Epidemiological Profile and Environmental Analysis of West Nile Virus in Kent County, Michigan, 2002

Full Report

KENT COUNTY HEALTH DEPARTMENT

GRAND RAPIDS, MICHIGAN

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Written by:
Julie Kettlehut Payne, MPH
Kent County Health Department Communicable Disease Epidemiologist

Kent County Health Department, 700 Fuller N.E., Grand Rapids, MI 49503, Phone: (616) 336-3030

Introduction

Epidemiology is a scientific discipline, and has been referred to as "the basic science of public health." The word epidemiology comes from the Greek words epi, meaning "on or upon" demos meaning "people," and logos meaning the "study of." Epidemiology is "the study of the distribution(frequency and pattern) and determinants(cause) of health-related states or events in specified populations and application of this study to the control of health problems." Descriptive Epidemiology answers the "who, what, when, and where, questions" (distribution). Analytical Epidemiology answers the "why" and "how" questions (determinants) (CDC,1998). The term epidemic is used to describe a period of time when the number of cases of a disease are greater than normal. Kent County, Michigan had never had a human case of WNV until the summer of 2002. Therefore, the 57 cases that were reported in 2002 would be defined as an epidemic. The term outbreak is also often used and it has the same meaning. This epidemiologic profile attempts to study the impact of the West Nile Virus on the people of Kent County and explore answers to the questions that were posed during and after the West Nile Virus epidemic of 2002.

Descriptive Epidemiology

Arboviruses

Arthropod**-bo**rne **viruses,** i.e., arboviruses, are viruses that are transmitted between vertebrate hosts(humans or animals having a spinal column) and blood feeding arthropods (mosquitoes, flies, and ticks). Infections occur in vertebrate hosts when an infected arthropod feeds on the blood of a vertebrate host. These arthropods are referred to as vectors. Vectors transmit disease from one organism to another. Arboviruses that cause human encephalitis (inflammation of the brain) are members of three virus families: *Flaviridae,* the *Togaviridae* (genus Alphavirus), and *Bunyaviridae*.

Most humans that acquire arbovirus infections either have no symptoms or have flu-like symptoms. Onset of disease may be sudden with a fever, headache, muscular pain, general discomfort, and a need to lie down. Infection may, however, lead to encephalitis, with permanent neurologic impairment, or to death. Fortunately, only a small percentage of infected persons progress to encephalitis.

Since the disease is viral in nature, antibiotics are not effective for treatment and no beneficial antiviral drugs have yet been discovered. Treatment primarily involves comfort measures, and efforts to deal with the problems associated with the swelling of the brain (e.g. loss of the automatic breathing activity of the brain), as well as other complications such as bacterial pneumonia that can be treated.

Arboviruses are found throughout the world, however, five types of virus agents are found in the United States: West Nile Virus (WNV), St. Louis encephalitis (SLE), eastern equine encephalitis (EEE), western equine encephalitis (WEE), and La Crosse encephalitis (LAC), all of which are transmitted by mosquitoes. Another virus, Powassan, is a minor cause of encephalitis in the northern United States, and is transmitted by ticks. EEE and SLE have both been found in Michigan and are transmitted by mosquitoes to humans, horses, birds and other animals.

West Nile Virus is a flavivirus belonging to the Japanese encephalitis virus strain that includes the closely related St. Louis encephalitis (SLE) virus, Kunjin and Murray Valley encephalitis viruses, as well as others (Chart 1, page. 4). West Nile Virus is spread by the bite of an infected mosquito, and can infect people, horses, many types of birds, and some other animals (CDC, 2003).

West Nile Virus Background

The West Nile Virus was first detected in a woman with a fever in the West Nile District of Uganda, Central Africa in 1937. Since that time the West Nile Virus has been found in North Africa, West and Central Asia, the Middle East, and Europe. Before arriving in the United States in 1999, the most recent outbreak of the virus had occurred in the Democratic Republic of Congo in 1998 (Table 1).

Table 1

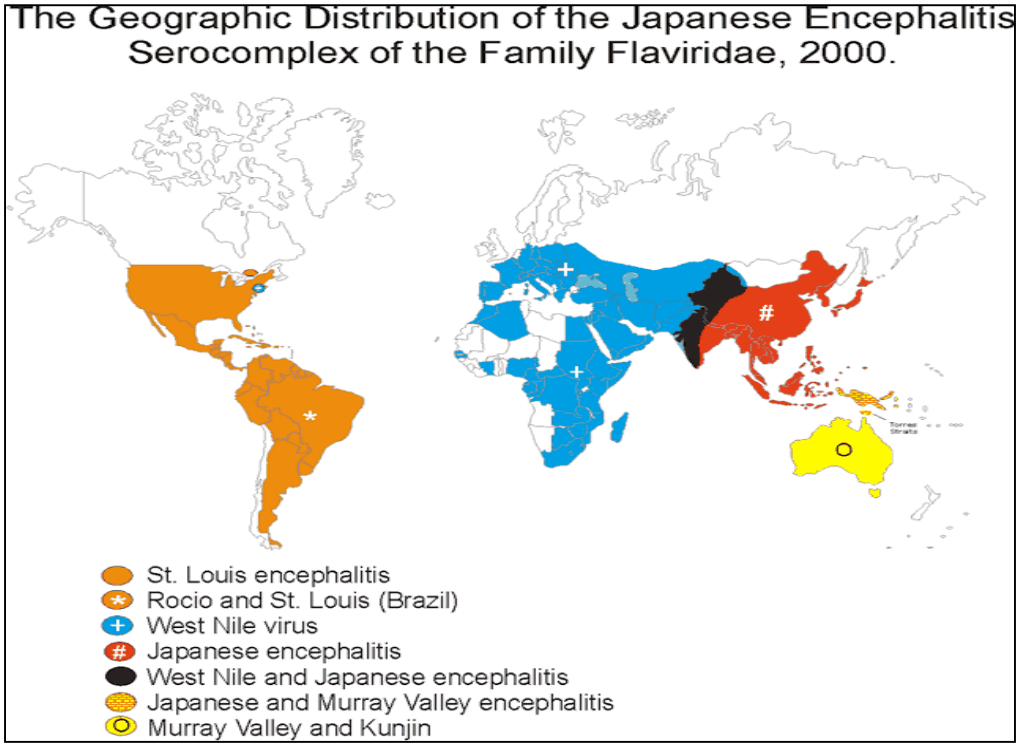
West Nile Outbreaks throughout the World

Uganda, Africa	1937
Israel Epidemics	1951-1954 and 1957
Rhone Delta, France	1962
South Africa	1974
Algeria	1994
Romania	1996 and 1997
Czech Republic	1997
Democratic Republic of Congo	1998
Russia	1999

The first U.S. outbreak of WNV was in New York City in August of 1999. Dr. Deborah Asnis, an infectious-disease specialist reported two cases of encephalitis with accompanying muscle weakness to the New York City Department of Health. A disease investigation ensued revealing that the West Nile virus was the cause of the outbreak in crows and humans. Until that time the virus had never before been identified in the Western Hemisphere (NEJM, 2002).

When this outbreak occurred, it was initially thought to be attributed to St. Louis Encephalitis. That is because SLE and West Nile viruses are antigenically related (substance that comes in contact with animal tissues and produce sensitivity), and cross reactions (one can be confused for the other) are observed in most blood tests. Samples taken from birds, mosquitoes, and human brain tissue permitted the discovery of West Nile virus in North America and prompted more specific (improved detection of the agent) testing.

Chart 1 (CDC, 2003)



During 2002, three new West Nile Virus concerns developed. West Nile was found to be transmitted through organ transplants, through breast milk, and transplacentally (mother-to-child in the womb) (CDC, 2003). Ten transfusion-associated investigations are currently being conducted in Michigan (*EpiInsight*, Michigan Department of Community Health, 2002). One transfusion-associated case involves a mother who is believed to have transmitted the West Nile Virus to her infant via her breast milk. Investigations are ongoing nationwide to determine whether WNV is transmitted by transfusion or transplantation. Despite the fact it is known that WNV infection can be transmitted by breast milk, the one child that it was transmitted to remained healthy. At this point in time, breastfeeding continues to be recommended as the benefits outweigh the risks.

It is still not known when and how the West Nile Virus was introduced in North America, though international travelers, infected mosquitoes, or imported infected birds are considered plausible suspects. Richard Pollack, Ph.D, a professor at the Harvard School of Public Health recently discovered that the strain that was isolated in New York was "virtually identical to a strain that was isolated the previous year in Israel, but less closely related to isolates from outbreaks from other countries." Most recent numbers of West Nile Virus indicate that as of December 2002, the virus had been found in 46 U.S. different states, with 41 states having human cases (CDC, 2003).

Mosquito-borne diseases are not new to Michigan, and are believed to have been present in Michigan since before the time of the first European settlers. Evidence of an outbreak of mosquito-borne malaria was documented in an 1858 50th anniversary celebration address at the

then Michigan Agricultural School, now known as Michigan State University. Records from 1947 indicate that viral equine encephalitis was an "annual occurrence in Michigan." The first Michigan case of mosquito-borne Eastern Equine encephalitis occurred in 1980, and resulted in the death of a St. Joseph County boy (MDA, 2002). Cases of St. Louis encephalitis, which is closely related to the West Nile Virus, were found in Michigan in 1975. These cases were part of a larger outbreak that occurred in the United States. The New England Journal of Medicine reported that the 2002 outbreak of West Nile is "strikingly similar" to the outbreak of St. Louis encephalitis that occurred in 1975 (NEJM, 2002).

Clinical Diagnosis

West Nile **meningitis** (inflammation of the membrane around the brain and spinal cord**)** is identified by fever, headache, stiff neck, and pleocytocis (the presence of more cells than normal in a particular area). West Nile **encephalitis** (inflammation of the brain) is distinguished by fever, headache, and altered mental status ranging from confusion to comas with or without additional signs of brain dysfunction (e.g. paralysis, problems with the senses, abnormal reflexes, convulsions, and other abnormal movements).

