Evaluation of the West Nile Surveillance System for the State of Kansas

MPH Capstone Experience Project
Conducted at
Kansas Department of Health and Environment

By

Katie Flock, DVM

Table of Contents

Abstract:

Background:

West Nile virus (WNV) is an arboviral disease that has caused an estimated 29,624 clinical illnesses and 1,161 deaths in the United States since its emergence in 1999. A national WNV surveillance program was established by the Center for Disease Control and Prevention by providing states with grant funds to construct surveillance systems in 2000. Kansas launched statewide surveillance efforts in 2001. This project describes the evaluation of the WNV surveillance system in Kansas to determine its level of effectiveness as a public health tool including recommendations to improve the system.

Methods

The surveillance system was evaluated utilizing the CDC's 2001 MMWR *Updated Guidelines for Evaluating Public Health Surveillance Systems.* The surveillance system was also compared to the CDC's *Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control* published in 2003. Key personnel in Kansas and neighboring states were interviewed during this evaluation. Mosquito pool collection data was evaluated for 2008 and 2009 for time lapse between collection and reporting of results. Records from Kansas's Electronic Disease Surveillance System 2003-2009, were analyzed using SAS 9.1.3 to determine number of days between non-human cases and human illness onset dates. A WNV surveillance system survey was created and utilized to interview public health officials in 4 surrounding states.

Results

Mosquito pool collection is conducted in 13 of 105 Kansas counties by the Kansas State University Entomology Department between May and October of each year. For 2008 and 2009, the combined range of time between collection and reporting of mosquito pool results was 6-87 days with a median of 23 days. When positive mosquito data was compared to human onset dates for 2003-2009 the time between positive mosquito pools and positive human cases, ranged from 36 days prior to human illness onset to 82 days after with a median of 24 days after human onset dates.

Conclusions

WNV is now considered endemic in the state of Kansas and is an established seasonal health threat for its residents. Mosquito pool collection data was shown to be a poor predictor of human disease. The timeliness of testing, reporting of results, and the evidence of human cases prior to detection in mosquito populations indicates that this method of surveillance is not providing adequate information to implement public health interventions. Resources would be better utilized if they were focused on educational efforts in disease prevention and mosquito control measures.

Introduction:

West Nile virus (WNV) was first isolated in 1937 from a febrile woman in the West Nile district in the Northern Province of Uganda [(1)]. In the years that followed its discovery, it was determined to be transmitted by mosquitoes and to have an avian amplification component to the lifecycle [(2)]. After the original isolation of WNV, the virus has been implicated in sporadic outbreaks of mild illness in Africa, the Middle East, western Asia, and Australia [(3)]. The first human cases resulting in death associated with WNV encephalitis were reported in Israel in the 1950s [(4)]. Since the mid-1990s, the frequency and severity of WNV outbreaks have increased with outbreaks in Romania (1996), Russia, the United States (1999) and Israel (2000) [(5)] [(6)]. Equine encephalitis associated with WNV was first identified in the 1960s, with the largest equine outbreak occurring in France in 2000 [(7)] [(8)]. The virus was limited to the Old World until it made its début into the Western Hemisphere in New York City in 1999 [(9)]. Since that time, the virus has spread across the United States, Canada and has been documented in Mexico and the Caribbean [(3)].

West Nile virus is a single-stranded RNA virus in the family *Flaviviridae,* genus *Flavivirus.* Serologically, it is a member of the Japanese encephalitis virus antigenic complex, which includes St. Louis, Japanese, Kunjin (Australian subtype of WNV), and Murray Valley encephalitis viruses [(10)]. The virus is maintained in an enzootic bird-mosquito-bird cycle until significant amplification allows for bridge-vector mosquitoes (mosquitoes that feed on both humans and birds) to transmit the virus to humans and other animal species [(11)]. Viral amplification occurs in the enzootic cycle until late summer to early fall when female bridge-vector mosquitoes begin diapause and start taking blood meals. Humans and other mammalian species are considered to be incidental host because they do not develop sufficient viremias to contribute to mosquito transmission [(7)].

Although 64 species of mosquitoes have been reported to the Center for Disease Control and Prevention (CDC) to be carriers of the West Nile virus, not all have the ability to transmit the virus.

Of the mosquito species identified with the virus, those of the *Culex* species have been thought to be the most important in transmission. *Culex pipiens, Cx. restuans,* and *Cx. quinquefasciatus* are considered to be the most important maintenance vectors because they are primarily ornithophilic, abundant, and have been shown to have high incidence of WNV [12] [13]. Mosquito species suspected of contributing the most to transmission to humans include *Culex pippins* L. and *Cx. restuans* in the northeastern and north-central regions, *Cx. tarsalis* and *Cx. quinquefasciatus* in the western United States and *Cx. nigripalpus* and *Cx. quinquefasciatus* in the southeastern regions [13] [14].

Most WNV infections in humans occur from the bite of an infected mosquito; however, other modes of transmission have been documented. Novel modes of transmission include blood transfusion, organ transplantation, breast milk ingestion, intrauterine, and occupational exposure [3]. West Nile virus infections in humans can cause a spectrum of manifestations ranging from no clinical symptoms to severe neurologic signs and death [5]. Clinical disease may appear after an incubation period of 3-14 days and symptoms last from 3-6 days[15]. The majority of human infections are asymptomatic. A serosurvey conducted during the 1999 New York outbreak, showed approximately 20% of infected persons developed clinical signs, and of these, only half visited their physicians [11].

West Nile virus Fever (WNF) is described as a febrile illness of sudden onset with non-specific flu-like symptoms. Patients may have high fever, malaise, anorexia, nausea, vomiting, headache, mayalgia, lymphadenopathy, and retro-orbital pain [5] [10]. A maculopapula or pale roseolar rash was reported in some patients and was more commonly noted in children [10]. In addition to WNF, an infection may result in West Nile Neuroinvasive Disease (WNND). Those affected with WNND usually have a febrile prodrome before the development of neurological symptoms [10]. It is estimated that only 1 in 150 patients with WNF progress to severe neurologic illness [11]. The neurological signs associated with WNV are similar to other flaviviruses and depend on the section of the nervous system affected. Clinical signs may be associated with inflammation of the meninges

(meningitis), the brain parenchyma (encephalitis), the spinal cord (myelitis) or any combination of the above. In rare cases, patients may present with an acute polio-like flaccid paralysis [5].

There is no established treatment for West Nile virus infection or a preventative vaccine for humans. Severe cases require hospitalization with supportive care of complications such as respiratory paralysis, pneumonia, pressure sores, and seizures [10]. Case fatality rates among patients hospitalized during recent outbreaks have ranged from 4-14%. These rates were higher among older patients [11]. Advanced age is the most significant risk factor for death, with patients over 70 years old being most at risk [5]. Survivors of neuroinvasive WNV disease can have significant long-term deficits including fatigue, memory loss, difficulty walking, muscle weakness, and depression 18 months or more following infection [5] [16] .

WNV in the Western Hemisphere

West Nile virus made its début into the Western Hemisphere in New York City and surrounding areas in 1999 [9], when in late August and early September these areas experienced an outbreak of human encephalitis. These cases were consistent with an arboviral disease and were initially indicated to be caused by the North American St. Louis Encephalitis virus (SLEV) [17]. SLEV and WNV are closely related and cross-react on serological tests. Simultaneously, it was noted that American crows (*Corvus brachyrhynchos*) and fish crows (*Corvus ossifragus*) were dying of viral encephalitis in the same geographic area as the human encephalitis cases [18]. In addition to crows, deaths of several exotic avian species occurred in zoological parks in the Bronx and Queens during the same time period [4]. Necropsy samples taken from Chilean flamingos (*Phoenicopterus chilensis*) from the Bronx zoo were submitted to the National Veterinary Services Laboratory (NVSL) where a flavivirus-like particle was identified by electron microscopy. The isolates were forwarded to the CDC for identification [18] [4]. The viral isolates were determined to be from a strain of the West Nile virus.

After the identification of WNV in avian species, human serologic results were re-evaluated to include WNV in the screening panel. Patients previously thought to have SLEV had stronger serologic reactions to WNV than to the SLEV [17]. It was determined at this time that the two outbreaks were associated. Shortly after the observation of avian and human cases of encephalitis, veterinarians in the New York City area started to see cases of equine encephalitis as well. Necropsy samples from four horses were sent to either the NSVL or to the CDC and were identified to be infected with WNV. In the 1999 outbreak, twenty equines with neurologic disease were confirmed as WNV cases by either positive plaque reduction neutralization test (PRNT) titer to WN virus or isolation of virus confirmed by primer sequence [19].

The West Nile virus strain isolated from the 1999 New York outbreak (NY99) was almost identical to a strain that had circulated in Israel from 1997 to 2000 [6] [18]. This genetic similarity suggests that the virus was imported to the Western Hemisphere from the Middle East. Although the exact method of introduction will remain unknown, several theories have been introduced, including introduction of an infected human or bird, or the unintentional importation of a WNV-positive mosquito [3] [5].

Public health officials feared that WNV would overwinter and begin another epidemic in the spring of 2000, this proved true when the virus was found to overwinter in populations of female *Culex* mosquitoes. The CDC and the U.S. Department of Agriculture (USDA) recommended that surveillance efforts be initiated along the Atlantic and Gulf coasts from Massachusetts to Texas [20]. Unlike in the Old World, WNV caused a significant mortality rate in avian species, especially in the Corvid family (crows, jays and magpies). These avian deaths provided one simple way for the nation to track the spread of the virus. In 2000, the virus spread north and south from New York City, and it reached the southeastern United States, including the Florida Keys, the summer of 2001. In 2002 the first cases were documented in Canada, Mexico, Jamaica, Guadeloupe and the Dominican Republic

[4]. By 2005, West Nile virus had successfully spread across the United States, being documented in all lower 48 states and the District of Columbia.

