Arboviral Disease Surveillance
2018 Report
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Background

Arboviruses (arthropod-borne virus) are commonly spread to humans through the bites of infected mosquitoes, ticks, sand flies, midges, and other invertebrate vectors. This report focuses on mosquito transmitted arboviruses. West Nile virus (WNV) is the leading cause of domestically acquired arboviral disease in the United States and Kansas¹. WNV was first identified in the United States in 1999 and spread throughout the United States. Natural transmission involves a mosquito-bird-mosquito cycle; animals such as humans and horses do not circulate enough virus to re-infect a blood-feeding mosquito, and thus are referred to as "dead-end" or "accidental" hosts. Several species of mosquitoes are responsible for transmission of arboviruses but *Culex* species are the primary vector for WNV in the United States.

The incubation period for arboviral infections vary. The incubation period for WNV ranges from 3 to 15 days with an average incubation period of approximately one week. Arboviral infections may be asymptomatic or may result in illness of variable severity. Approximately 80% of people who become infected with WNV do not develop any symptoms¹. About one in five people who are infected develop a fever with other symptoms such as headache, body aches, joint pains, vomiting, diarrhea, or rash¹. Most people with ‘West Nile virus Fever’ recover completely but fatigue and weakness can last for weeks or months¹. Less than 1% of people who are infected develop a serious neurological illness, such as encephalitis or meningitis, and approximately 10% of people who develop this kind of an infection will die¹.

From 1999 – 2018 there were a total of 50,830 cases and 2,330 deaths in the United States from WNV with 664 cases and 35 deaths that occurred in Kansas². Kansas has among the highest incidence of WNV neuroinvasive disease in the country where Kansas almost always exceeds the national incidence³. From 1999 - 2016, the incidence of WNV neuroinvasive disease was 0.60 cases per 100,000 people in Kansas, as compared to 0.40 cases per 100,000 people for the U.S³

The Kansas Department of Health and Environment (KDHE) began surveillance for WNV in 2001 with a grant from the Centers for Disease Control and Prevention (CDC). The first WNV positive mosquito specimens were collected on July 23, 2002; the first equine case and human case had onset of WNV on 6 August and 8 August 2002 respectively⁴. Although this mosquito surveillance system is focused on WNV it is important to note that all arboviral diseases, when diagnosed in humans, are required to be reported to KDHE by laboratories and healthcare providers among others. WNV, when diagnosed in horses, is required to be reported to the Kansas Department of Agriculture⁵.

A cooperative agreement through the CDC to KDHE funds mosquito surveillance in Kansas. Our surveillance program in Kansas has evolved since it was first implemented by KDHE in 2001. In the beginning the goal of mosquito surveillance was to determine when and where WNV arrived in Kansas. After WNV became established in our state in 2002 the goal shifted to develop an early warning system to determine when people would be most at risk for acquiring the disease. A systematic surveillance system evaluation of data from 2002 – 2009 found WNV was detected in mosquitoes weeks after transmission to humans had occurred⁶. This surveillance method was not useful to determine potential risk of WNV transmission to people. In 2010, mosquito surveillance was not conducted as we evaluated potential methods to
improve mosquito surveillance for WNV in Kansas. In 2011 mosquito surveillance was performed in response to floods in Atchison and Doniphan counties in northeast Kansas utilizing a different survey method than in previous years.

In 2012, mosquito surveillance was conducted in nine counties; one Encephalitis Vector Survey (EVS) trap per county per week from mid-May – mid-October. From 2013 – 2016, mosquito surveillance was conducted solely in Sedgwick County where WNV neuroinvasive disease cases had historically been reported most frequently in Kansas. In 2017, KDHE received additional funding for mosquito surveillance from CDC as part of the Zika virus response. We were able to add two additional counties, Reno and Shawnee, to the mosquito surveillance network. In 2017, Johnson County funded mosquito surveillance in their communities and KDHE tested their mosquitoes for WNV. However, mosquito surveillance in Johnson County was discontinued in 2018.