Mild Infection

Most WNV infections are mild and clinically unremarkable. Centers for Disease Control states that approximately 20% of those infected will develop a mild illness. This condition is referred to as West Nile Fever. The incubation period ranges from 3 to 14 days. Symptoms generally last three to six days. Reports from earlier outbreaks describe the mild form of WNV infection beginning with the sudden onset of a fever, general discomfort, a decreased appetite, nausea, vomiting, eye pain, headache, muscular pain, rash, and enlarged lymph nodes.

Severe Infection

Approximately 1 in 150 WNV infections will result in severe neurological disease. The most significant risk factor for developing severe neurologic disease is advanced age. Encephalitis is more commonly reported than meningitis. In recent outbreaks, symptoms occurring among patients hospitalized with severe disease include fever, weakness, gastrointestinal symptoms, and change in mental status. A minority of patients with severe disease developed a maculopapular (discolored and elevated) rash or morbilliform (resembling measles) rash involving the neck, trunk, arms, or legs. Several patients experienced severe muscle weakness and paralysis. Neurological presentations of severe WNV infection included ataxia (inability to coordinate muscles involved in movement), cranial nerve abnormalities, myelitis (inflammation of the spinal cord) optic neuritis (inflammation of eye nerves), polyradiculitis (inflammation of nerve roots), and seizures (CDC, 2003).

While West Nile Virus infection can be suspected in a person based on clinical symptoms and patient history, laboratory testing is required for diagnosis. Experimental studies have shown that the virus replicates in peripheral sites (outer surface of the body) before it moves to the central nervous system (CNS). It is suspected that the virus may move from the blood to the CNS through the olfactory tract (nasal passages). Based on this clinical information, Kent County cases were classified in the following ways (Table 2, page 7):

Table 2		
Classification	**Frequency**	**Percent**
West Nile Fever	2	3.5
Meningitis/Encephalitis	11	19.3
Meningitis	17	29.8
Encephalitis	27	47.4
Total	57	100.0

Laboratory Diagnosis

Laboratory diagnosis of human arboviral encephalitis has changed greatly over the last few years. In the past, identification of antibodies relied on four tests and was more time consuming. Today, testing can be done soon after infection. The most commonly used WNV laboratory test measures antibodies (immune or protective proteins) that are produced very early in the infected person. These antibodies, called IgM antibodies, can be measured in blood or cerebrospinal fluid (CSF), which is the fluid surrounding the brain and spinal cord. This blood test may not be positive when symptoms first occur; however, the test is positive in 90% of infected people within 8 days of onset of symptoms.

During the WNV outbreak of 2002, the demand for laboratory testing reagents (substances added to a solution to produce a reaction) available from the Centers for Disease Control was high nationwide. The Michigan Department of Community Health had to prioritize CSF fluid specimens over blood specimens to ensure that testing for the most severely ill patients was available.

Laboratory testing for West Nile Virus is somewhat complicated and there is a lag time between specimen collection and final results. In the case of CSF, an initial test is run and if it is positive, it is considered a presumptive positive. If there is a sufficient amount of specimen, the test is then repeated and if it is positive, it is considered to be a confirmed case of West Nile Virus. However, if the test result comes back "equivocal," a request is made for an additional blood test. These cases are called probable cases. Furthermore, if there is an insufficient amount of CSF for testing, a request is made for a blood test in order to confirm a case.

Blood specimens were not given priority by the Michigan Department of Community Health in 2002 unless they were accompanied by clinical information indicating central nervous system involvement (testing blood specimens is a more complex process). Initial positive results are reported as preliminary positive results. The blood is then retested, if it is again positive, it is considered a probable case. In order to confirm a case, another blood specimen is requested which is required to be taken at least 21 days after the first specimen. If the second specimen is obtained, a test called a Plaque Reduction Neutralizing Test (PRNT) is run and compared to the initial specimen in order to confirm a case. If it is not possible to obtain another specimen, a PRNT is run on the initial specimen. If the PRNT is positive, this is also considered to be a confirmed case of West Nile Virus (MDCH, 2002).

In other instances, blood work from a patient with central nervous system involvement may have an initial positive result but have a negative PRNT (a false positive for WNV). This indicates they could have encephalitis because of another closely-related flavivirus (such as St. Louis encephalitis). The result could be positive because of the cross-reactivity that can occur with flaviviruses. The PRNT is able to definitively discriminate between the viruses. This additional tests requires growth of the virus and may take a week or longer (plus shipping time) to conduct.

Case Definition

A **probable case** of West Nile Virus is defined as an encephalitis (inflammation of the brain) or meningitis (inflammation of the tissues that cover the brain and spinal cord) case occurring during a period when arborviral transmission is likely, and with supportive lab tests.

A **confirmed case** of West Nile Virus is defined as an encephalitis or meningitis case that is laboratory confirmed.

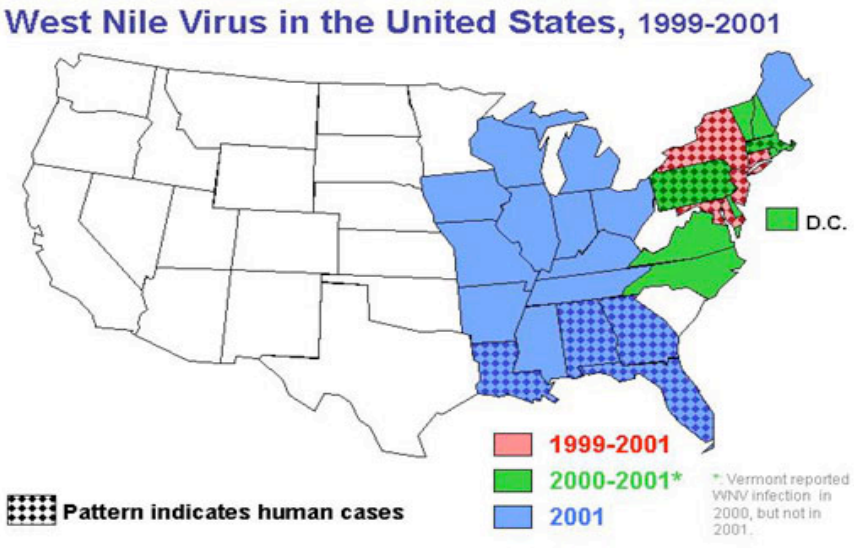
Distribution

In terms of distribution, epidemiology encompasses both the frequency (repeated occurrence) and pattern of health events in the population. Frequency refers to the number of events, but also the rate or "risk" of disease in the population. Calculating a rate (the number of cases divided by the size of population) is the best way to make comparisons across different populations.

United States

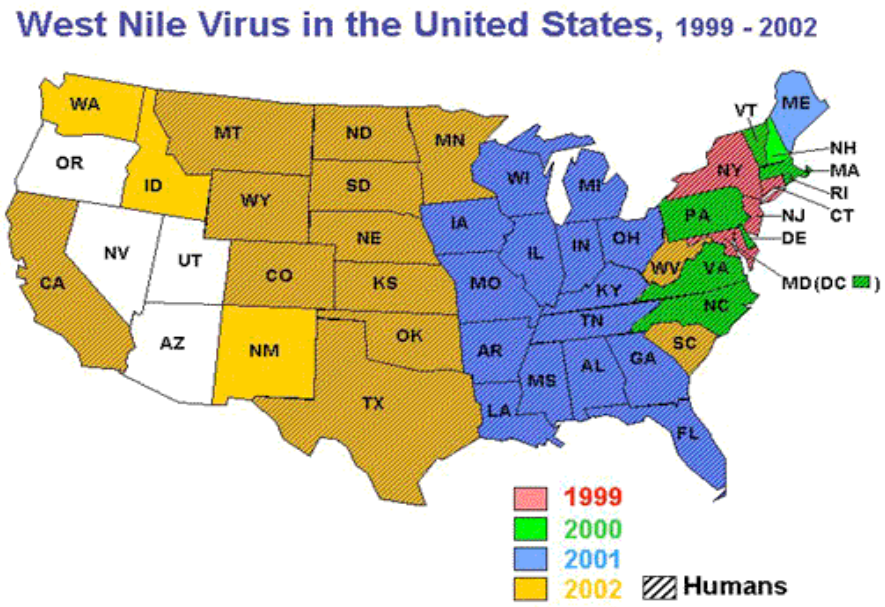
As the West Nile Virus migrated westward during 1999-2001, no human cases of West Nile had been found in Illinois, Michigan, Ohio or Indiana (Chart 2).

Chart 2



However, during 2002 a vastly different picture emerged across the United States (Chart 3). The 2002 outbreak of West Nile was much worse than all three previous years combined. Some suspect that migrating birds between the north and south spread it. Other suspect it was spread by mosquitoes in cars, in planes, and in trains. Human cases were found as far westward as Montana, and even bypassed some states to reach California.

Chart 3



During the summer and fall of 2002, the greatest number of cases were seen in Illinois (836 cases) and Michigan (574) with Ohio (434), Indiana (294), and Louisiana (329) following in succession (Table 3).

Table 3

Leading U.S. States in Number of Cases

as of 1/31/03

Rank	State	Number of Cases	Population
1	Illinois	836	12,482,301
2	Michigan	574	9,990,817
3	Ohio	434	11,373,541
4	Indiana	294	6,114,774
5	Louisiana	329	4,465,430

Rates allow the size of the population to be taken into account when examining the impact of disease on an entire population. Although the number of cases is still changing as results from last year's season continue to come in, a crude rate that is taken at a specific point in time allows comparisons to be made across the different states. In examining these results (see table below) Louisiana (rate of 7.4 per 100,000) and Nebraska (7.2 per 100,000) have the highest rates of disease based on the proportion of people that were ill out of their entire state's population. Illinois (6.7 per 100,000), Mississippi (rate of 6.6 per 100,000) and Michigan (rate of 5.7 per 100,000) followed. These five states ranked the highest for West Nile Virus out of all 41 states that have human cases (Table 4).