Since the introduction of WNV into the United States, there have been a total of 29,624 human cases reported to the CDC. Of the 29,624 cases, 12,088 (40.8%) were reported WNND, 16,765 (56.6%) were reported as WNF, 771 (2.6%) were clinically unspecified at this time. Of the total number of cases, 1,161 (3.9%) of cases were reported to be fatal.

WNV in Kansas

In 2001, the Kansas Department of Health and Environment (KDHE) started a West Nile virus surveillance program using funds provided by Epidemiology Laboratory Capacity (ELC) grant from the CDC. The original surveillance was started to track the spread of WNV in the United States and to provide information about potential vectors, seasonality, geographic areas of increased activity and potentially susceptible species. At this time, surveillance efforts included voluntary submission by the public of dead birds for testing, mosquito pool collection, and reporting human, equine and other animal cases. Positive avian and other animal results are not required to be reported and reporting was done as an agreement between testing laboratories and the KDHE.

The first WNV activity in Kansas was identified in a mosquito pool of *Culex tarsalis* mosquitoes collected on July 23, 2002. The first documented case of WNV in Kansas appeared on August 8, 2002 when a horse was reported to be infected. The first human case had an onset date of August 6, 2002. In 2002, 103 of 105 counties reported WNV in horses, birds, mosquitoes, or humans. There were 22 reported human cases in 2002 with the epidemic continuing in 2003 when 90 people were reported with WNV fever, meningitis, encephalitis, or acute flaccid paralysis. Since this outbreak, Kansas has reported West Nile virus activity in the state every year.

In 2009, WNV surveillance included passive human disease reporting and mosquito pool collection and testing. Since 2002, in accordance with K.S.A. 65-118 and K.S.A. 65-128, all

arboviral diseases, including West Nile virus, Western Equine Encephalitis, and St. Louis encephalitis must be reported to KDHE, Division of Health, Bureau of Surveillance and Epidemiology within 7 days of confirmed or suspect cases. Cases are reported by health care providers, hospitals and laboratories across the state.

Mosquito pool testing begins in May and continues until late fall. In 2009 mosquito testing was conducted in 13 counties in an attempt to represent all five regions of the state. CDC miniature light traps model 512, were used for mosquito collection. Traps were set after 3pm in locations near standing bodies of water. Traps were left overnight and retrieved the following morning. The collection cups were removed from the traps and tied shut. The cups were then placed in a cooler with dry ice to facilitate freezing of the mosquitoes. Once the mosquitoes were frozen, they were placed in a Nalgene bottle labeled with city, date, and trap site. The collection cups were stored in a -80^{o} C freezer until processed. The mosquitoes are sorted by species; all non-*Culex* mosquitoes were discarded. The *Culex* species mosquitoes were sorted into pools of 1-50 mosquitoes from each site. For testing there were at least 5 mosquitoes for *Culex pipiens* and 7 mosquitoes for all other *Culex* species. Once they had been sorted and pooled they were submitted to the Kansas Health and Environmental Laboratory for testing for WNV. Mosquito pools were tested by reverse transcriptase (RT)-PCR with similar protocol as described by Lanciotti et.al [(24)].

Results were submitted to the Bureau of Surveillance and Epidemiology and a quality assurance coordinator enters the data into a Microsoft Excel® spread sheet. Both human and mosquito pool results are entered into Kansas's Electronic Disease Surveillance System (KS-EDSS), an electronic database system. This system is used to share information with the CDC through ArboNet, a national, electronic surveillance system established and maintained by the CDC to assist states in tracking mosquito-borne diseases. The State Epidemiologist, Mr. Charlie Hunt, MPH, and local health departments are notified via e-mail of any positive results.

The emergence of West Nile virus in the Western Hemisphere was a major event in arbovirology. Not only because of potential disease outbreaks, but also because it reminded the world that pathogens are dynamic and with increased global movement of people and goods, the threat of disease invasion is constant. The introduction of a pathogen into an area where there are competent vectors and a naïve human population can prove to be devastating. At the time of the 1999 outbreak, the United States had limited capacity for arboviral surveillance and control measures; the entry of WNV unveiled a substantial weakness in the U. S. public health system. Although the United States has several other mosquito-borne encephalitis diseases such as Eastern and Western Equine Encephalitis and St. Louis Encephalitis, most states had no standing arboviral surveillance or control measures in place.

Until the WNV epidemic, the United States had not dealt with a large scale outbreak of viral encephalitis since 1974 when St. Louis Encephalitis virus caused 1,967 cases across 32 states. When WNV emerged and started to spread across the continent, states were encouraged and provided funding to develop and implement programs for surveillance, prevention and control [(17)]. These surveillance efforts were focused on identifying and documenting WNV infections in birds, mosquitoes and equines as sentinel animals that would alert health officials to the possibility of human disease.

It is important to periodically evaluate public health surveillance systems to ensure that problems of public health importance are being monitored efficiently and effectively. Evaluating surveillance systems help to improve the quality, efficiency, and usefulness of the program. Currently Kansas conducts WNV surveillance by monitoring human cases and by testing mosquito pools collected in specific areas of the state for the virus.

The main focus of this current evaluation is the comparison of mosquito testing and human infections. The time lapse between collection of mosquito pools and reporting of results, correlation

of positive mosquito pools and human cases and use of data collected from the surveillance system were are analyzed in this evaluation. In addition, historical data was analyzed to determine the timing between animal and avian cases compared to human cases by county to determine if previous methods of surveillance provided quality sentinel information. The results of this current evaluation will be utilized by the KDHE to make further decisions about the course of action for the West Nile virus surveillance system in Kansas.

Materials and Methods:

With the help of the KDHE Bureau of Surveillance and Epidemiology staff and my direct supervisor Dr. Ingrid Garrison, DVM, MPH, DACVPM, the Environmental Health Officer and State Public Health Veterinarian, the West Nile virus surveillance system was evaluated using the guidelines described in the CDC's 2001 *Updated Guidelines for Evaluating Public Health Surveillance Systems.* The surveillance system was also compared to the CDC's *Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control* published in 2003.

Engage the Stakeholders

The first step in evaluating the surveillance system is to engage the stakeholders. Stakeholders are defined as "persons or organizations that use data for the promotion of healthy lifestyles and the prevention and control of disease, injury, or adverse exposure" [(21)]. People directly involved with the surveillance system were interviewed by direct communication. Dr. Ludek Zurek, Associate Professor in the Entomology Department at Kansas State University, supervisor and coordinator for mosquito pool collection, was interviewed on November 10, 2009 to discuss the mosquito pool collection and testing process. Dr. Roman Ganta, Associate Professor in the Department of Diagnostic Medicine/Pathobiology at Kansas State University was interviewed on

January 9, 2010. Dr. Ganta supervises the virology lab at the Kansas State University Veterinary Diagnostic Laboratory. This is where avian, equine and other animal testing for WNV is conducted. In the interview we discussed the number of equines tested annually and the method of reporting for horses. Administrators from local health departments in counties that had a positive mosquito pool in 2009 were contacted on January 20, 2010 to determine how they respond to the notification of a positive pool.

Describe the Public Health Importance

Data for the state of Kansas was retrieved through the Kansas Electronic Disease Surveillance System (KS-EDSS). Cases were evaluated from January 1, 2002 to December 31, 2009. West Nile virus cases are classified as either suspect, probable, or confirmed for surveillance purposes. This classification is based on a combination of clinical disease and supporting laboratory data. Laboratory criteria for diagnosis is defined by the CDC as: a four-fold or greater virus specific serum antibody titer, or; isolation of virus from or demonstration of specific viral antigen or genomic sequences in tissue, blood, cerebrospinal fluid (CSF), or other body fluid, or; virus-specific immunoglobulin M (IgM) antibodies demonstrated in CSF by IgM antibody-capture enzyme immunoassay (EIA), or; virus-specific IgM antibodies demonstrated in serum by EIA and confirmed by demonstration of virus-specific serum immunoglobulin G (IgG) antibodies in the same or a later specimen by another serologic assay (e.g., neutralization or hemagglutination) [(22)].

Confirmed cases are cases with clinical symptoms consistent with West Nile virus associated illness and with one of the laboratory diagnostics listed above. Probable cases are defined as an encephalitis or meningitis case, with or without neurological involvement, occurring during a period when arboviral transmission is likely and with the following supportive serology: a single or stable (less than or equal to two-fold change) but elevated titer of virus-specific serum antibodies, or; serum

IgM antibodies detected by antibody-capture EIA but with no available results of a confirmatory test for virus-specific serum IgG antibodies in the same or a later specimen. Cases that do not meet the criteria for confirmed or probable status remain suspect cases.

Only cases classified as confirmed or probable were identified in the data search and, exported to a Microsoft Excel® spread sheet. Names and address of individuals were not included in exported data to maintain privacy of the patients. Data was separated into case classifications of encephalitis/meningitis, fever, other clinical/unspecified, fatalities and total numbers. These numbers were separated by year. Cases were evaluated by clinical classification, age, and sex. All cases from years 2002-2009 were plotted on an epi-curve by the established Morbidity and Mortality Weekly Report (MMWR) week. The Morbidity and Mortality Weekly Report is a weekly scientific publication prepared and published by the CDC which contains data and reports on specific health and safety topics.

