of WNV cases among the Texas equine population, of veterinarians' perceptions, beliefs and knowledge of WNV, and of the economic impact of WNV on the equine population in Texas. It is estimated that the horse population in Texas is in excess one million horses (Gibbs et al, 1998). Results from the survey suggest that from this large population of horses, there were over 2,000 cases of equine WNV statewide in 2003. Of the 2,022 cases of diagnosed WNV, only 24 horses died as a direct cause of the disease. In 418 cases, euthanasia was elected either by the owner or the veterinarian. These results suggest a case fatality rate of 40% which is normal in comparison to others equine WNV studies in the U.S. Since no prior studies have been conducted on the equine population in Texas, these results can serve as a benchmark for future studies.

The results of the survey suggest that there could be a need for WVN education among veterinarians in areas of prevention strategies, control, and treatment. Only half of veterinarians in this survey recommend prevention strategies to their clients. Less than half of veterinarians who have not treated a case of WNV believe that they are receiving enough education on the disease. Approximately half of the veterinarians who responded to the survey believe that the vaccination regimen is effective in the treatment of WNV. Results from the survey also indicate that only a small percentage

equine were vaccinated after signs of illness. Future studies should be conducted to examine owner knowledge and beliefs on WNV vaccinations and prevention strategies.

These statistics show a very meaningful connection between the veterinarians who treated cases of WNV and their perception of self-knowledge (Question 1). A significant link was also discovered between those veterinarians who did not treat cases of WNV and those that believe that veterinarians are receiving enough training education concerning WNV. However, chi-square results of Question 3 (effectiveness and reliability of the vaccine) and those who treated West Nile Virus do not indicate a significant relationship.

The economic impact of WNV on the Texas equine population was also examined. The 2003 Colorado and Nebraska study estimated the economic impact by multiplying the number of horses lost by the average purchase price of a horse in 1998. Gibbs et al. (1997) estimated that the average purchase price of a horse in Texas for the year 1997 was $5,249, however, later figures indicate an average cost of a horse in Texas to be $4,200. Therefore, using this formula, it can be estimated that the economic loss due to WNV fatalities in 2003 totaled $1,205,400. Moreover, adding the cost of vaccination and the estimated fatality cases, it can be approximated that equine WNV cost owners an estimated $7,455,400 for 2003.

This study is limited because the information in the surveys was self-reported, however, this is a valid method of studying veterinarian attitudes. Also, many of the values given for number of cases in the survey were ranges; thus the exact number of cases could not be determined. Moreover, many veterinarians responding to the survey identified themselves as having a small animal practice only. Full economic impact of WNV in equines could not be determined because value of the horses that were euthanized or died was not solicited in the surveys.

Understanding the effects and treatments of WNV is essential in controlling this disease in the equine population. More research and education on WNV in the equine population is needed to prepare veterinarians and equine owners. Estimates of yearly cases of equine WNV should be collected in order to understand the impact of the disease and its changing patterns. Secondly, vaccinations and prevention strategies should also be surveyed in order for researchers to understand their effectiveness. Moreover, study results indicate that more education is needed to encourage vaccination and other preventive measures. There is an opportunity to fill this void by providing educational collaborative efforts between Veterinary Medicine and Public Health. Potential studies could also include surveys of owners' beliefs of prevention strategies and treatment methods of WNV in equines. The economic impact of WNV in equines must be fully examined to show the full impact of the disease on the state of equine were vaccinated against WNV prior to illness and an even smaller percentage.

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