Table 4

Leading U.S. States in order of Rank

as of 1/31/03

Rank	State	Rate
1	Louisiana	7.4
2	Nebraska	7.2
3	Illinois	6.7
4	Mississippi	6.6
5	Michigan	5.7

Michigan

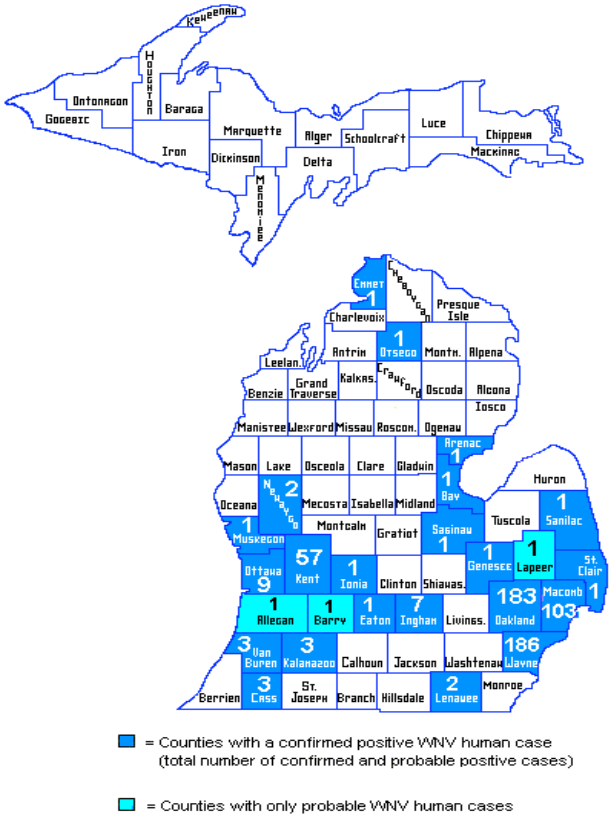
In Michigan, Wayne (186 cases) and Oakland (183 cases) counties ranked the highest in terms of their numbers of cases (Table 5, below, and Chart 4, page 10), followed by Macomb (103), Kent (57) and Ottawa (9) counties.

Table 5

Number of Cases as of 1/17/03

	Rank	Total	Confirmed	Probable
Wayne	1	186	155	31
Oakland	2	183	154	29
Macomb	4	103	70	33
Kent	3	57	51	6
Ottawa	5	9	8	1

Chart 4



However, when county rates are compared, Oakland county ranks number one with (15 per 100,000 cases), followed by Macomb (13 per 100,000), Kent (10 per 100,000), Wayne (9 per 100,000), and Ottawa (4 per 100,000). This is an interesting finding as Wayne County actually has the largest population. (Table 6 below and Chart 5)

Table 6

Rate by County as of 1/17/03

Rank of Rate	County	Rate/100,000	Rank of Population	Population
1	Oakland	15	2	1,194,156
2	Macomb	13	3	788,149
3	Kent	10	4	574,335
4	Wayne	9	1	2,061,162
5	Ottawa	4	5	238,314

Chart 5 Rate (and number) of WNV cases by County per 100,000 population, as of 1/17/03

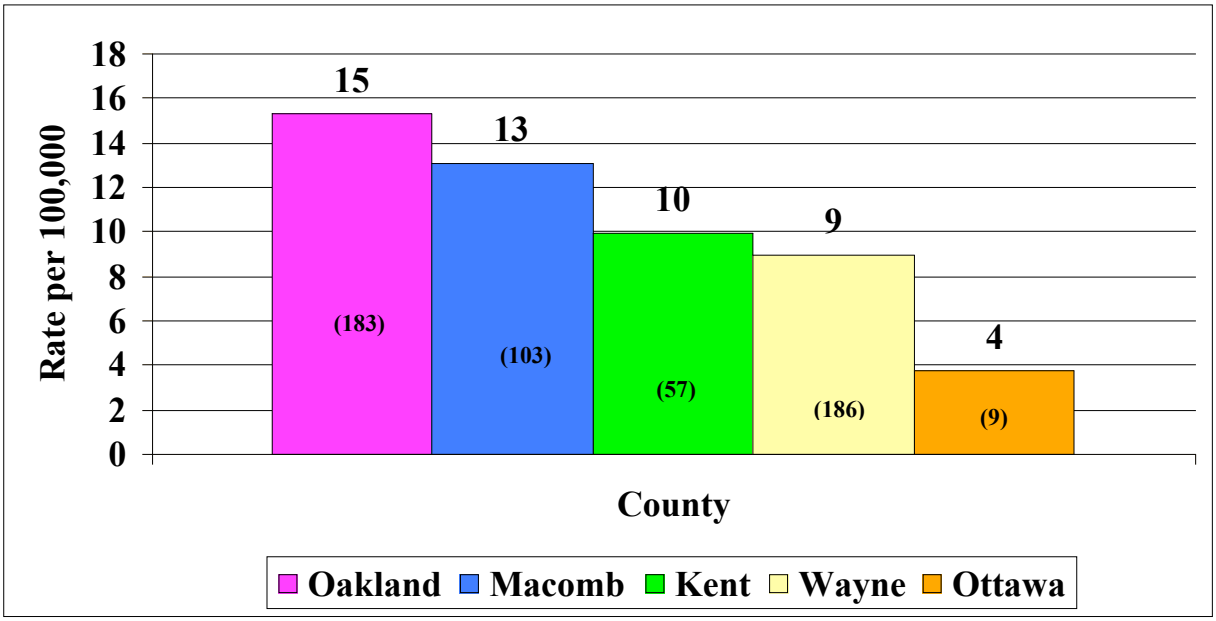
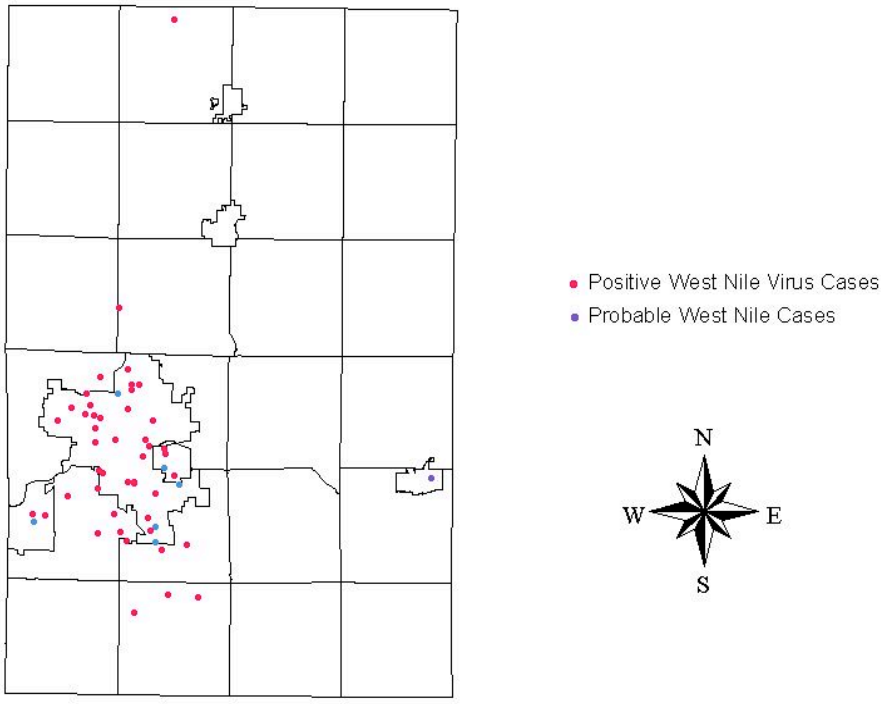


Chart 6 West Nile Virus in Kent County



Urban/Suburban/Rural

The REGIS (Regional Geographic Information System) was employed to examine the geographic distribution (pattern) of West Nile Virus disease in Kent County. As is evidenced by the Kent County map (Chart 6), the bulk of West Nile cases (39 cases) occurred within the City of Grand Rapids amounting to 68.4% of all cases (Table 7, page 12). Sorting out East Grand Rapids (4 cases or 7%), 61% percent of cases still remained to be found in the City of Grand Rapids. This indicates that West Nile Virus is primarily an urban phenomenon in Kent County.

Table 7					
West Nile Cases By City including total Grand Rapids			**West Nile Cases with East Grand Rapids Sorted out of Total Grand Rapids**		
	Frequency	Percent		Frequency	Percent
Total Grand Rapids	39	68.4	Grand Rapids	35	61.4
Kentwood	6	10.5	Kentwood	6	10.5
Wyoming	4	7	East Grand Rapids	4	7
Grandville	3	5.3	Wyoming	4	7
Caledonia	2	3.5	Grandville	3	5.3
Cedar Springs	1	1.8	Caledonia	2	3.5
Comstock Park	1	1.8	Cedar Springs	1	1.8
Lowell	1	1.8	Comstock Park	1	1.8
			Lowell	1	1.8

A further examination by postal zip code suggests that the greatest number of cases were found in the 49504 zip code, followed by the 49506, 49508, 49509, and 49505 and so on (Table 8).