In 2017, KDHE developed West Nile virus ‘Risk Levels’. The goal of these risk levels was to translate the mosquito surveillance data into discrete measures of risk of acquiring a WNV infection. Elements of existing WNV risk models from other states were used to develop a Kansas model based on available resources.

**Methods**

**Mosquito Surveillance**

**Mosquito Collection**

Mosquito surveillance for WNV was conducted from 16 May to 24 October 2018 by Dr. D. Christopher Rogers with the Kansas Biological Survey (KBS). Surveillance was conducted weekly in Reno, Sedgwick, and Shawnee counties. The traps were placed where the highest densities of potential mosquito oviposition and resting habitat was found, potential bird/mosquito movement corridors, bird nesting habitats (riparian corridors), and in conjunction with large human populations.

EVS traps, with dry ice as a carbon dioxide source, was primarily used to collect mosquitoes. These traps typically attract mosquitoes that feed on humans or other mammals; our primary mosquito genus of interest was *Culex*. Five traps were set each week in Reno, Sedgwick, and Shawnee counties and always at the same monitoring sites. The traps were placed at their designated locations in the early evening and were collected the following morning. The trap contents were secured in a container and labeled with the address and GPS coordinates of the trap location. The mosquitoes were then transported on dry ice to KBS at the University of Kansas for identification.

**Mosquito Identification**

The KDHE contracted with KBS to enumerate and identify mosquitoes to species level. Upon arrival, all mosquito samples were checked in, and stored in a -80°C ultracold freezer. All mosquitoes were identified on a chill table under a Wild M-8 stereo dissection microscope,
using the appropriate standard references and the KBS voucher reference collections. Mosquito counts greater than 1,000 per trap were divided into a smaller subset for identification due to budget constraints (proportional extrapolation identifications). All mosquito taxa were recorded and enumerated. Mosquitoes of the genus *Culex* (*Culex* spp.), the most common WNV vector, were separated out, labeled according to location and date collected, and returned to the -80°C ultracold freezer. Once all collections were identified, the *Culex* spp. subsets were transported overnight in an ice chest with dry ice to the University of Nebraska-Lincoln lab for arboviral testing. Results from the enumeration and identification were entered in a Microsoft® Excel® spreadsheet and submitted by KBS to KDHE weekly via e-mail. Mosquito data was presented for each trap as total numbers, total taxa, total source (e.g. tree hole/container species, floodwater species, et cetera) use numbers, total *Culex* spp., total *Aedes aegypti/ albopictus* numbers, coupled with the same data for previous years for direct comparison, and concurrent temperature and precipitation data.

**Arboviral Testing of Mosquitoes**

*Culex* spp. were tested for WNV, Saint Louis encephalitis virus, and Western Equine encephalitis virus at the University of Nebraska-Lincoln laboratory. Mosquitoes were divided into homogenizer vials by date and trap location containing up to 75 mosquitoes each and tested for WNV by reverse transcription polymerase chain reaction (RT-PCR). The results were entered in an Excel® spreadsheet and sent to KDHE. All results were posted to KDHE’s website and reported to the ArboNET a national arboviral surveillance system managed by CDC and state health departments.

**Human Case Surveillance**

West Nile virus, and all other arboviral diseases, are reportable diseases in Kansas. It is a passive surveillance system; healthcare providers or laboratories are required to report cases to KDHE. Cases were classified according to the most recent CDC case definition (Appendix A). Confirmed and probable cases are reported to CDC and are included as the case count (e.g. confirmed + probable = total number of cases). It is important to note that these definitions are to be used for case counts only and should not be used to make a clinical diagnosis. In addition, the county in which the person resides is used as the case’s location for surveillance purposes, although they may have been infected elsewhere. Prior to 2011, Kansas only reported confirmed cases, therefore, we are only able to compare case counts and rates of WNV from 2011 to present.