Timeliness

Time between mosquito collection and reporting of test results to KDHE was evaluated. Years 2008 and 2009 had adequate data for this evaluation. To determine the usefulness of mosquito pool testing, avian and other animal cases as sentinels for human illness, data was analyzed to determine the number of days between positive non-human cases and positive human cases. Non-human cases include mosquito pools, avian and animal cases. Animal cases included all animal species except for avian and mosquito cases. We compared report date of non-human cases to onset of illness for human cases by county. Data was used from 2003 to 2009; cases from 2002 were excluded due to lack of mosquito pool test results. All mosquito pools, avian and animal cases were exported from KS-EDSS. All positive human, mosquito pools, avian, and animal pools were analyzed using SAS 9.1.3 to calculate the days between non-human cases and human cases that

occurred in the same year and the same county. The range and median was calculated when there was enough data for this analysis.

Onset dates for human illness and mosquito pool result dates were separated by MMWR week and by year for years 2003-2006 and 2008-2009. Mosquito collection was not performed in 2007. Human and mosquito data was exported from KS-EDSS and entered into Microsoft Excel (2007) spreadsheets. These spreadsheets were then utilized to demonstrate graphically when human and mosquito pools peek by MMWR week.

Other States

During this evaluation, the state's neighboring Kansas (Oklahoma, Missouri, Nebraska, and Colorado) were all interviewed by phone or with an e-mailed questionnaire on March 3, 2010. The purpose of these interviews was to compare Kansas's system to neighboring states and to gain ideas of other efforts in the prevention and control of WNV. The main points of the interview were to determine what types of surveillance is being done and if monitoring will continue. Contact information for individuals is available in Appendix C.

Results:

Describe the Public Health Importance

Of the 890 human cases entered into KS-EDSS, 877 were Kansas residents, of these 153 cases were confirmed and 142 were of probable status. Of the 295 human cases, 194(65.8%) cases were reported as West Nile neuroinvasive disease, 99(33.6%) as West Nile fever, 2 (0.68%) were clinically unspecified, and 13 (4.4%) of cases were reported to be fatal. Human case break down by year is demonstrated in Table 1.

Table 1. Human Cases in Kansas Reported in EDSS January 1, 2002 - December 31, 2009

Year	Encephalitis/Meningitis	Fever	Other Clinical/ Unspecified	Totals	Fatalities
2009	3	10	0	13	0
2008	14	17	0	31	0
2007	14	26	0	40	2
2006	17	13	0	30	4
2005	17	8	0	25	1
2004	18	25	0	43	2
2003	89	0	2	91	4
2002	22	0	0	22	0
Totals	**194**	**99**	**2**	**295**	**13**

Number of human cases and fatalities by year are represented in Figure 1. The highest incidence occurred in 2003 with 91 reported cases and 4 fatalities. In 2006 there were 4 fatalities as well but only 30 cases were reported. The incidence decreased considerably from 2008 with 31 cases to 2009 with only 13 reported cases. The incidence rate in 2003 was 3.4 cases per 100,000 individuals in Kansas, this compared to 1.4 cases per 100,000 on the national level. In 2008, the incidence rate for Kansas was 0.2 cases per 100,000 compared to 0.4 nationally. The age of cases by range and median are noted by year and the number and percent of total for sex of cases is reported in Table 2. For all years the age of cases ranged from 1 to 94 years of age with a median of 52. Of all cases, 59.2% were male, 39.8% were female and 3 cases (1%) had no sex recorded.

Table 2. All Human Cases by Age and Sex for Years 2002 - 2009

Year	Age (years)		Sex		
	Range	**Median**	**Male**	**Female**	**Unknown**
2009	2-81	51	8 (61.5%)	5 (38.5%)	
2008	5-83	43	16 (53%)	14 (47%)	
2007	1-86	52	20 (49%)	21 (51%)	
2006	9-86	57	20 (65%)	11 (35%)	
2005	16-86	57	19 (76%)	6 (24%)	
2004	7-84	48	29 (62%)	18 (38%)	
2003	2-94	54	64 (60%)	39 (37%)	3 (3%)
2002	8-83	51	15(58%)	11 (42%)	

From 2002-2009 the highest number of cases were seen in the >55 years of age group seen in Figure 2. In addition, that group had the highest proportion of WNND with 103 of 135 cases (76.3%)

compared to the next highest group, 36-54 years of age, with 53 of 86 cases (61.6%) noted in Figure 3. When cases are evaluated by date of onset of illness, shown in Figure 4, the peak WNV season appears to be from week 29 to 41. One case with a MMWR week of 5 was excluded from the data set. The MMWR weeks 29-41 correspond to approximately mid-July to mid-October.

Figure 1.

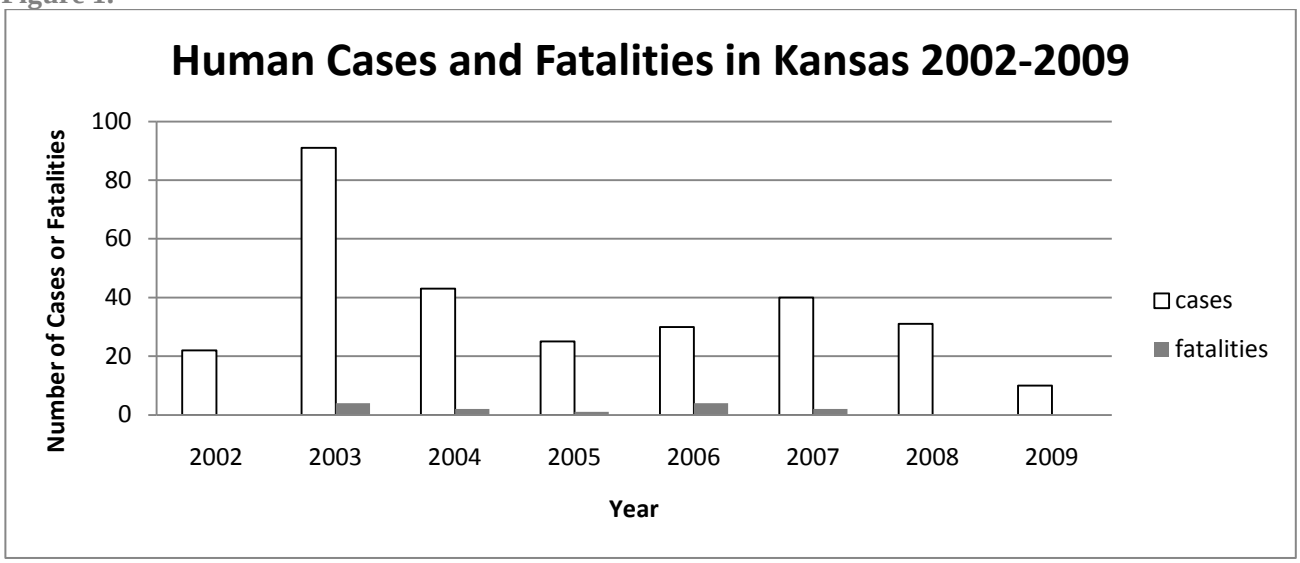


Figure 2.

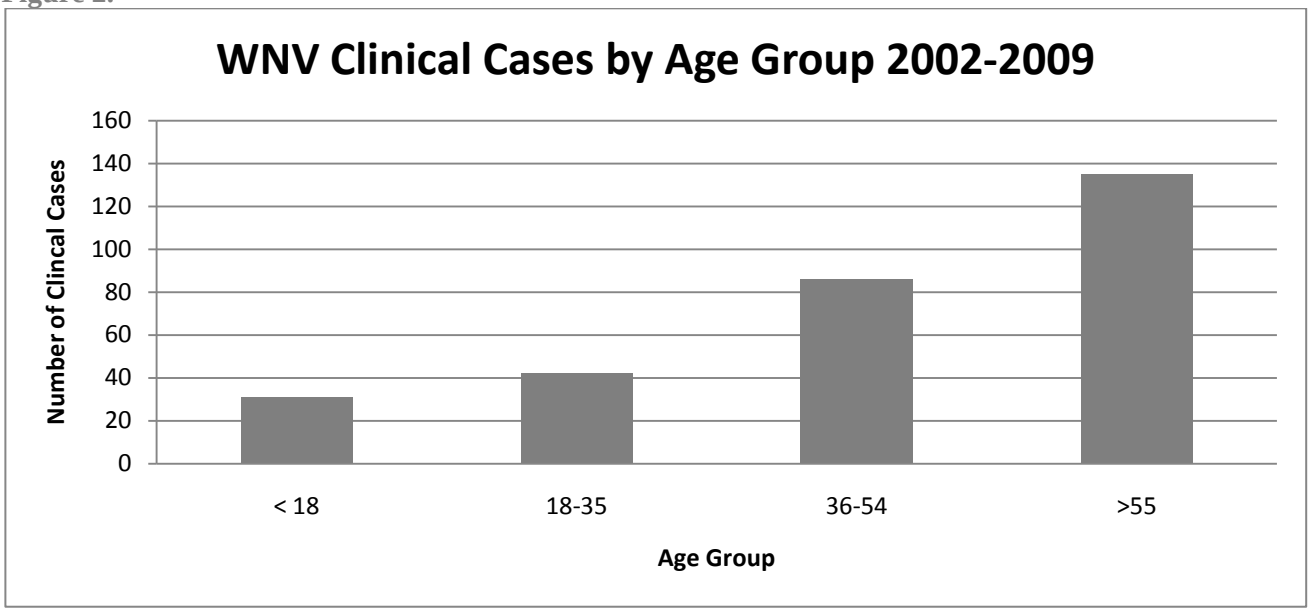


Figure 3.