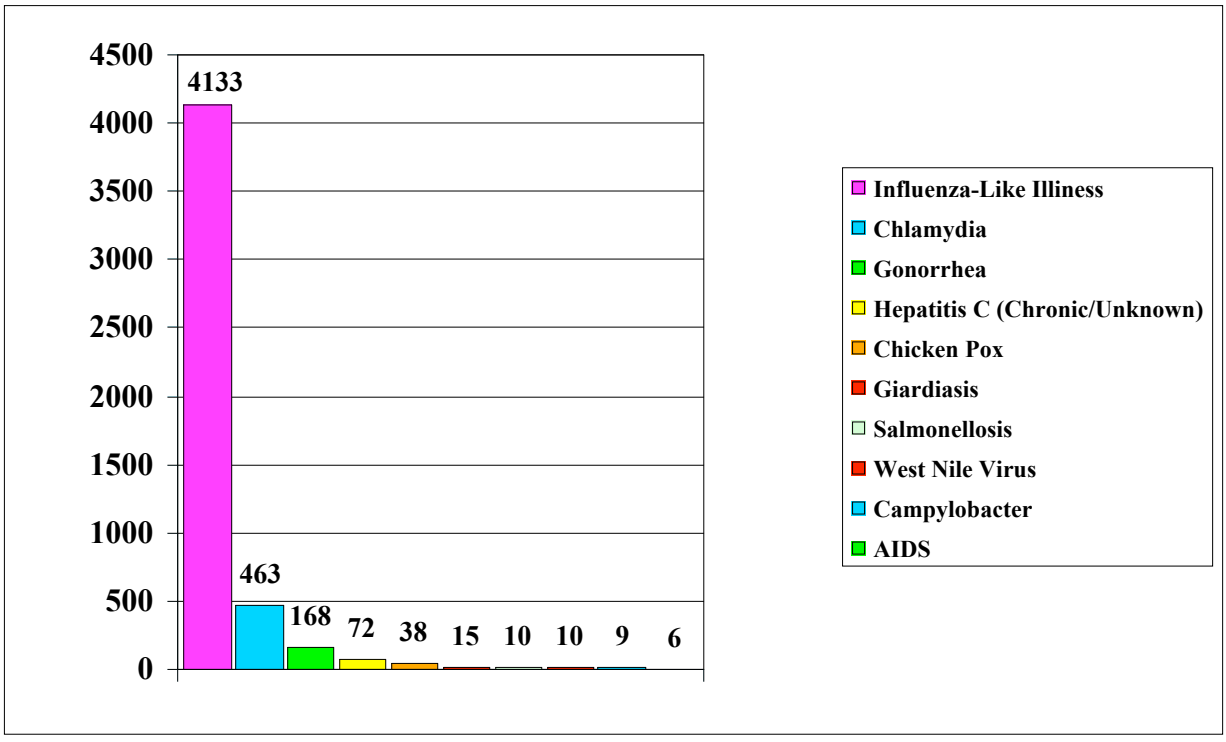
Table 8 West Nile Virus Cases By Zip Code					
	Frequency	Percent		Frequency	Percent
49504	11	19.3	49507	2	3.5
49506	7	12.3	49319	1	1.8
49508	6	10.5	49321	1	1.8
49509	6	10.5	49331	1	1.8
49505	5	8.8	49417	1	1.8
49503	4	7	49501	1	1.8
49548	4	7	49512	1	1.8
49418	3	5.3	49544	1	1.8
49316	2	3.5			
Total Case Frequency=57					

How does the frequency of West Nile Virus compare to other diseases in Kent County?

There are 77 notifiable diseases that are required to be reported to the health department by physicians and other health care professions to their local health department. In 2002, West Nile Virus was added to list of diseases that are required to be reported. Bacterial and viral meningitis and encephalitis were already required to be reported, so it was expected that these conditions would be reported until West Nile Virus was ruled in or out. Influenza-like illnesses rank number one among reportable conditions in 2002 (Chart 7). The Kent County Health Department asks schools to report their cases of influenza. Therefore, number of influenza cases displayed on the chart drastically under represents the number of cases that are observed countywide among both children and adults. The rate of Chicken Pox is also underrepresented as rates on not calculated using the number of school aged children in the denominator. Other diseases are reflected accurately. The rates from 2002 indicate that West Nile Virus ranked eighth among the ten leading notifiable diseases in Kent County.

Chart 7

Leading 10 Notifiable Diseases in Kent County, 2002



Numbers for influenza-like illness and chickenpox are compiled from school reports only.
AIDS numbers are for cases diagnosed in 2002.

How does the frequency of West Nile Virus deaths compare to the number of deaths from other conditions in Kent County?

There were a total of 4 deaths from West Nile Virus in 2002. In comparison to deaths from other illnesses, West Nile Virus deaths were not one of the ten leading causes of disease in Kent County. Whereas heart disease ranked 1st with 208 cases per 100,000, the death rate from West Nile Virus was less than 1 per 100,000 (Chart 8). All of the deaths occurred among the elderly population (Table 9), and three of the four deaths were males (Table 10).

Chart 8

Ten Leading Causes of Death in Kent County vs. West Nile Virus

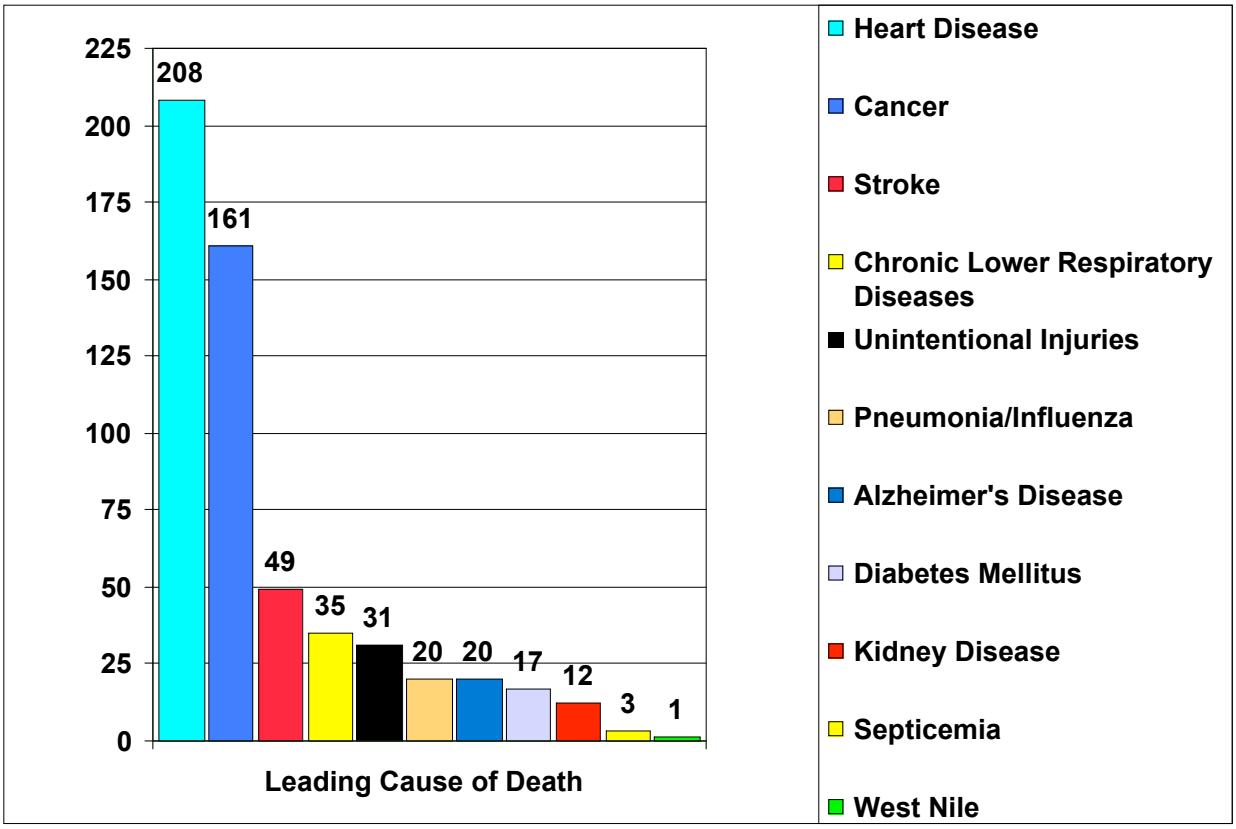


Table 9	
Age Group	Number of Deaths
60-79	3
80+	1

Table 10	
Sex	Number
Male	3
Female	1

Sex

The majority of cases (67%) of WNV in Kent County were male (Chart 9). In the State of Michigan as a whole, 55% of the cases were male and 45 % were female. A further breakdown by disease classifications shows that the more severely ill cases were male (Table 11).

Chart 9 2002 Kent County WNV Cases by Sex

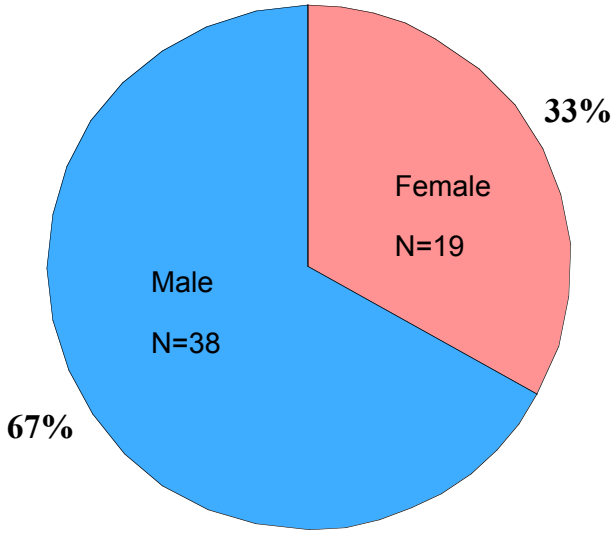


Table 11

Sex Classification Cross Tabulation

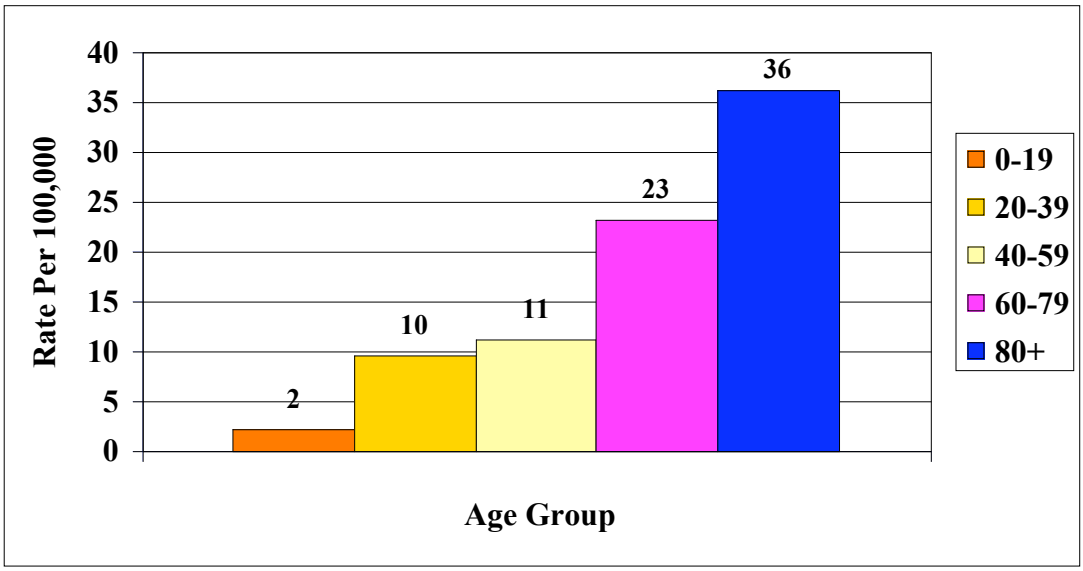
		Classification				Total
		Encephalitis	Fever	Meningitis	Meningitis/Encephalitis	
Sex	Female	8		6	5	19
	Male	19	2	11	6	38

Age

National data indicated that the young and old were at greatest risk for WNV, and the greatest proportion of Kent County cases occurred among the elderly population; other age groups followed in descending order (Chart 10). In Kent County, ages of WNV cases ranged from 6 to 88 years old, and the average age of all cases was 50 years old. The most frequently occurring age was 36 years old, which occurred four times.