The cases were entered into EpiTrax, Kansas’ electronic disease surveillance system, and the corresponding local health department completed the investigation. The Arboviral Diseases Investigation Guideline contains information to provide technical assistance with local surveillance and disease investigation. They contain disease-specific information, sample letters, reporting forms, sample communication sheets, and other tools to assist the local health department. Once the case investigation is complete, all confirmed and probable cases are reported to the national ArboNET surveillance system and the results are posted to the ArboNET website. Information on human WNV case counts and rates can be found in KDHE’s annual publication, Reportable Infectious Diseases in Kansas.
The incidence rate (number of cases per 100,000 people) of WNV neuroinvasive disease cases for Reno, Shawnee, and Sedgwick County was compared to the State of Kansas, the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota), and the United States. Incidence rates were limited to neuroinvasive disease cases as reporting for these cases is believed to be more consistent and complete than for non-neuroinvasive disease cases.

**Animal Case Surveillance**

West Nile virus infections in horses are required to be reported to the Kansas Department of Agriculture’s Division of Animal Health. Horses may serve as a sentinel of WNV activity in Kansas. Kansas does not perform routine surveillance of dead birds for WNV. However, the Kansas Department of Wildlife, Parks, and Tourism shares WNV positive laboratory results, when diagnosed in wildlife, as a courtesy with KDHE.

**Mosquito Control**

The State of Kansas does not maintain a vector control program. Mosquito control, if performed, is conducted by city or county governments. A 2015 survey found that none of the cities (apart from the City of Wichita) or counties (other than Reno, Sedgwick, and Shawnee) that performed mosquito control used mosquito surveillance to guide their abatement decisions. The Reno, Sedgwick, and Shawnee County Health Departments shared mosquito surveillance data weekly with the municipalities where the traps were located and provided control recommendations as needed.

**West Nile Virus Risk Levels**

In 2018, KDHE modified the criteria used to calculate the West Nile virus Risk Levels (WNV RL). We divided all 105 counties into the standard six regions of Kansas (NE, NC, NW, SW, SC, and SE). Shawnee county mosquito data was used to calculate WNV RL for NE Kansas, Sedgwick county mosquito data was used to calculate WNV RL for SE Kansas, and Reno county mosquito data was used to calculate WNV RL for the remaining four regions. Percent change of *Culex* spp. mosquitoes from the same week the previous year, average daily temperature in the region over the previous two weeks, and five-year historical case data in the region were used. Weekly average numerical values were calculated and assigned to one of four RLs (minimal, low, moderate, high). Risk levels were updated weekly from 6 June -26 October 2018 and posted on the KDHE Arboviral Disease webpage.

Risk levels (RLs) were evaluated to determine if current factors used to calculate RLs accurately reflected the risk of transmission. In post-season analysis, a second model was explored where, if ≥40 *Culex* spp. mosquitoes were trapped in a county during a week, that factor increased to the maximum value. One week was subtracted from onset dates of cases to determine the region’s RL during the likely exposure period. RLs in all six regions, positive predictive value (PPV), and sensitivity of both models were compared.
Results

Mosquito Surveillance

Mosquito Identification

Mosquito collection began on 4 June 2018 and continued weekly through 26 October 2018 for a total of 24 surveillance weeks. All mosquito species had been previously identified in Kansas.

Mosquito Abundance

There were 20,141 mosquitoes collected during 355 trap nights (Reno County = 115, Shawnee County = 120, Sedgwick County = 120) in 2018. A trap night is calculated as the number of traps per night multiplied by the number of nights of surveillance. There were five traps run once per week in Reno, Sedgwick, and Shawnee counties. We decreased the number of traps in Sedgwick County from nine traps to five traps in 2017. This was done to conserve resources. Some traps malfunctioned, or were otherwise unable to be placed, and therefore were not included in the number of trap nights.

Prior to 2017 mosquito surveillance was last performed in Reno County in 2003 and a different method was used. Therefore, we did not compare previous years. There were 10,827 mosquitoes total collected in Reno County with 25% of them *Culex* spp. Despite a substantial increase in the total number of mosquitoes collected there was a significant decrease in the proportion of *Culex* spp. collected (Table 1). Another mosquito, *Aedes triseriatus* the vector for La Crosse encephalitis virus, had a significant increase in 2018 with nearly 2,000 collected compared to 2017 with only 61 collected (Table 1).

Table 1. Mosquito species collected by year, Reno County*.