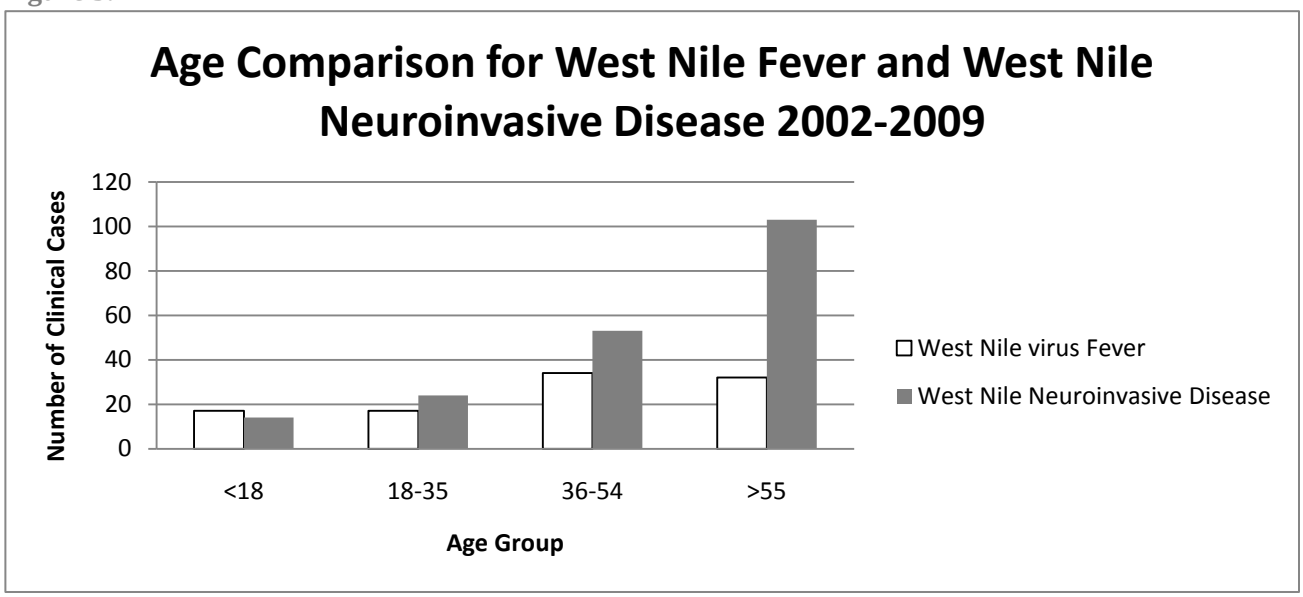
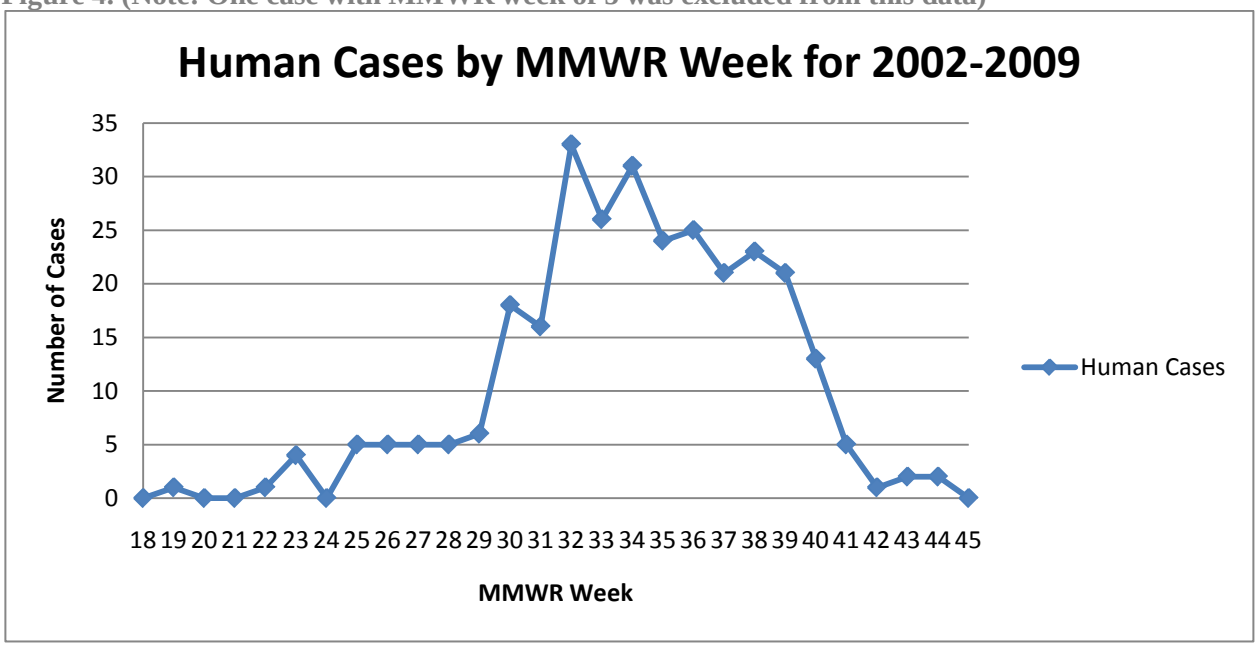


Figure 4. (Note: One case with MMWR week of 5 was excluded from this data)



Timeliness

The range and median for the number of days between mosquito pool collection to report date of results for years 2008 and 2009 are demonstrated in Table 3. The range for both years combined was 6 to 87 days and the median 23 days.

Of the 890 human cases in KS-EDSS, 877 were Kansas residents, 871 cases were from years 2003 thru 2009, of these cases, 456 had a reported onset date, of which 288 were of confirmed or

probable status. There were 122 animal cases reported; of the 365 avian cases in KS-EDSS, 205 were positive cases; of the 2992 mosquito pools entered into the system, 115 were positive.

The time between non-human and human cases are summarized by year in Appendix A. Fields with N/A indicated that there were no non-human and human cases that occurred in the same county. When all years were combined, animal cases ranged from 49 days prior to human cases to 110 days after human cases, with a median of 22.5 days after to human cases. Avian cases ranged from 60 days prior to human cases, to 58 days after human cases with a median of 1 day after human cases. Positive mosquito pools ranged from 36 days prior to human cases to 82 days after human cases, the median for positive pools was 24 days after human cases. These numbers are demonstrated in Table 4.

Table 3. Time Between Mosquito Pool Collection and Report Date

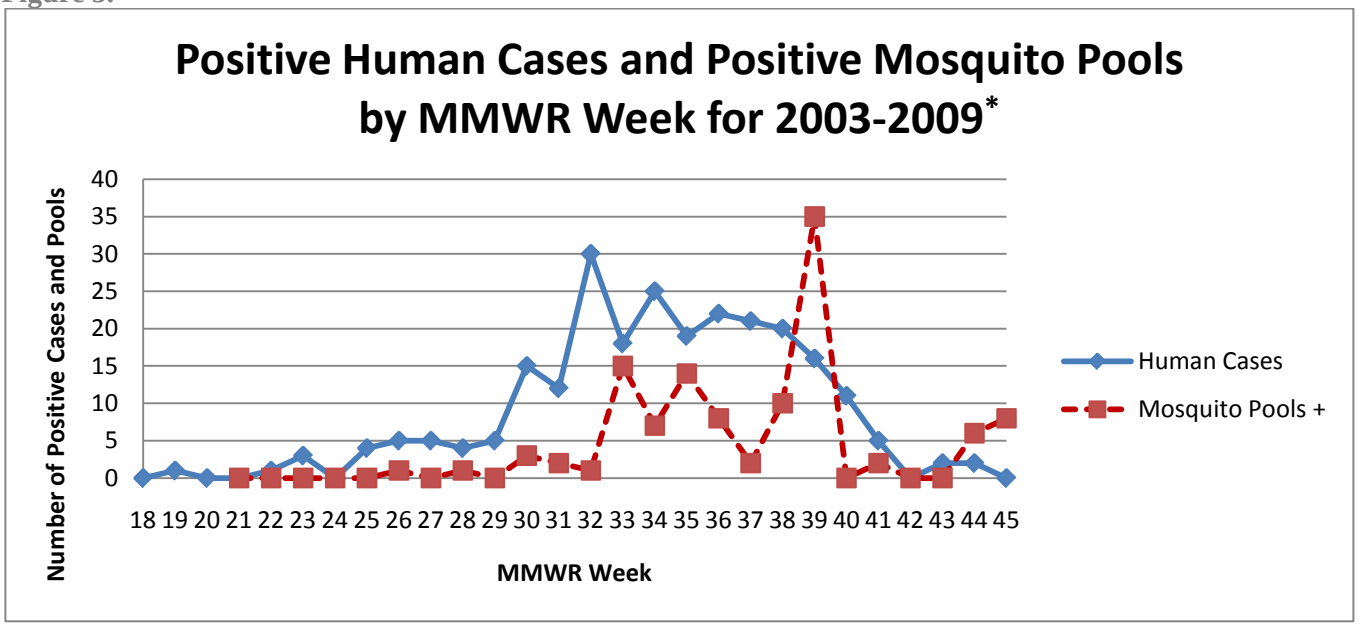
Year	Range (days)	Median (days)
2009	6-87	22
2008	6-43	24

Table 4. Time Between Non-Human and Human Cases in the Same County for 2003-2009

All Years	Animal to Human (days) N= 24	Avian to Human (days) N=49	Mosquito to Human (days) N= 16
Range	49 prior to 110 after	60 prior to 58 after	36 prior to 82 after
Median	22.5 after	1 after	24 after

Mosquito pool result dates and human illness onset dates by MMWR week for combined years of 2003-2006 and 2008-2009 can be found in Figure 5. MMWR week separation for all years can be found in Appendix B. For all years combined, human cases began to rise on MMWR week 25 and peaked week 32 while mosquito pools started to rise in week 32 and peeked on MMWR week 39.