Chart 10

Rate of Kent County WNV Cases by Age per 100,000



As stated previously, the most significant risk factor for developing severe neurologic disease is advanced age and in Kent County 17 people (30%) who had encephalitis or meningitis/encephalitis were sixty years or older (Table 12).

Table 12

60-80+ Age and Symptom Classification

Cross Tabulation

Classification			Total
	Encephalitis	Meningitis/Encephalitis	
60-69	0	3	3
70-79	7	1	8
80+	5	1	6
Total	12	5	17

Race/Ethnicity

The majority of WNV cases were 27 were white (37%), three (5%) were black, one (1%) was American Indian/Eskimo, and eight (14%) did not identify a race. Of the eight that did not identify a race, five (8%) identified themselves as of Hispanic ancestry, and two (3%) said they were of another ancestry (Table 13).

Table 13

		Ethnicity		
		Unknown/Don't know	Hispanic	Other
Race	Unknown/Don't know	8	4	0
	American Indian/Eskimo	1	0	1
	Black	3	0	0
	White	27	1	1
Total		39	5	2

A Small Number of Cases - Devastating Symptoms

Information on patient symptoms was collected by the Communicable Disease Nursing Staff at the Kent County Health Department. These nurses contacted the Infectious Disease Nurses at the three local acute care hospitals and requested medical chart information so that a required West Nile data surveillance form could be completed and sent to the Michigan Department of Community Health. Due to their tireless efforts, the following information was learned.

Information collected on patient temperature revealed that temperatures ranged from 99° to 107° (median 103.2°, average 102.8°) upon admission. The frequency of symptoms or physical finding is presented in Table 14 (page 18). Gastrointestinal and neurologic findings predominated. In terms of neurologic findings (headache, stiff neck, photophobia, muscle weakness, or change in mental status), almost all of the cases had a fever (98%), 90% had a headache, 72% had muscle weakness, 68% had an altered mental status and 58% had a stiff neck. Smaller percentages of individuals had gastrointestinal symptoms; 46% were nauseated, 40% vomited, and 16% had diarrhea.

Table 14				
Symptoms or Physical Finding	Number	% (Yes)	Number (Not Assessed)	% (Not Assessed)
Seizures	2	4	10	18
Diarrhea	9	16	2	4
Lethargic	16	28		
Vomiting	23	40	2	4
Nausea	26	46	4	7
Muscle Pain	32	56	8	14
Stiff Neck	33	58	2	4
Altered Mental Status	39	68	2	4
Muscle Weakness	41	72	4	7
Headache	51	90	1	2
Fever	56	98		

Additional information collected from the text of the medical chart indicated other symptoms of concern (Table 15).

Table 15 Information on additional symptoms recorded in the medical record	
Shortness of Breath	2
Difficulty Swallowing	2
Impaired Taste	3
Dementia	4
Blurred Vision	4
Double Vision(Diplopia)	5
Photophobia	7
Altered Speech	8
Face drooping	9
Difficulty Walking	10

It is not clear what the long-term health effects of WNV are. One study conducted in New York (CDC, 2001) found that 10 patients (53%) recovered but "not to their full level" before illness, seven (37%) recovered fully, and two (11%) died. The Health Department will assist local infectious disease doctors in conducting a follow-up study on the long-term effects of West Nile Virus infection.

Length of Hospitalization

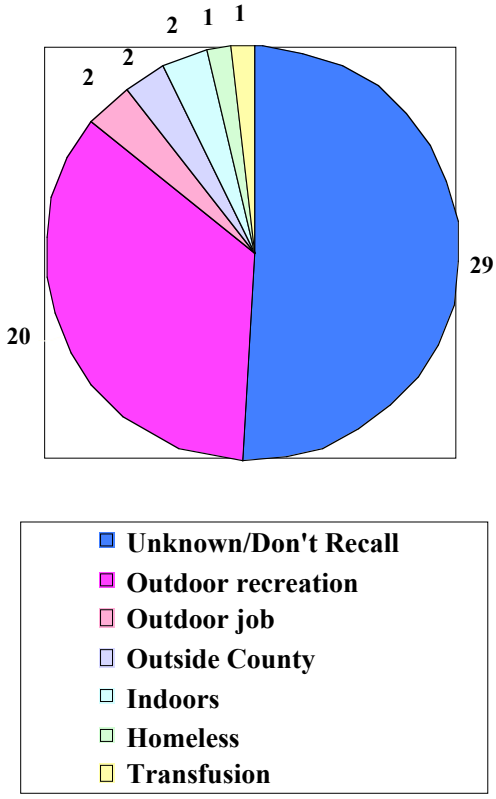
The number of days spent at an acute care hospital for those hospitalized for West Nile Virus ranged from 1-26 days (Table 16). The average number of days spent at the hospital was six. Although these patients were released from the acute care hospital, several went on to spend time or visit a rehabilitative hospital for appointments. Nine individuals did not stay in the hospital. A further breakdown of the data (those over 65 and those under 65) does not show any significant difference in length of stay by age group.

Age Group * Days Spent in Hospital Cross tabulation

Table 16

	1-6 days	7-14 days	15-22 days	23-26 days	Total
Under 65	18	7	2	1	28
Over 65	7	6	3	1	17
Total	25	13	5	2	45

Chart 11 Suspected Exposure



Suspected Exposure

Although 29 people (51%) could not remember a specific exposure, 28 people (49%) could either remember being bitten or thought they might know how they could have been bitten. Twenty cases said they engaged in some sort of outdoor recreation: golfing, gardening, camping, going to the lake/fishing, canoeing, walking the dog, feeding the birds, mowing the lawn, taking a nature walk, and just being outdoors. The remainder (14%) attributed exposure to having an outdoor job (4%), being bitten while in their home (4%), while traveling outside of the county (4%), due to being homeless (1%), and due to having a blood transfusion (1%). Of the two individuals that were bitten in their home, one attributed exposure to sleeping on a porch and the other to sleeping with the window open due to hot weather (Chart 11). At least seven people could remember being bitten multiple times.

Other Risk Factors

The severity of West Nile Virus is thought to be influenced by other risk factors such as being immunocompromised, recently having an organ transplant, or a blood transfusion. Those having a compromised immune system may have received chemotherapy, may have some other disease that compromises the immune system, or have had a transplant. Four individuals identified themselves as being immunocompromised. Of the four, two said they had recently had a transplant, and all four said they had recently had a blood transfusion. To date, only one of the four cases is strongly suspected to have received the WNV through a blood transfusion; the Michigan Department of Community Health continues to investigate this case.

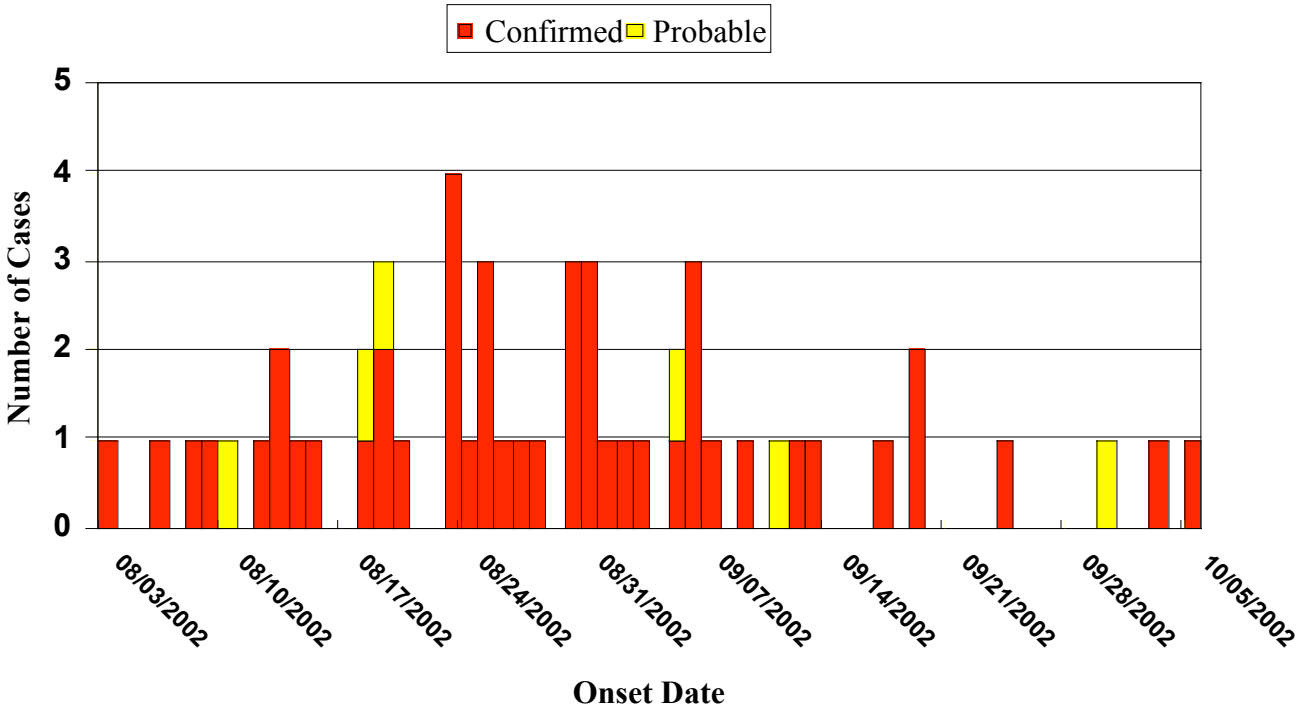
Timeframe

Most cases of arboviral encephalitis occur in the temperate zone of the world (i.e., between latitudes 23.5° and 66.5° north and south) from June through September, when arthropods are most active. In milder (i.e., warmer) parts of the country, where arthropods are active late into the year, cases can occur year around.