<table>
<thead>
<tr>
<th>Mosquito Species</th>
<th>2017 # (%)</th>
<th>2018 # (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total mosquitoes</td>
<td>3,623</td>
<td>10,827</td>
</tr>
<tr>
<td>Total <em>Culex</em> spp.</td>
<td>1,863 (51)</td>
<td>2,728 (25)</td>
</tr>
<tr>
<td><em>Aedes triseriatus</em> (Say, 1823)</td>
<td>61 (2)</td>
<td>1,989 (18)</td>
</tr>
<tr>
<td><em>Aedes vexans</em> (Meigen, 1830)</td>
<td>775 (21)</td>
<td>1,004 (9)</td>
</tr>
<tr>
<td><em>Culex tarsalis</em> (Coquillett, 1896)</td>
<td>1,533 (42)</td>
<td>2,091 (19)</td>
</tr>
<tr>
<td><em>Culex pipiens</em> (L., 1758) /quinquefasciatus (Say, 1823)</td>
<td>64 (2)</td>
<td>39 (0.4)</td>
</tr>
</tbody>
</table>

*The percent (%) of mosquito species was calculated by dividing the number (#) of that species by the total number of mosquitoes collected during 2017 season from 6 traps and the 2018 season from 5 traps.*

Overall the number of total mosquitoes in Sedgwick County stayed nearly the same when compared to 2017 (Table 2). The decrease is most significant in the number of *Aedes vexans* (a nuisance mosquito that does not spread disease) captured. However there was an increase
in the proportion of *Culex* spp. when compared to 2017 (Table 2). The proportion of total *Culex* spp. was higher in 2018 than the previous four years (2014 – 2017).

Table 2. Mosquito species collected by year, Sedgwick County*.

<table>
<thead>
<tr>
<th>Mosquito Species</th>
<th>2014†</th>
<th>2015†</th>
<th>2016†</th>
<th>2017†</th>
<th>2018†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># (%)</td>
<td># (%)</td>
<td># (%)</td>
<td># (%)</td>
<td># (%)</td>
</tr>
<tr>
<td><strong>Total mosquitoes</strong></td>
<td>17,700</td>
<td>39,624</td>
<td>21,790</td>
<td>4,322</td>
<td>4,497</td>
</tr>
<tr>
<td><strong>Total <em>Culex</em> spp.</strong></td>
<td>2,137 (12)</td>
<td>8,103 (20)</td>
<td>3,253 (15)</td>
<td>1,299 (30)</td>
<td>2,279 (51)</td>
</tr>
<tr>
<td><em>Aedes vexans</em> (Meigen, 1830)</td>
<td>11,728 (68)</td>
<td>25,736 (65)</td>
<td>10,987 (50)</td>
<td>1,750 (41)</td>
<td>957 (21)</td>
</tr>
<tr>
<td><em>Culex tarsalis</em> Coquillett, 1896</td>
<td>1,425 (8)</td>
<td>6,698 (17)</td>
<td>1,979 (9)</td>
<td>593 (14)</td>
<td>1,152 (26)</td>
</tr>
<tr>
<td><em>Culex pipiens</em> L., 1758 /quinquefasciatus Say, 1823</td>
<td>892 (5)</td>
<td>1,307 (3)</td>
<td>890 (4)</td>
<td>77 (2)</td>
<td>104 (2)</td>
</tr>
</tbody>
</table>

*The percent (%) of mosquito species was calculated by dividing the number (#) of that species by the total number of mosquitoes collected during the 2017 season from 9 traps.
†From 2014 – 2017 there were nine EVS traps in Sedgwick County. In 2018 there were five EVS traps.

Mosquito surveillance was last performed in Shawnee County in 2009 using a different method, therefore, we did not compare 2017 and 2018 data to previous years. There were 10,859 total mosquitoes collected in Shawnee County with twenty-two percent *Culex* spp. (Table 3). Although there were relatively the same number of total mosquitoes collected there was a significant decrease in the proportion of *Culex* spp. from 2017 (69%) to 2018 (22%) (Table 3).

Table 3. Mosquito species collected by year, Shawnee County*.