Figure 5.



*** Excludes data from 2007 – Mosquito pool collection was not performed in 2007**

Other States

In addition to human surveillance, all states interviewed indicated that WNV equine data was collected. Equine cases are reportable in 3 of the 4 states to the Department of Agriculture and these results are then shared with the State Health Department. Dead bird reporting is conducted in 2 states with dead bird reporting and testing conducted in 1 of the 4 states. Mosquito pool collection and testing is done in all 4 surrounding states and is funding by the ELC grant. Collection is conducted by several different personnel including local health departments, mosquito control agencies, private citizens, and State Universities. Mosquito collection in these states was conducted in the following number of counties for 2009: 27/93 (29%), 19/64 (29.7%), 4/77 (5.2%) and 14/114 (12.3%) This compares to 13/105 counties (12.4%) in the Kansas.

All four states indicated that the State Health Department issues press releases for the first positive test result for each county. All states indicated that the level of surveillance would not be continued if funding from the CDC is terminated. Only one state indicated that continued surveillance would be possible without funding; all others were unsure at this time but were not optimistic about continued surveillance. One state had expressed concern that if mosquito surveillance was no longer conducted, their city mosquito control agencies might have difficultly obtaining permits for larvicidal application with the stronger regiments set by the National Pollutant Discharge Elimination System (NPDES), which controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Another state had expressed the need for an increased amount of mosquito based surveillance for other potential emerging arboviral diseases such as Dengue and Malaria.

Discussion:

In 2009 mosquito pool collection was conducted in 13 of 105 counties (12%) in Kansas. These counties were: Scott, Finney, Trego, Graham, Mitchell, Barton, Pratt, Riley, Butler, Shawnee, Coffey, and Crawford. In 2009 there were 4 positive mosquito pools in three counties; Scott, Finney and Trego. When administrators for these 3 counties were contacted, all indicated that they did not increase mosquito control for the indicated area or release an announcement to the public. All counties did express that if a public service announcement (PSAs) was given to them that they would release it to local media sources. The major goal of mosquito-based surveillance is to provide sentinel information for public health officials to increase mosquito control and education efforts in an attempt to decrease human exposure and disease. After we evaluated mosquito-based surveillance in the state of Kansas it was determined that mosquito pool testing was not a predictor of human disease.

Positive animal cases, including equine cases, were voluntarily reported to KDHE from 2002 – 2007. With the introduction of an effective vaccine for horses, the number of cases declined dramatically. The number of horses tested at the Kansas State Veterinary Diagnostic Laboratory has decreased over the last few years to less than 10 tested in 2009 and no positive results recorded. Equine cases had been thought to be good sentinel animals because they are highly conspicuous, numerous, and widely distributed in some areas. They may be particularly useful sentinels in rural areas, where dead birds may be less likely to be detected. According to the CDC in 2002, "equine WNV disease cases were the first indication of WNV activity in 95 (16%) of the 589 counties where human disease was reported. The majority of these 95 counties were located in the central and western U.S." [23] When Kansas equine date was analyzed, it was determined that equine cases were not effective sentinels for human illness in Kansas. The median time between animal and human infections was 22.5 days after human illness onset dates.

When we evaluated avian cases as sentinel species in Kansas it appeared that although avian cases appeared before human cases it was still not of adequate lead time for effective control measures to be implemented to prevent human infections. According to the CDC, avian morbidity/mortality surveillance had appeared to provide the most sensitive system for early detection for WNV activity. The guidelines set forth by the CDC encourage avian surveillance to be a component of every state's arbovirus surveillance system. Kansas conducted avian surveillance from 2001 to 2006 by testing dead birds submitted by state residents. This method of surveillance was discontinued in 2007 when only 2 birds were submitted for testing in 2006. It was concluded at that time that minimal data was being collected and deemed non-useful as an indicator for human cases.

Conclusions:

Mosquito based surveillance for detection of West Nile virus activity is not a successful tool for public health interventions in the state of Kansas. Minimal funding limits the number of locations for mosquito collection and does not provide ample data that is representative of the state's mosquito population. Early detection of WNV in mosquito populations is aimed at allowing public health officials to implement prevention measures to limit human infections. This method of surveillance is heavily reliant on timeliness of testing and reporting results from collected mosquito pools. Time between date of first collection and date of reported test results is usually prolonged. This extended time period does not give local public health offices adequate time to implement mosquito control measures or release of public service announcements for preventative educational material in an effort to decrease human exposure.

There is concern that another arboviral disease will enter the United States, if current surveillance efforts are discontinued leaving the nation in the same place it was back in 1999. Current methods of mosquito surveillance do not include testing for other arboviral disease and thus would not currently detect infection. It is now known what resources are needed and available in the state to re-instigate surveillance if there is a need in the future. The prevention and control measures for all arboviral diseases are the same and efforts should focus on educational material on vector control and prevention of bites instead of surveillance.

West Nile virus should now be considered an endemic disease and there is no longer a great need for mosquito based surveillance to occur in the state of Kansas. WNV is an established seasonal health threat to residents of Kansas and resources would be better utilized if they were focused on educational efforts in disease prevention and mosquito control measures.

Improving education can be accomplished by implementing several different techniques. One simple method would be to maintain an accurate and updated website. Maps of WNV for Kansas

have not been updated since 2006 and may give the public the impression that there has not been WNV activity since then. In addition, there could be increased outreach to county extension offices and to Master Gardener programs in the state. Both of these organizations have contact with community members who are usually involved with outdoor activities. This could be done by providing them with PSAs or website links to display on their websites. These programs have often increased involvement with the community and the Master Gardener programs may be able to provide educational information to those citizens >55 years of age whom are at greater risk of severe disease.

Through previous surveillance efforts, the seasonality of WNV was able to be identified with human cases starting in mid-July and continuing through mid-October. Timely public service announcements about mosquito control and prevention of mosquito bites should be released in June and again in August. Releasing of public service announcements (PSAs) and having them broadcasted by local media has been problematic in the past. In a 2003 evaluation of WNV education campaign in Kansas, evaluators found that no television or radio stations in a 10-county sample had broadcasted PSAs provided to them; only 5 of 23 newspapers printed the provided material. In the 2003 evaluation, many stations have policies that prohibit opening of unsolicited e-mails with attachments. One idea to increase the utilization of PSAs by local media sources is to provide the resources through a secure link on the KDHE website and provide letters to administrators encourage the use of WNV public service announcements. Although funding is limited, purchasing of advertising for the prevention of all vector borne diseases may prove to be useful.

Animal and avian cases are still tested at the Kansas State University Veterinary Diagnostic Laboratory. This information was initially shared with KDHE and this distribution of results could be reintegrated into the WNV data base. Although the numbers of animal and avian cases are

decreased and the level of effectiveness of this information is unknown at this time, this information is one cost-effective way of monitoring WNV activity in Kansas.

Continued public educational efforts should not only focus on the prevention of WNV, but should also focus on all vector borne diseases. As incidence of WNV continues to decrease as expected, the level of concern of citizens is also expected to decrease. One advantage of vector disease control is that no one wants to be bitten by mosquitoes. Educational material about vector control and the use of personal protection against bites will be the future for WNV and other vector diseases.

Appendix A

Time Between Non-Human and Human Cases in the Same County for 2003

2003	Animal to Human (days) N= 17	Avian to Human (days) N= 36	Mosquito to Human(days) N=7
Range	49 prior - 82 after	56 prior - 58 after	51 after - 5 after
Median	14 after	3 after	37 after

Time Between Non-Human and Human Cases in the Same County for 2004

2004	Animal to Human (days) N= 2	Avian to Human (days) N=13	Mosquito to Human(days) N=5
Range	39 after - 33 after	60 prior - 32 after	36 prior - 82 after
Median	N/A	9 prior	19 after

Time Between Non-Human and Human Cases in the Same County for 2005

2005	Animal to Human (days) N= 2	Avian to Human (days) N= 0	Mosquito to Human(days) N=2
Range	19 prior - 84 after	N/A	30 prior - 21 after
Median	N/A	N/A	N/A

Time Between Non-Human and Human Cases in the Same County for 2006

2006	Animal to Human (days) N= 2	Avian to Human (days) N= 0	Mosquito to Human(days) N=1
Range	110 after - 23 after	N/A	32 after
Median	N/A	N/A	N/A