Epidemic Curve

The first case of West Nile Virus in Kent County had a disease onset date of August 3, 2002, and the number of cases peaked on August 30, 2002. The last date of symptom onset was October 5, 2002. This pattern is defined as a common source outbreak (a group of people is exposed to a particular disease) with an intermittent (alternating) exposure (Chart 12).

Chart 12 Onset Date of Symptoms Among Human WNV Cases in Kent County, as of 12/31/02



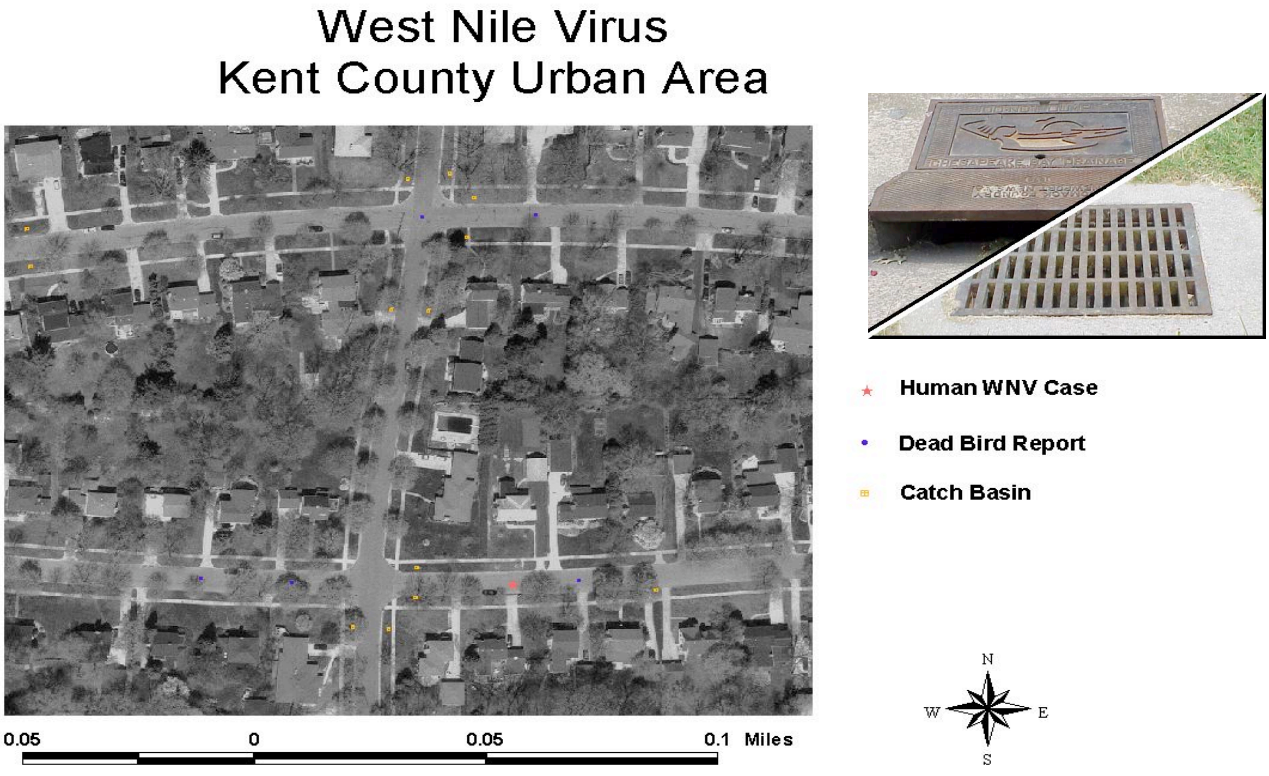
Analytical Epidemiology

Ornithology and Entomology (Study of Birds and Bugs)

As mentioned previously, WNV is transmitted to birds by infected mosquitoes. Due to the large numbers of birds (and other animals) that have been infected, West Nile Virus is now thought of as an epizootic (an epidemic with animals). In Kent County 3,976 reports of dead birds (many reports included multiple birds) were phoned into the Health Department from May 30, 2002 to December 16, 2002. As reported in the *Grand Rapids Press*, a number of birds died at the Kent County Zoo as well. Equine surveillance is carried out by the Michigan Department of Agriculture. Because the numbers of dead birds are so high and the number of human cases of West Nile Virus is low in comparison, types of mosquitoes and what they like to bite is being examined further by entomologists.

The mosquito most often associated with WNV in Michigan is the *Culex pipiens*, the northern house mosquito. This genus of mosquito can be identified by their "loud singing buzz." It is found in urban and rural areas. Past research has indicated that these mosquitoes may like to feed on birds early in the season, and humans (and other animals), later in the season. Interestingly, recent information from Edward Walker, Ph.D., an entomologist at Michigan State University, seems to indicate that humans are generally not the favored feeding choice for these mosquitoes. Other mosquito species that like to bite both birds and humans (bridge vectors) may

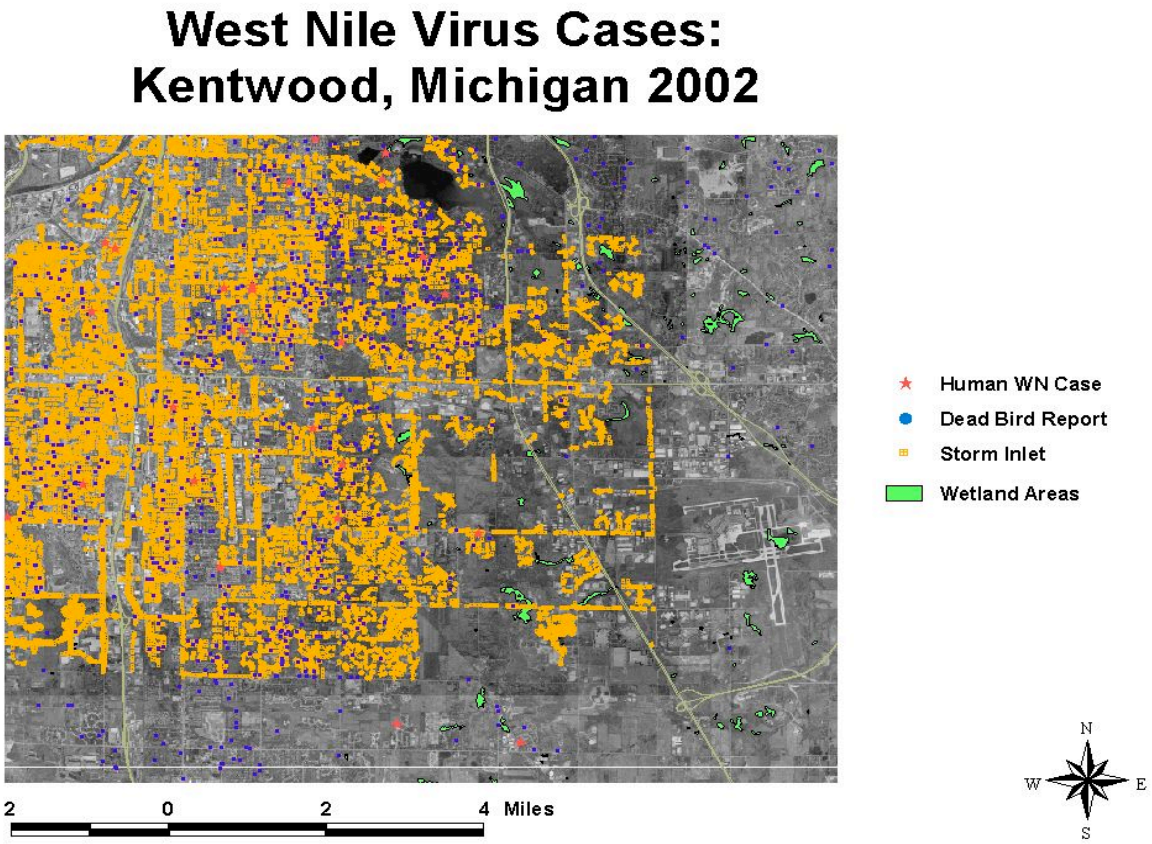
Chart 13



prove to be a bigger threat in contracting WNV. Bridge vectors bite infected birds (previously bitten by *Culex pipien*s) and then bite humans. The Centers for Disease Control have found that there are 36 mosquito species from which the West Nile Virus was either isolated, antigen was detected, or RNA was detected through a variety of tests.

Culex pipiens breed rapidly in a variety of containers with standing water such as bottles, cans, tanks, gutters, birdbaths, and urns. They are frequently found in water with a high organic content i.e. containing fertilizer, rotting, or dead material. This type of water can be found in blocked draining street gutters (Charts 13 and 14), sewer catch basins, polluted ground pools, sewage lagoons (Chart 15, page 23), open septic tanks, polluted ditches, failing septic system drain fields and drains from sewage disposal plants (MDA and MMCA, 2002).