<table>
<thead>
<tr>
<th>Mosquito Species</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># (%)</td>
<td># (%)</td>
</tr>
<tr>
<td><strong>Total mosquitoes</strong></td>
<td>9,139</td>
<td>10,859</td>
</tr>
<tr>
<td><strong>Total <em>Culex</em> spp.</strong></td>
<td>6,333 (69)</td>
<td>2,406 (22)</td>
</tr>
<tr>
<td><em>Aedes vexans</em></td>
<td>907 (10)</td>
<td>7,474 (69)</td>
</tr>
<tr>
<td><em>Culex tarsalis</em></td>
<td>65 (0.7)</td>
<td>205 (2)</td>
</tr>
<tr>
<td><em>Culex pipiens/quinquefasciatus</em></td>
<td>38 (0.4)</td>
<td>46 (0.4)</td>
</tr>
<tr>
<td><em>Culex erraticus</em></td>
<td>6,010 (66)</td>
<td>1,168 (11)</td>
</tr>
</tbody>
</table>

*The percent (%) of mosquito species was calculated by dividing the (#) of that species by the total number of mosquitoes collected during the 2018 season from 5 traps. In 2017 there were 6 traps.
Arboviral Testing of Mosquitoes

In 2018 there were 203 vials of mosquitoes tested for WNV, St. Louis Encephalitis virus, and Western Equine Encephalitis from Reno (65), Sedgwick (72), and Shawnee (66) counties. Reno county had the highest number (6) and proportion (9%) of positive vials followed by Sedgwick county (3, 4%), then Shawnee county (1, 2%) (Figure 1). The first WNV positive vial from all three counties was collected during MMWR week 34 (week ending August 25, 2018). Reno county reported their first St. Louis Encephalitis virus-positive mosquitoes the same week.

Figure 1.

Human Case Surveillance

Forty-seven human WNV cases were reported in the State of Kansas in 2018 (Table 5). This was an increase of 20 cases from 2017 (N = 27). There were 24 cases of non-neuroinvasive WNV and 23 cases of neuroinvasive WNV. This was a 91% increase in the number of neuroinvasive disease cases compared to 2017 (Table 4).

The first case of WNV had onset of illness in July; the majority (62%) of cases had disease onset beginning in September (Figure 2).
In the previous four years the majority (83%, four-year median) of cases had onset of disease in August and September. In 2017 seven percent of cases had disease onset in May; this was the earliest reported cases since 2012 which had one case with a disease onset in April. The median age of case-patients was 54 years (range 5 – 89 years) and most were male. Twenty cases (74%) were hospitalized. Five deaths caused by WNV were reported in 2018.

Table 4. Human West Nile virus case characteristics, Kansas, 2013-2018.

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cases</td>
<td>92</td>
<td>54</td>
<td>34</td>
<td>37</td>
<td>27</td>
<td>47</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>59.5</td>
<td>54</td>
<td>60</td>
<td>59</td>
<td>54</td>
<td>58</td>
</tr>
<tr>
<td>Range</td>
<td>12-85</td>
<td>10-78</td>
<td>26-82</td>
<td>26-88</td>
<td>5-89</td>
<td>18-85</td>
</tr>
</tbody>
</table>

Number of Cases (%)

<table>
<thead>
<tr>
<th>Gender</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>63 (68)</td>
<td>32 (61)</td>
<td>21 (62)</td>
<td>28 (76)</td>
<td>22 (81)</td>
<td>33 (70)</td>
</tr>
<tr>
<td>Female</td>
<td>29 (32)</td>
<td>20 (39)</td>
<td>13 (38)</td>
<td>9 (24)</td>
<td>5 (19)</td>
<td>14 (30)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month of Disease Onset</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>May</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2 (7)</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>0</td>
<td>0</td>
<td>2 (6)</td>
<td>3 (8)</td>
<td>2 (7)</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>3 (3)</td>
<td>1 (2)</td>
<td>3 (9)</td>
<td>7 (19)</td>
<td>3 (11)</td>
<td>4 (9)</td>
</tr>
<tr>
<td>August</td>
<td>13 (14)</td>
<td>23 (43)</td>
<td>12 (35)</td>
<td>13 (35)</td>
<td>9 (33)</td>
<td>13 (28)</td>
</tr>
<tr>
<td>September</td>
<td>67 (73)</td>
<td>27 (50)</td>
<td>15 (44)</td>
<td>9 (24)</td>
<td>8 (30)</td>
<td>29 (62)</td>
</tr>
<tr>
<td>October</td>
<td>9 (10)</td>
<td>3 (6)</td>
<td>2 (6)</td>
<td>5 (14)</td>
<td>3 (11)</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (2)</td>
</tr>
</tbody>
</table>