Time Between Non-Human and Human Cases in the Same County for 2007

2007	Animal to Human (days) N= 1	Avian to Human (days) N= 0	Mosquito to Human(days) N=0
Range	23 after	N/A	N/A

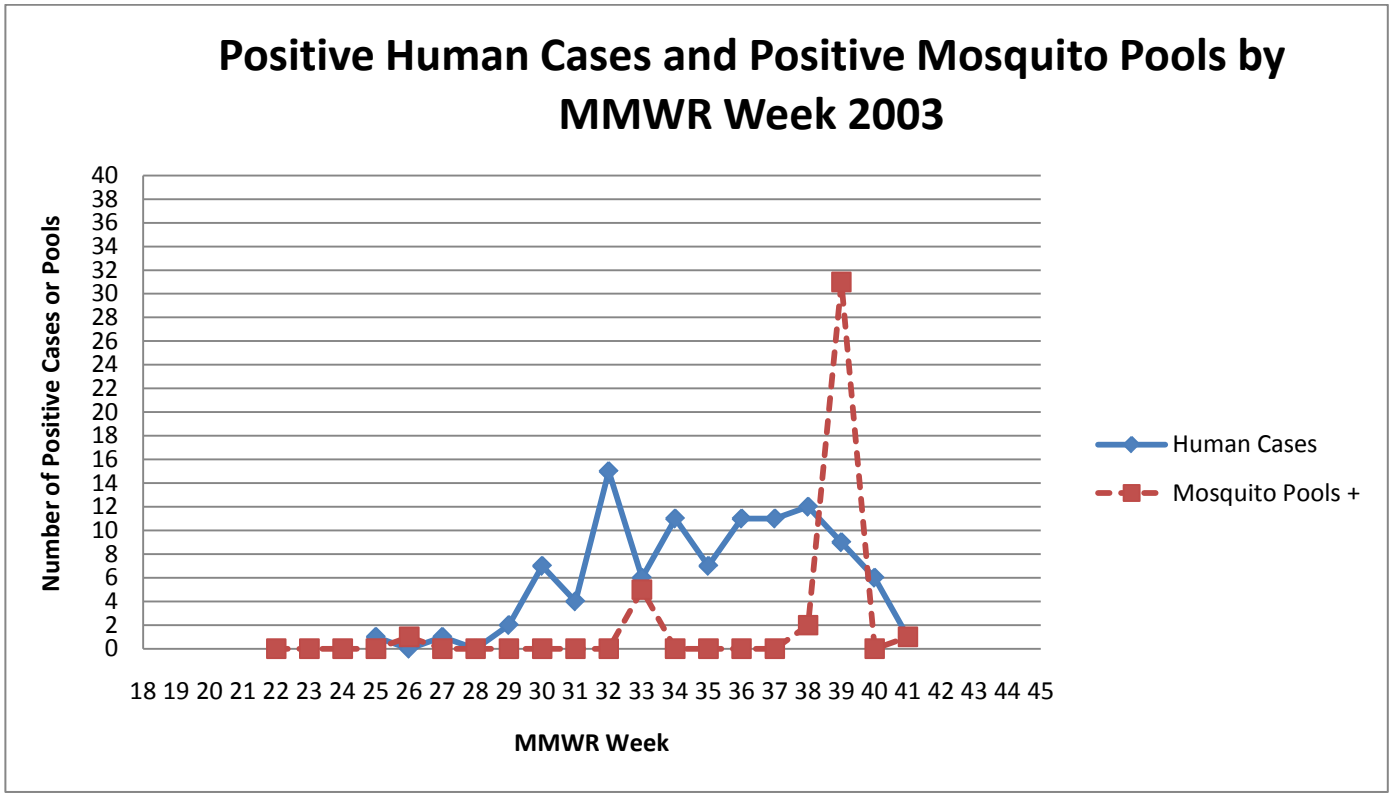
Time Between Non-Human and Human Cases in the Same County for 2008

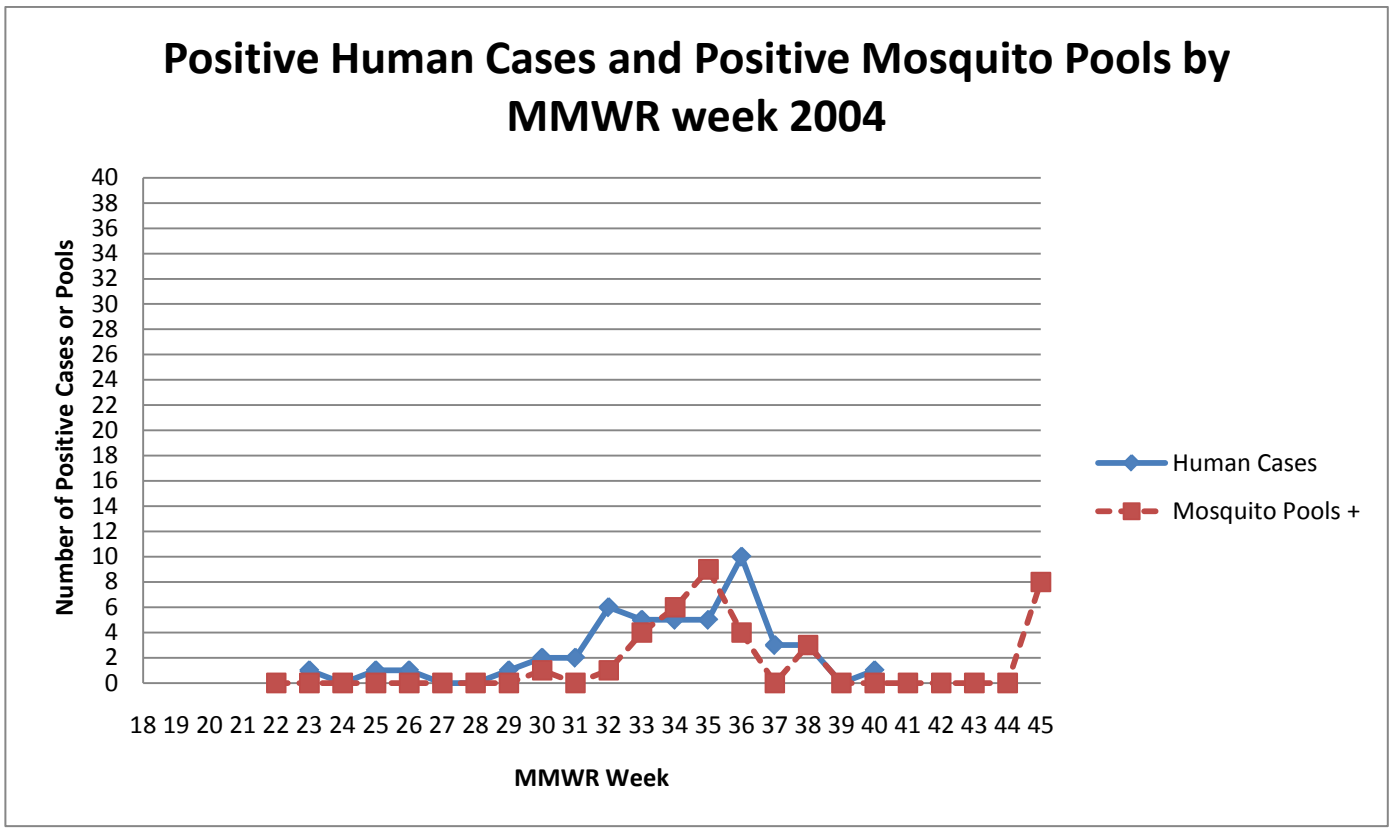
2008	Animal to Human (days) N= 0	Avian to Human (days) N= 0	Mosquito to Human(days) N=0
	N/A	N/A	N/A

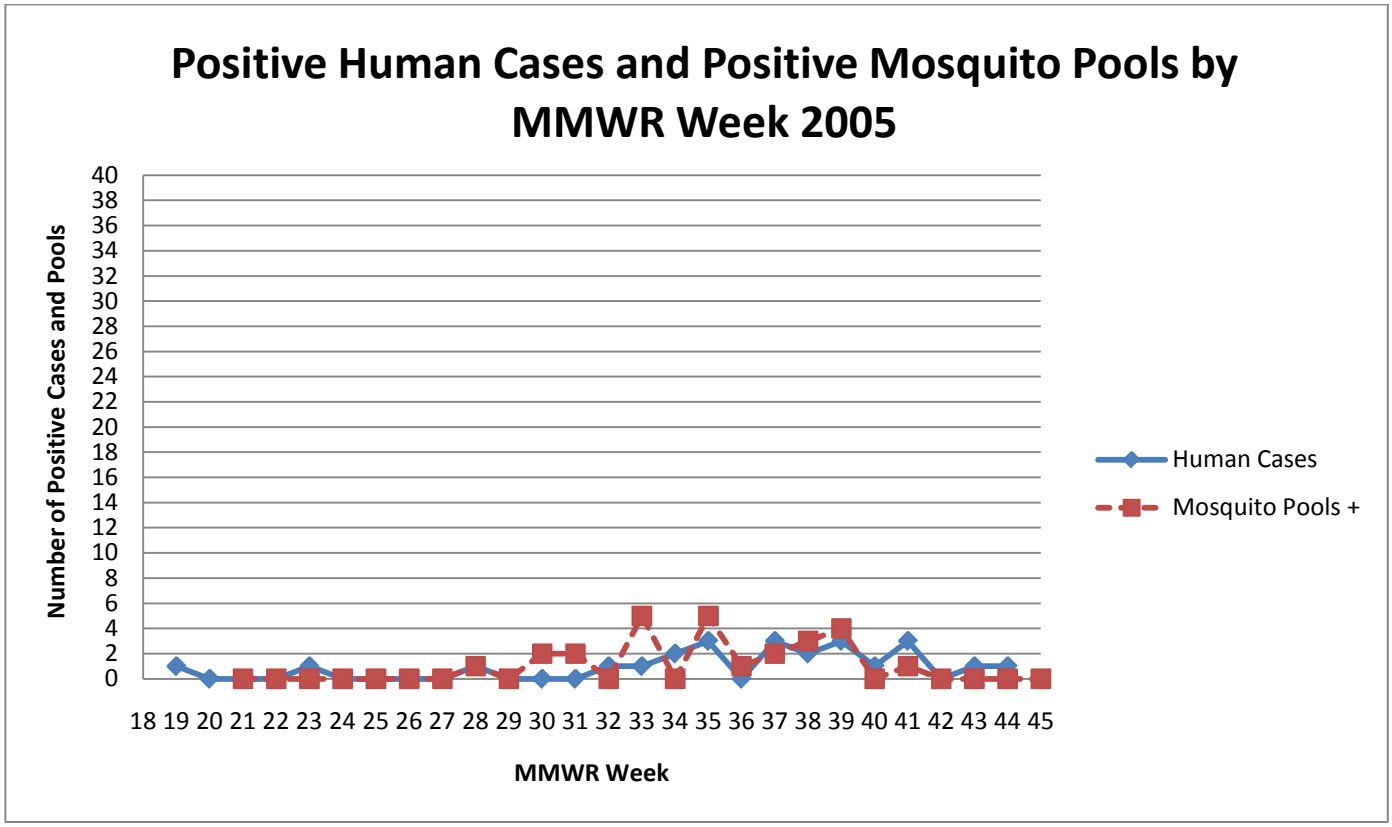
Time Between Non-Human and Human Cases in the Same County for 2009