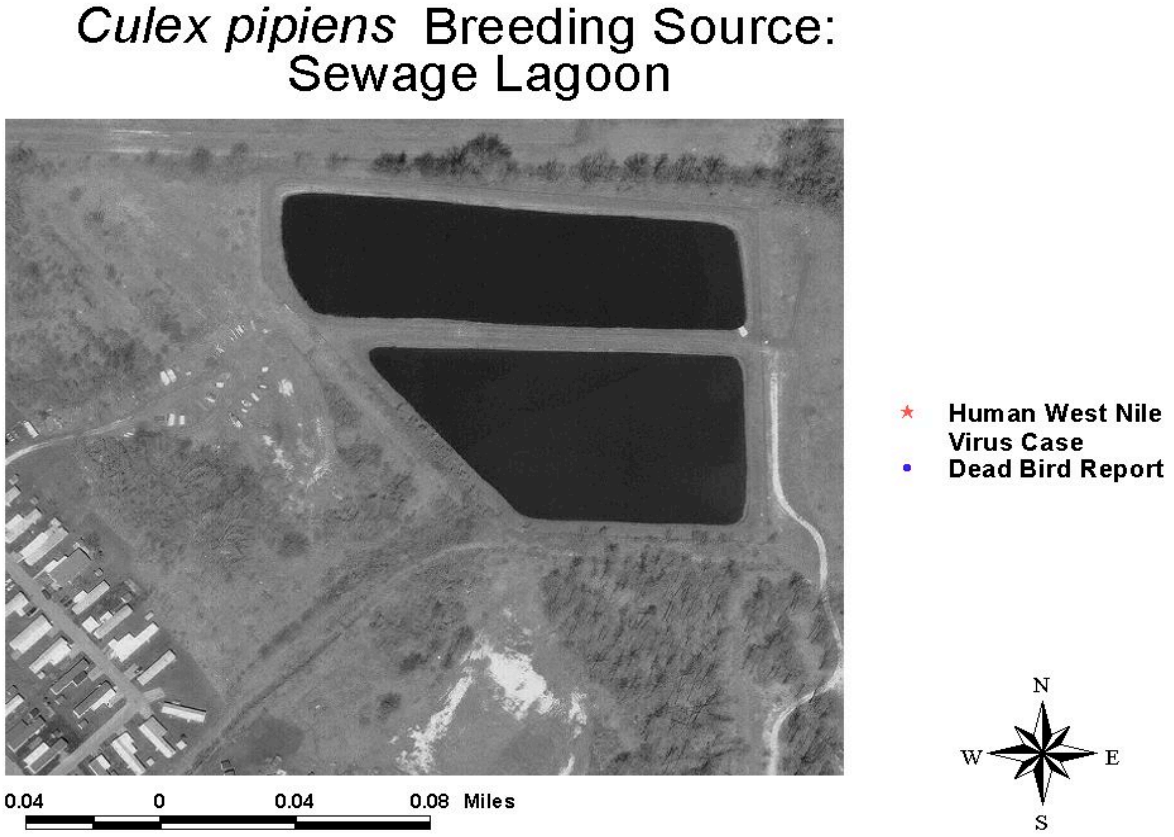
Chart 14



Mosquitoes breed 24 to 48 hours after females emerge from their pupal state. After mating, females may lay their eggs in groups ranging from 50 to 400. These groups (called egg rafts) float on surface of water. During warm weather eggs may hatch in a day or two. It typically takes eight to ten days for mosquitoes to develop from their larval (egg to worm-like) to pupal (worm-like to shrimp-like) stages. During cooler weather it may take two weeks or longer to get through these stages. Only females feed on blood in order to obtain protein for egg production. Males live

from a few days to a week and females live several weeks to several months. These mosquitoes fly only short distances away. Larvae remain only a short distance from adult mosquitoes. The *Culex* is not very active during the day and can be found near houses, chicken houses, and various shelters (resting). If disturbed, they may feed during the day. These mosquitoes are not attracted to light, and they are known to bite inside and outside of homes. The females remain in a resting state during the winter (over wintering).

Chart 15



Dr. Walker has trapped *Culex* mosquitoes in and around trees and has found that traps at eye level may catch only five mosquitoes but those thirty feet up into have caught up to 400 mosquitoes. He is exploring whether these mosquitoes go up to crow roosts to feed at night (Natural Science, 2002).

Research by Dr. Walker also examined 58 mosquito pools in Michigan. Fifty-five were from the *Culex* species, and there was one each from the *Aedes vexans, Ochlerotatus trivittatus*, and *Coquillettidia perturbans*. These mosquitoes can be found in a variety of different habitats and may lay their eggs differently (Table 17).

Table 17 Species of bridge vector mosquitoes in Michigan

Genus	Species	Habitat	Eggs
Aedes	vexans	Temporary pools	Laid in or on soil in low lying areas
Coquillettiddia	perturbans	Permanent bogs, marshes with heavy aquatic vegetation	Rafts on water
Ochlerotatus	triseriatus	Treeholes(basal part of tree), containers	Singly above water level
Ochleroatus	trivittatus	Floodwater &woodland pools	Singly on damp, low surface

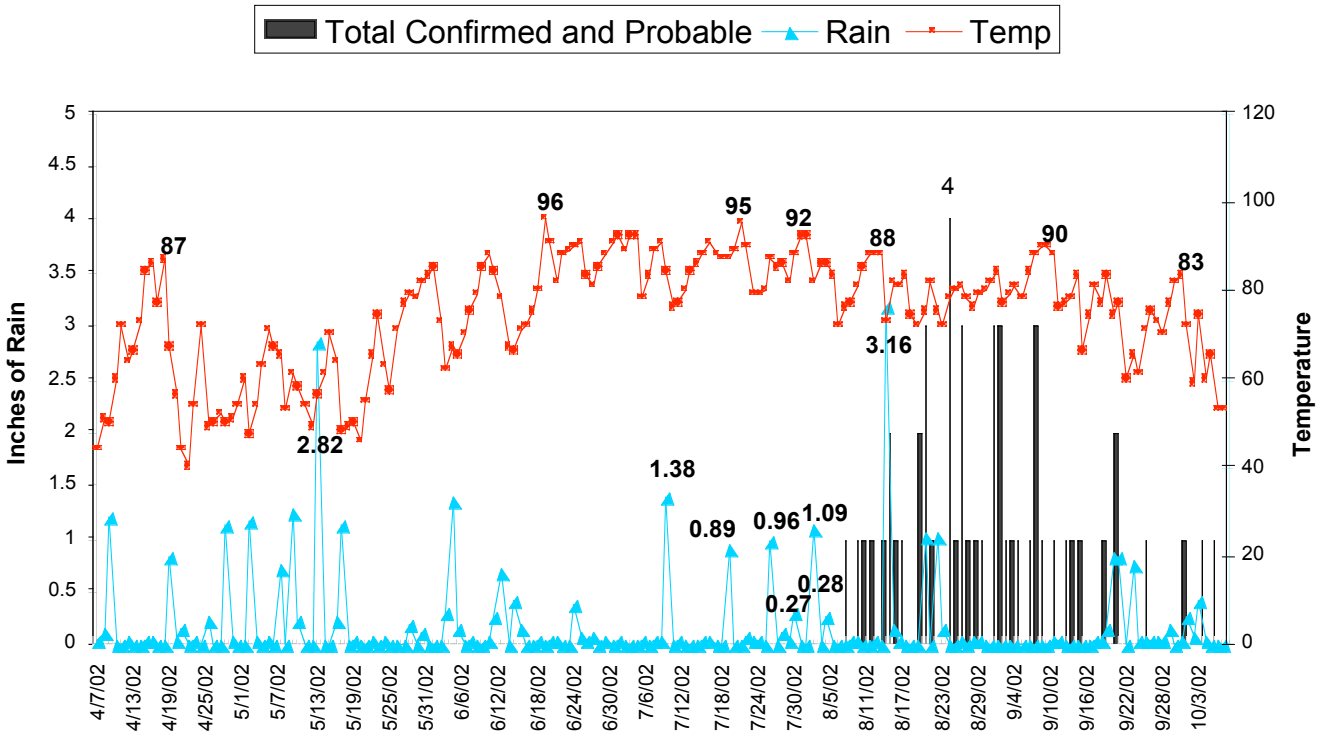
Source: Michigan Mosquito Manual, 2002

Temperature and Rainfall

Heat and the presence of motionless water create conditions that are favorable for *Culex* breeding and incubation. Whereas the *Culex* tends to be found in dryer conditions, excess rain could promote "floodwater mosquitoes" such as the *Aedes*, which could greatly increase the chances that people are bitten.

Chart 16 shows the daily City of Grand Rapids rainfall averaged for four water gauges, as well as daily temperature data for the City of Grand Rapids (unofficial National Weather Service Data from 2002) prior to the onset of West Nile Virus cases. Data dating back to early spring

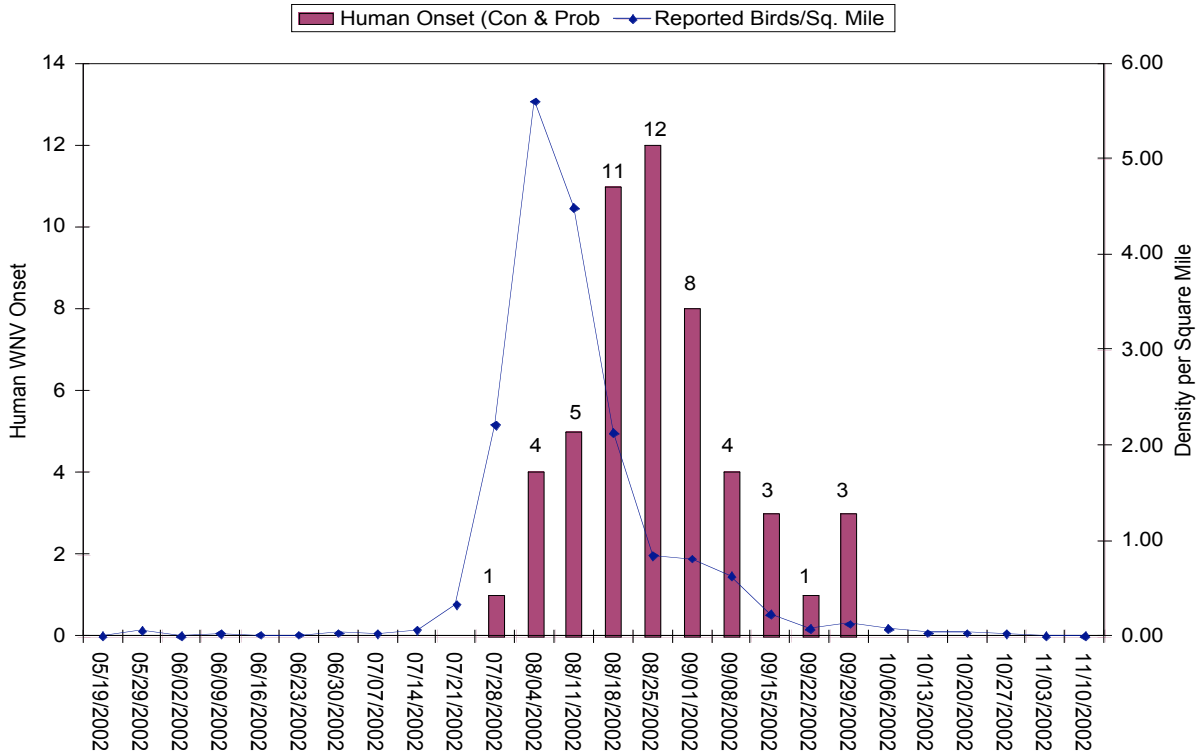
Chart 16 2002 Temperature, Rainfall, and Onset of Human WNV Cases in Kent County



indicate a downward trend in the rainfall from April through October (i.e., monthly rainfall averages are highest in the spring and decrease over the summer months). Temperature for the same time period remained relatively stable. Looking back three months prior to onset of the first WNV case, the average monthly precipitation (1971-2000) for Grand Rapids in May is 3.35 inches (in.), however in 2002 it was 7.81 in. June's average is 3.67 in., however in 2002 it was 3.79 in. July's average is 3.56 in., and in 2002 it was 3.75 in.