Clinical Status

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuroinvasive disease</td>
<td>33 (36)</td>
<td>18 (33)</td>
<td>12 (35)</td>
<td>17 (46)</td>
<td>12 (44)</td>
<td>23 (49)</td>
</tr>
<tr>
<td>Non-neuroinvasive disease</td>
<td>59 (64)</td>
<td>38 (70)</td>
<td>22 (65)</td>
<td>20 (54)</td>
<td>15 (56)</td>
<td>24 (51)</td>
</tr>
<tr>
<td>Hospitalized</td>
<td>56 (61)</td>
<td>27 (52)</td>
<td>20 (59)</td>
<td>25 (68)</td>
<td>20 (74)</td>
<td>28 (60)</td>
</tr>
<tr>
<td>Died</td>
<td>8 (9)</td>
<td>0</td>
<td>2 (6)</td>
<td>5 (14)</td>
<td>0</td>
<td>5 (11)</td>
</tr>
</tbody>
</table>
Peak cases occurred approximately three weeks later, mid-September, than in previous years (Figure 2). This pattern occurred in both Kansas and the United States.

**West Nile virus Neuroinvasive Disease**

From 2017 to 2018 the neuroinvasive incidence rate remained the same in Reno County (zero cases) and Sedgwick County (1 case), the State of Kansas (0.41 per 100,000), and the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) (0.56 cases per 100,000). The incidence rate of WNV for Kansas was lower than the incidence rate for the United States (0.44 per 100,000) in 2018 (Table 5).

There was one case of neuroinvasive WNV disease in Shawnee County in 2018 compared to two cases in 2017 (Table 5). The three-year median (2015-2017) for neuroinvasive disease in Shawnee County was one case.
Table 5. West Nile virus neuroinvasive disease count and incidence rate* by year, 2014-2018.

<table>
<thead>
<tr>
<th>Region</th>
<th>2014 Count</th>
<th>2014 Rate</th>
<th>2015 Count</th>
<th>2015 Rate</th>
<th>2016 Count</th>
<th>2016 Rate</th>
<th>2017 Count</th>
<th>2017 Rate</th>
<th>2018 Count</th>
<th>2018 Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedgwick County</td>
<td>0</td>
<td>-</td>
<td>2</td>
<td>0.39</td>
<td>4</td>
<td>0.78</td>
<td>1</td>
<td>0.20</td>
<td>1</td>
<td>0.19</td>
</tr>
<tr>
<td>Shawnee County</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>1</td>
<td>0.56</td>
<td>2</td>
<td>1.12</td>
<td>1</td>
<td>0.56</td>
</tr>
<tr>
<td>Reno County</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>2</td>
<td>3.14</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Kansas</td>
<td>18</td>
<td>0.62</td>
<td>12</td>
<td>0.41</td>
<td>17</td>
<td>0.58</td>
<td>12</td>
<td>0.41</td>
<td>23</td>
<td>0.79</td>
</tr>
<tr>
<td>West North Central†</td>
<td>104</td>
<td>0.50</td>
<td>82</td>
<td>0.39</td>
<td>175</td>
<td>0.82</td>
<td>118‡</td>
<td>0.56</td>
<td>364</td>
<td>1.70</td>
</tr>
<tr>
<td>United States</td>
<td>1,347</td>
<td>0.42</td>
<td>1,455</td>
<td>0.47</td>
<td>1,310</td>
<td>0.40</td>
<td>1,425</td>
<td>0.44</td>
<td>1,658*</td>
<td>0.51</td>
</tr>
</tbody>
</table>

*Number of cases per 100,000 population, based on U.S. Census population estimates for July 1, 2018.
† West North Central region; Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.
‡ Data from [https://www.cdc.gov/mmwr/volumes/68/wr/mm6831a1.htm](https://www.cdc.gov/mmwr/volumes/68/wr/mm6831a1.htm). Accessed Dec. 5, 2019.