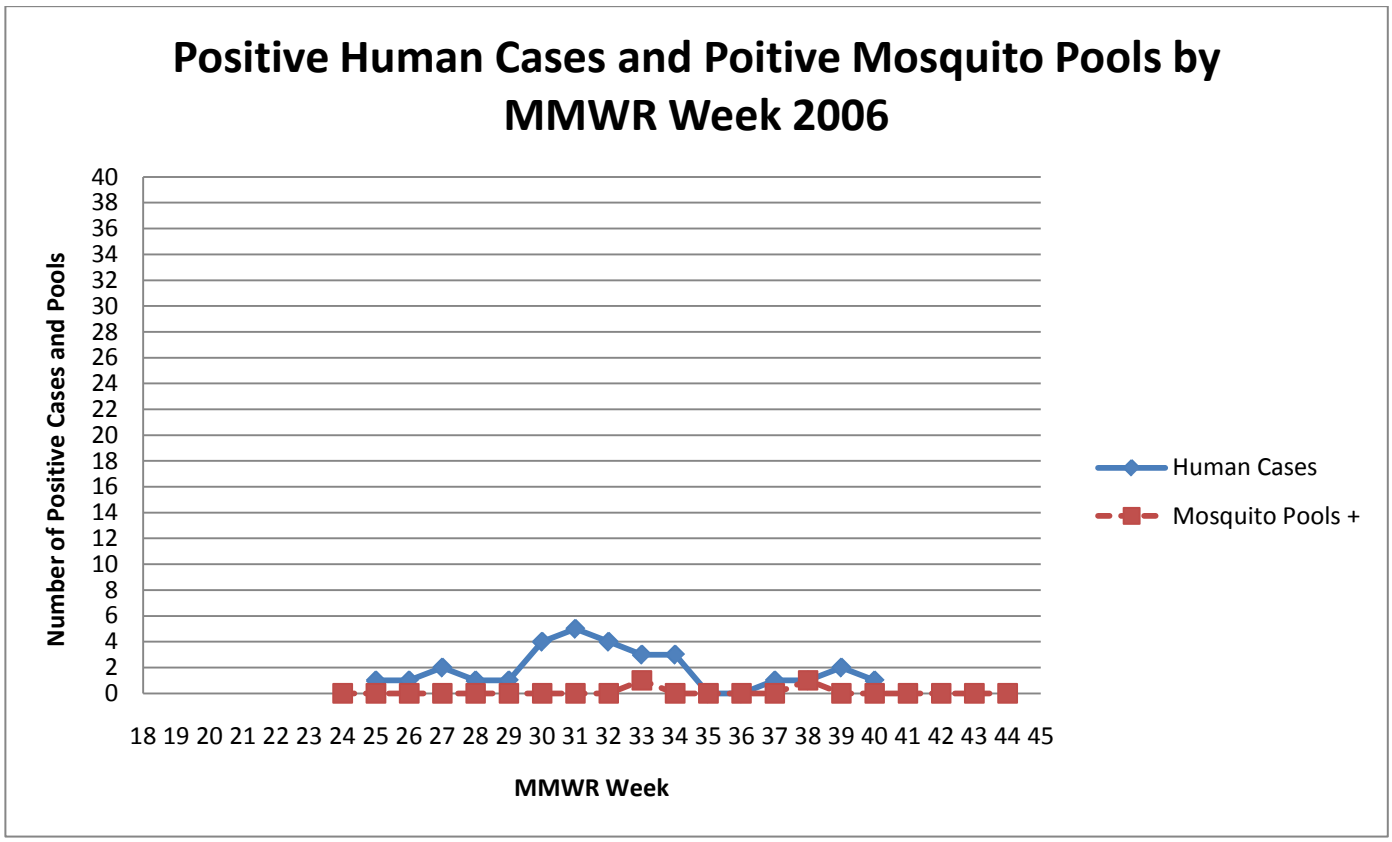
2009	Animal to Human (days) N= 0	Avian to Human (days) N= 0	Mosquito to Human(days) N=1
Range	N/A	N/A	43 after

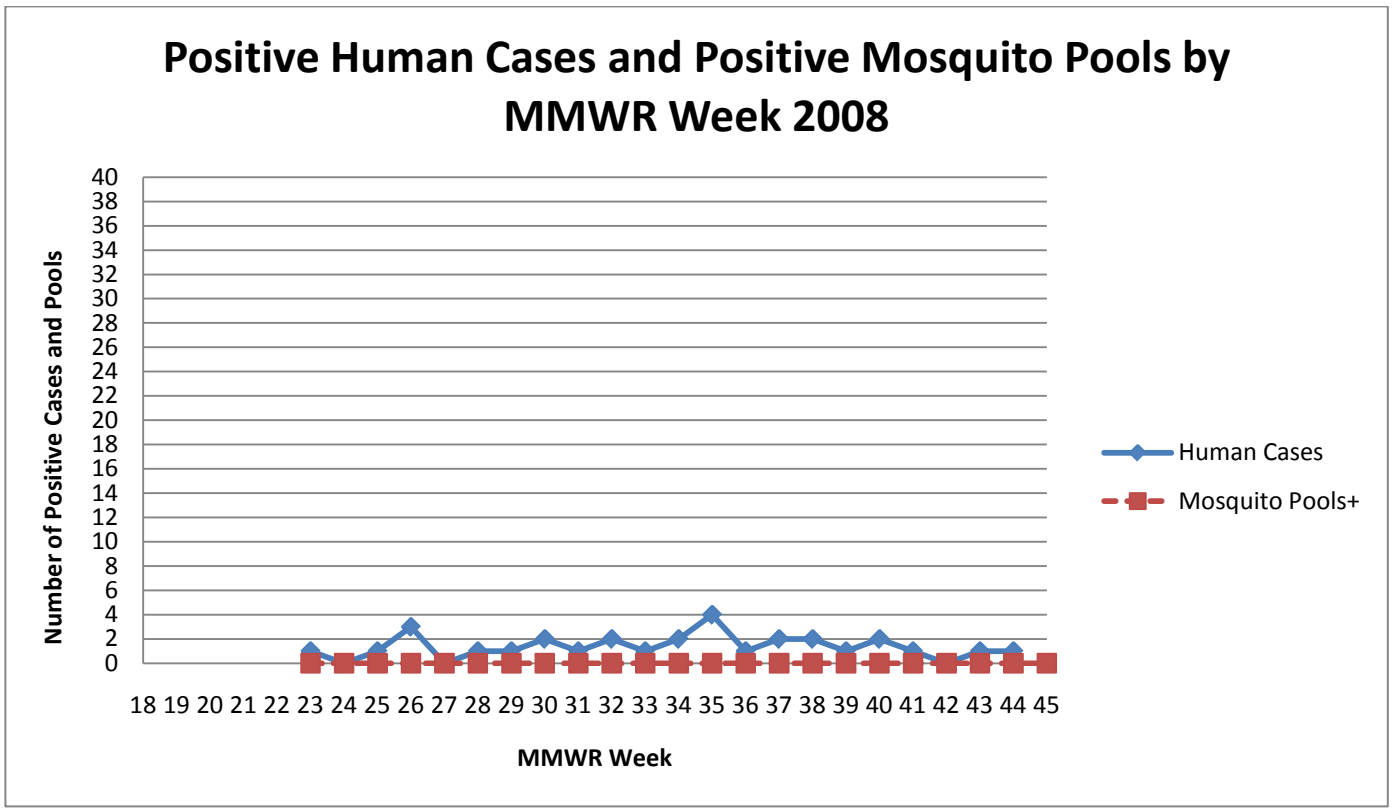
Appendix B

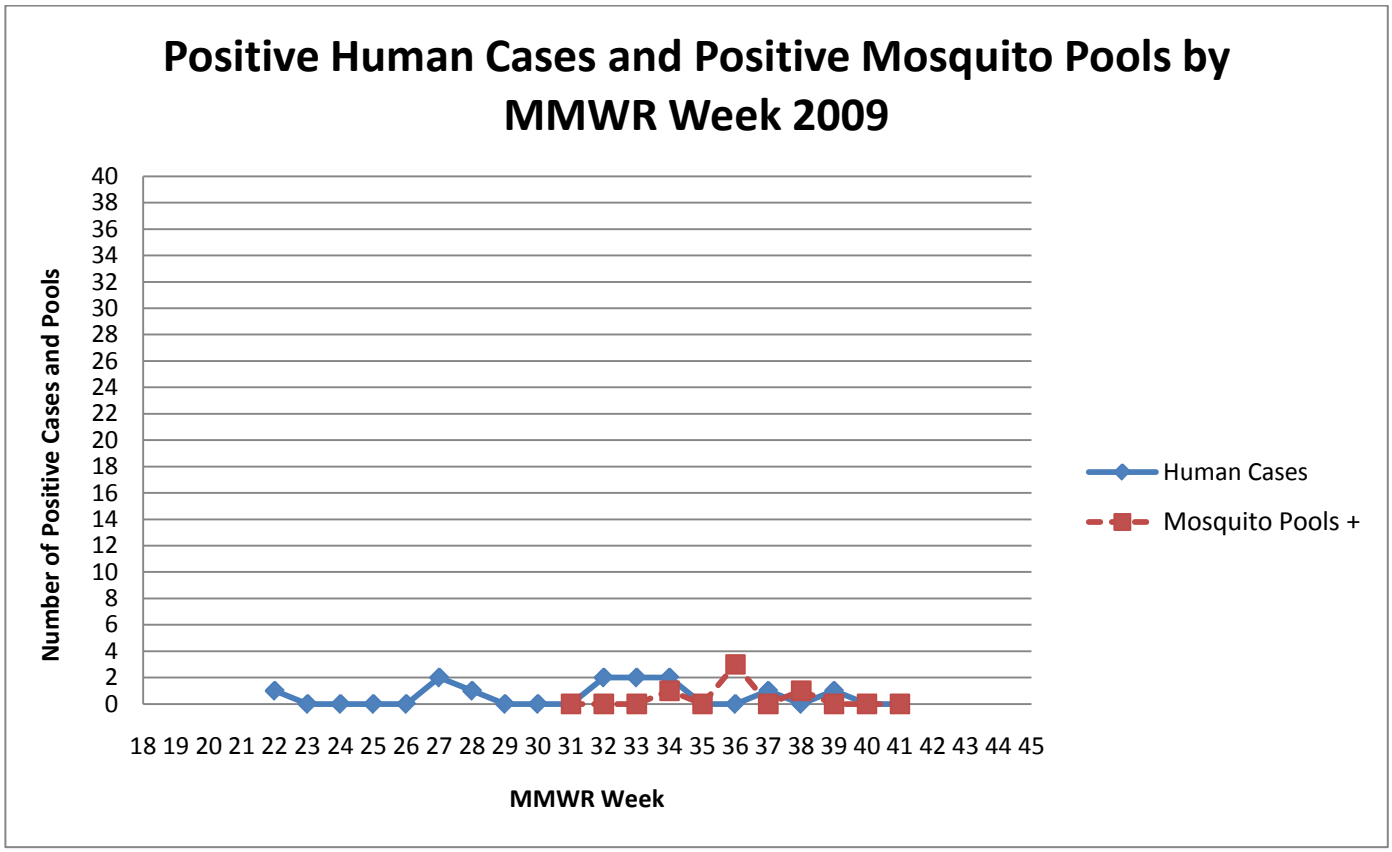

Positive Human Cases and Positive Mosquito Pools by MMWR Week 2003
Number of Positive Cases or Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools +


Positive Human Cases and Positive Mosquito Pools by MMWR week 2004
Number of Positive Cases or Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools +


Positive Human Cases and Positive Mosquito Pools by MMWR Week 2005
Number of Positive Cases and Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools +


Positive Human Cases and Poitive Mosquito Pools by MMWR Week 2006
Number of Positive Cases and Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools +


Positive Human Cases and Positive Mosquito Pools by MMWR Week 2008
Number of Positive Cases and Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools+


Positive Human Cases and Positive Mosquito Pools by MMWR Week 2009
Number of Positive Cases and Pools
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
MMWR Week
Human Cases
Mosquito Pools +

Appendix C

Missouri
Karren Yates
Vector Borne Disease Program Coordinator
Division of Community and Public Health: Department of Health and Senior Services
(573) 751-4749
karren.yates@dhss.mo.gov

Oklahoma
Kristy Bradley, DVM, MPH
State Public Health Veterinarian and State Epidemiologist
Oklahoma State Department of Health
(405) 271-4060
kristyb@health.ok.gov

Nebraska
Annette Bredthauer MS, DVM, MPH
State Public Health Veterinarian
Nebraska Department of Health and Human Services: Public Health Support
(402) 471-1374
Annette.bredthauer@dhhs.ne.gov

Colorado
Elisabeth Lawaczeck, DVM
State Public Health Veterinarian
Colorado Department of Public Health and Environment: Communicable Disease Epidemiology Program
(303) 692-2628
Elisabeth.lawaczeck@state.co.us

Works Cited

1. *A neurotropic virus isolated from the blood of a native of Uganda.* **Smithburn, JS., Hughes, TP., Burke, AW., and Paul, JH.** 1970, Am. J. Trop. Med. Hyg., Vol. 20, pp. 471-492.

2. *A study of the ecology of West Nile virus in Egypt.* **Taylor, RM., Work, TH., Hurlbut, HS., and Rizk, F.** 1956, Am. J. Trop. Med. Hyg., Vol. 5, pp. 579-620.

3. *West Nile virus:a growing concern?* **Gould, LH., Fikrig, E.** 2004, J. Clin. Invest. , Vol. 113, pp. 1102-1107.

4. *West Nile virus in the Americas.* **Pollock, CG.** 2008, J. Avian Med. Surg., Vol. 22, pp. 151-157.

5. *West Nile virus: a primer for the clinician.* **Peterson, LR., Marfin, AA.** 2002, Ann. Intern. Med, Vol. 137, pp. 173-179.

6. *West Nile virus: a reemerging global pathogen.* **Peterson, LR., Roehrig, JT.** 2001, Emerg. Infec. Dis, Vol. 7, pp. 611-614.

7. *West Nile virus in livestock and wildlife.* **McLean, RG., et. al.** 2002, Curr. Opinion in Infec. Dis. , Vol. 267, pp. 271-308.

8. *West Nile outbreak in horses in southern France, 2000: the return after 35 years.* **Murgue, B., Murri, S., Zientara, S., Durand, B., Durand, JP., and Zeller, H.** 2000, Emer. Infect. Dis , Vol. 7, pp. 692-696.

9. *Identification of a Kunjin/West Nile-like flavivirus in brains of patients with New York encephalitis.* **Briese, T., Jia XY., Huang, C., Grady LJ., adn Lipkin, WI.** 1999, Lancet, Vol. 354, pp. 1261-1262.

10. *West Nile envephalitis.* **Solomon, T., Ooi, MH., Beasley, WC., and Mallewa, M.** 2003, BMJ, Vol. 326, pp. 865-869.

11. *Epidemic West Nile encephalitis. New York, 1999: results of a house-hold-based seroepidemiological survey.* **Mostashari, F., et al.** 1999, Lancet, Vol. 358, pp. 261-264.

12. *Potential North American vectors of West Nile virus.* **Turell, MJ., Sardelis, MR., Dohm, DJ., and O'Guinn, ML.** 2001, Ann. NY. Acad. Sci. , Vol. 951, pp. 317-324.

13. *West Nile virus risk assessment adn the bridge vector paradigm.* **Kilpatrick, AM., Kramer, LD., Campbell, SR., Alleyene, EO., Dobson, AP., and Daszak, P.** 2005, Emerg. Infec. Dis., Vol. 11, pp. 425-429.

14. *Vector competence of California mosquitoes for West Nile virus.* **Goddard, LB., Roth, AE., Reisen, WK., and Scott, TW.** 2002, Emerg. Infec. Dis., Vol. 8, pp. 1385-1391.

15. *West Nile virus.* **Campbell, GL., Margin, AA., Lanciotti, RS., adn Gubler, DJ.** 2002, Lancet Inf. Dis. , Vol. 2, pp. 519-529.

16. *Long-term prognosis for clinical West Nile virus infection.* **Klee, AL. et al.** 2004, Emerg. Infec. Dis. , Vol. 10, pp. 1405-1411.

17. *West Nile virus: epidemiology adn ecology in North America.* **Komar, Nicholas.** 2003, Adv. Vir. Res. , Vol. 61, pp. 185-234.

18. *Origin of the West Nile virus responsible for an outbreak of encephalitis in the Northeastern United States.* **Lanciotti, RS., et al.** 1999, Science, Vol. 286, pp. 2333-2337.

19. *West Nile virus outbreak among horses in New York state, 1999 and 2000.* **Trock, SC., et al.** 2001, Emerg. Infec. Dis., Vol. 7, pp. 745-747.

20. *West Nile virus in overwintering culex mosquitioes, New York City 2000.* **Nasci, RS., et al.** 2001, Emerg. Infec. Dis., Vol. 7, pp. 1-4.

21.**Center for Disease Control and Prevention.** *MMWR Updated guidelines for evaluating pubic health surveillance systems.* 2003.

22. Center for Disease Control and Prevention. West Nile Virus website. *West Nile Virus: Surveillance Information and Guidance for Clinicians.* [Online] September 29, 2004. [Cited: March 22, 2010.] http://www.cdc.gov/ncidod/dvbid/westnile/clinicians/surveillance.htm#casedef.

23. Center for Disease Control and Prevention. West Nile Virus website. *West Nile Virus: Surveillance Information and Guidance for Clinicians.* [Online] September 29, 2004. [Cited: March 24, 2010.] http://www.cdc.gov/ncidod/dvbid/westnile/clinicians/surveillance.htm#casedef.