Other Arboviral Diseases

In 2018, there were four cases of other arboviral disease reported to KDHE. There were three cases of dengue virus infection and one case of Zika virus infection. All infections were acquired outside of the United State in countries where these diseases were endemic.

Animal Case Surveillance

There were nine WNV-positive animals reported to KDHE in 2018 (Table 6).

Table 6. Animal cases of West Nile virus – Kansas, 2018.

<table>
<thead>
<tr>
<th>Date of Specimen Collection</th>
<th>County</th>
<th>Region</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Aug.</td>
<td>Riley</td>
<td>Northeast</td>
<td>Bird</td>
</tr>
<tr>
<td>10 Aug.</td>
<td>Seward</td>
<td>Southwest</td>
<td>Horse</td>
</tr>
<tr>
<td>15 Aug.</td>
<td>Wichita</td>
<td>Southwest</td>
<td>Horse</td>
</tr>
<tr>
<td>1 Sept.</td>
<td>Lyon</td>
<td>Northeast</td>
<td>Horse</td>
</tr>
<tr>
<td>5 Sept.</td>
<td>Labette</td>
<td>Southeast</td>
<td>Horse</td>
</tr>
<tr>
<td>13 Sept.</td>
<td>Marion</td>
<td>Northcentral</td>
<td>Horse</td>
</tr>
<tr>
<td>19 Sept.</td>
<td>Butler</td>
<td>Southcentral</td>
<td>Horse</td>
</tr>
<tr>
<td>19 Sept.</td>
<td>Thomas</td>
<td>Northwest</td>
<td>Squirrel</td>
</tr>
<tr>
<td>30 Sept.</td>
<td>Leavenworth</td>
<td>Northeast</td>
<td>Horse</td>
</tr>
</tbody>
</table>

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West Nile Virus Risk Levels

After the conclusion of the mosquito surveillance season we evaluated our risk levels to determine if the current model accurately reflected the risk of WNV transmission. We compared two models; the current model (Model 1) included the percent change of Culex spp. mosquitoes from the same week the previous year, average daily temperature over the previous two weeks, and the five-year historical human case data. Model 2 included all Model 1 factors with addition of the following; if >40 Culex spp. mosquitoes were trapped in a county during a week, that factor increased to the maximum value. The number of Culex spp. mosquitoes used as the cutoff was based on an analysis performed on Kansas data in 20129. One week was subtracted from the onset of illness date of cases to determine the region’s RL during the likely exposure time frame. RLs in all six regions, positive predictive value (PPV), and sensitivity of both models were compared.

At the time of the analysis (12/11/2018), 40 confirmed or probable WNV cases had completed investigations; two cases occurred prior to mosquito surveillance and were excluded from the analysis. In Model 1, 23 weeks were high risk, 89 moderate, and 26 low. In Model 2, 28 weeks were high risk, 92 were moderate, and 18 were low (Figure 3).

In Model 1, ten (26%) persons had likely exposure during high risk weeks compared to 25 (66%) in Model 2. In Model 1, 28 (74%) persons had likely exposure during moderate risk weeks compared to 13 (34%) in Model 2. Zero cases in either model were likely infected during a low risk week. PPV increased from 0.22 in Model 1 to 0.38 in Model 2 and sensitivity increased from 0.19 in Model 1 to 0.56 in Model 2 (Figure 3).

Addition of the two-tier factor for Culex spp. in Model 2 increased the predictability and sensitivity of the WNV risk model. We will use Model 2 for the 2019 mosquito surveillance season.

Figure 3. Comparison of West Nile virus Risk Level Models.
Discussion

The incidence of WNV neuroinvasive disease in 2018 (0.96 per 100,000) was 134% higher than the median incidence of 0.41 during 2008 – 2017 (range = 0.03 [2011] - 1.31 [2013]). This is compared to a nearly 25% increase in the median incidence (0.41) for the entire U.S. during the same period (range = 0.13 [2009] - 0.92 [2012])7. We noted a substantial increase in the number of cases of WNV neuroinvasive disease beginning in 2012. It is important to note that some of the increase may be attributed to the change in the case counting methodology; prior to 2012 we counted confirmed cases only. From 2012 to present we counted confirmed and probable cases to align with the way CDC counts cases nationally. However only some of the increase can be attributed to this difference. There does appear to be an overall increase in the number of WNV neuroinvasive diseases cases in Kansas from 2012 to present. This may be, in part, due to healthcare providers testing more patients for the disease.

St. Louis encephalitis (SLE) is an arboviral disease spread through the bite of an infected *Culex* species mosquitoes. These are the same types of mosquitoes that can spread West Nile virus. SLE is maintained in a mosquito-bird-mosquito cycle. Birds (including the house sparrow, rock pigeon, blue jay, and American robin) may amplify the virus and spread it to mosquitoes, and then the mosquitoes spread the virus to people, and other birds.

Most people that are infected with SLE do not become ill. Those that become ill have clinical signs and symptoms like WNV ranging from a mild illness to encephalitis and death. SLE cases decreased substantially after the introduction and spread of WNV in the U.S.; from 2009 – 2018 there were an average of 7 cases reported annually11. The last outbreak of SLE in the United States occurred in Arizona in 201512. SLE and WNV are both members of the family Flaviviridae, genus *Flavivirus*13. These viruses cross-react with each other. This means that a test that is positive via serology for WNV could be SLE and vice versa. Confirmation of the specific type of *Flavivirus* is accomplished through virus-specific IgM and neutralizing antibodies14. This could mean that some SLE infections are misdiagnosed as WNV infections. However competitive exclusion may also be a factor in the decrease of SLE infections in humans15. WNV and SLE have some bird-host overlap therefore if the birds were infected with WNV they may be protected from infection with SLE15. The 2015 outbreak in Arizona was attributed to a strain of SLE from South America15.

SLE was found in mosquitoes for the first time in Reno County however no human cases of SLE have been reported in Kansas since 1987. From 1964-1987 there were 125 cases of SLE reported to KDHE16. We believe this may be, at least in part, to lack of testing for SLE in patients who present with clinical signs and symptoms of WNV. We encourage healthcare providers who suspect a patient to have a WNV infection to test for other arboviral diseases endemic in Kansas to include SLE and Western Equine Encephalitis.

Outbreaks of arboviruses, such as WNV, are difficult to predict due to the variety of factors that can influence transmission of this disease including weather (e.g. precipitation and temperature, animal and human host abundance), and human behaviors (e.g. use of repellent, outdoor activity, etc.)7.
References


Appendix A: West Nile virus surveillance case definition, 2018
Clinical Criteria for Surveillance Purposes

Neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND**
- Meningitis, encephalitis, acute flaccid paralysis, or other acute signs of central or peripheral neurologic dysfunction, as documented by a physician, **AND**
- Absence of a more likely clinical explanation.

Non-neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND**
- Absence of neuroinvasive disease, **AND**
- Absence of a more likely clinical explanation.

Laboratory Criteria for Surveillance Purposes

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, **OR**
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, **OR**
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, **OR**
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred, **OR**
- Virus-specific IgM antibodies in CSF or serum.

Surveillance Case Definitions

Confirmed:

Neuroinvasive disease

A case that meets the above clinical criteria for neuroinvasive disease and one or more the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, **OR**
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, **OR**
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, **OR**
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

**Non-neuroinvasive disease**

A case that meets the above clinical criteria for non-neuroinvasive disease and one or more of the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, **OR**
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, **OR**
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, **OR**
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

**Probable:**

**Neuroinvasive disease**

A case that meets the above clinical criteria for neuroinvasive disease and the following laboratory criteria:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.

**Non-neuroinvasive disease**

A case that meets the above clinical criteria for non-neuroinvasive disease and the laboratory criteria for a probable case:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.
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Our Mission

To protect and improve the health and environment of all Kansans