Although rainfall was above average for all three months, and was particularly high in May, the decrease in rainfall over the subsequent summer months may have favored *Culex* breeding. A recent Harvard University study suggests that drought conditions are associated with outbreaks of St. Louis encephalitis and West Nile Virus (Epstein and Defilippo, 2001). While frequent rains will serve to flush mosquito eggs and larvae from catch basins, lack of rain will leave standing water in the basins where mosquitoes continue to breed. As *Culex* mosquitoes are known to breed in catch basins, monitoring rainfall may prove to be an important part of WNV surveillance.

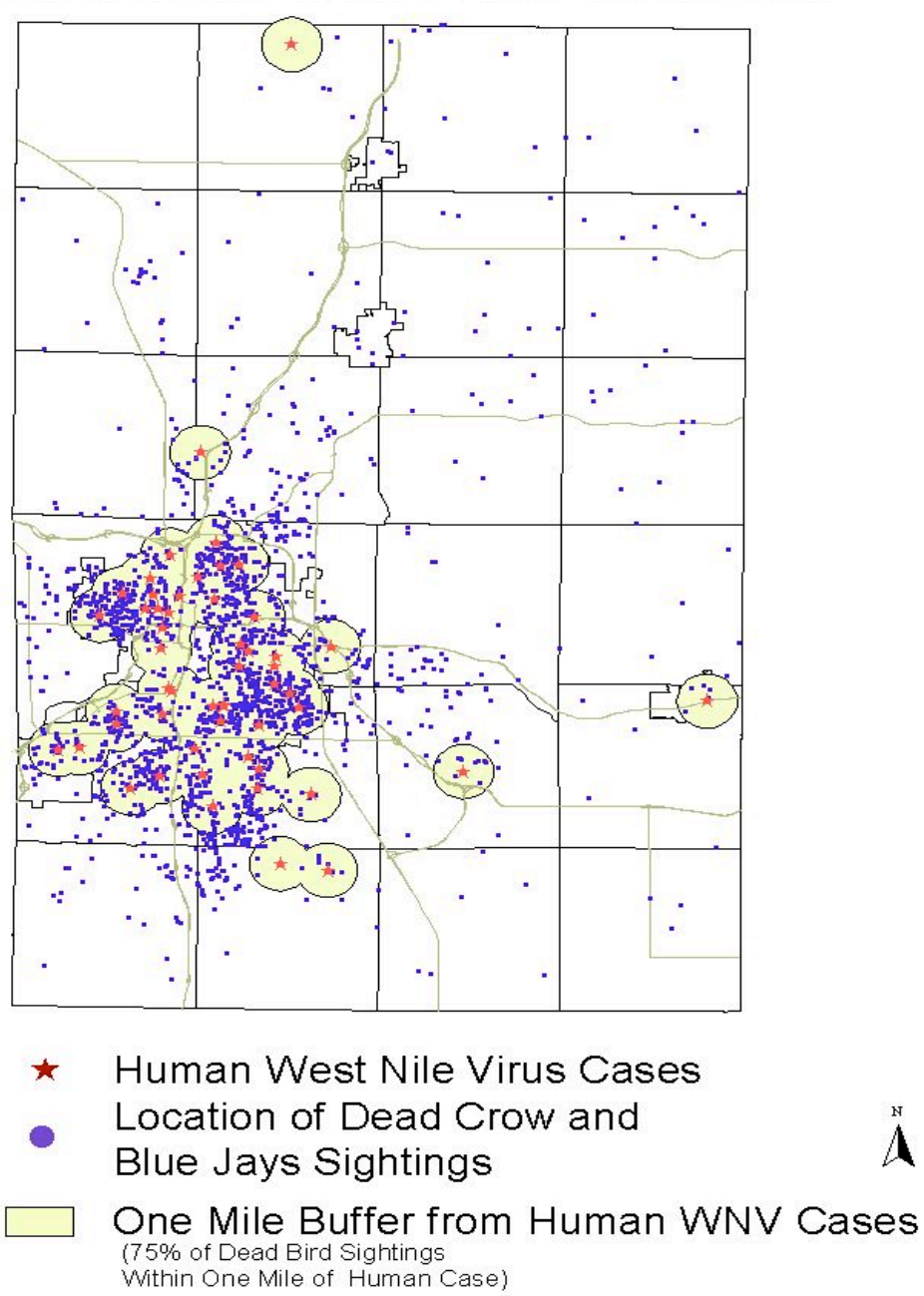
Chart 17 Prevalence of Dead Bird Reports in Relation to Human Case Onset



In addition to rainfall, temperature can also play a role in mosquito breeding. The average monthly temperature (1971-2000) in Grand Rapids for May is 58.1°, though in 2002 it was 62.3º; June is 67.1°, in 2002, 79.9º; and July is 71.4°, in 2002 it was 85.9º. Temperature was above average for all three months. These rainfall and temperature patterns are consistent with ideal breeding conditions for the *Culex*.

Data for dead crows shows that the number of dead birds reported to the Health Department increased sharply in the two weeks prior to the disease onset of the first human case of West Nile Virus. Interestingly, this data correlation is strikingly similar to a study conducted

Chart 18 Proximity of Human West Nile Virus Cases to Dead Bird Sightings



in New York. Eidson et.al (2001) found a "steep rise in the density of dead crows two weeks prior to the onset of the first human case." A similar phenomenon was observed in Kent County (Chart 17). This same study also examined dead crow density per square mile. Using REGIS to conduct a spatial analysis, a mile radius was drawn around each human case of West Nile Virus in Kent County. Intersections were ignored so that birds were not double counted. Through this analysis it was found that approximately 75% of all dead crows could be found within a mile radius of a WNV case (Chart 18). These analyses seem to indicate the dead birds may be a good indicator for predicting human cases. Observing the point at which cases peak may serve as an early warning sign of high risk periods for acquiring WNV.

Centers for Disease Control Recommendations

In the wake if the WNV outbreak of 1999 the Centers for Disease Control put forth the following recommendations.

1. Active **bird surveillance** to monitor WNV activity in wild and sentinal (caged) bird populations. In particular, crows are thought to be a sensitive way of detecting the existence of the WNV.
2. Active **mosquito surveillance** to detect and monitor WNV virus activity in mosquito populations and identify particular vectors. (Location and determination of breeding source, abundance, prevalence of arbovirus, and effectiveness of control measures).
3. Enhanced passive **veterinary surveillance**, by general alerts to veterinarians with emphasis on horses. This serves as a back-up system for looking at transmission outside of the bird-mosquito cycle.
4. Enhance passive **human surveillance** by general alerts to health care providers and surveillance at sentinal hospitals and laboratories.

Kent County Health Department's Response, 2002

Before Kent County's outbreak of WNV in 2002, the Kent County Health Department proactively ordered mosquito traps on July 25, 2002 and conducted mosquito surveillance at various sites throughout the County. The Health Department's first dead bird was reported on May 30. It was sent to the Michigan Department of Agriculture laboratory for testing. It was not until July 31st that a dead bird (that had been collected July 16) was found to be positive. Following the identification of a positive WNV bird, the Health Department immediately sent out a press release on July 31st. This press release stated that the Health Department would be conducting enhanced surveillance activities on dead birds and all dead birds should be reported to the Health Department**.** A computer database was developed and calls were logged as they came in. About this time, Culex mosquitoes trapped and identified by the Environmental Health Division, were analyzed by the Kent County Health Department lab, and were found to be positive for WNV**.** In addition to these activities the Health Department kept in touch with the Kent County Zoo and information was exchanged on sentinel and other dead birds.

In terms of human surveillance, information was disseminated via fax system ("blast fax") to area health care providers for the first time on August 7, 2002 warning providers of increased surveillance activities surrounding West Nile Virus. Information was also sent on

prioritization of lab specimens and specimen submission on August 23.In addition, veterinarians received information from the Health Department suggesting ways that animals' exposure to mosquitoes could be reduced.

Mosquito Control

A question that remains is whether mosquito surveillance activities should be conducted and what mosquito control measures, if any, should be instituted. There appears to be a debate among some experts as to whether mosquito surveillance is necessary as it is time and resource consuming. Other experts feel that a good WNV control program should include mosquito surveillance. These individuals believe that a survey of suspected breeding sources of culex pipiens and other culex mosquitoes is the first step in the line of defense against WNV.

Surveys

A survey can be carried out by an entomologist to identify species of mosquitoes, breeding sources, habitat locations, population densities, and species' flight ranges. Snow pools and woodland pools, emergent wetlands, and plant species associated with mosquito habitats are further identified. A Global Positioning System (GPS) is used to locate these sites. Michigan State University has a LanSat GIS office that develops maps to accompany these activities. Maps may depict sewage lagoons, catch basins, flooded fields and woodlands. The cost of both the survey and GIS mapping is estimated to be between $10,000 and $15,000.

After a survey is conducted, sites for conducting surveillance can be determined. Mosquitoes can be counted at these sites at biweekly or weekly intervals in order to evaluate the extent of mosquito infestation at a particular point in time. This information allows a control specialist to conduct a search for larval breeding locations. It can additionally be used to determine the best time and place for spraying, if that is considered as a control option.

Surveillance

Surveillance equipment can be simple and inexpensive (collecting tube, suction aspirator, vials, cages for collection) and be used during the day or night. One type of trap used on the Culex does not use light or CO2, it is called a gravid trap. These can be built or purchased through vendors. The trap uses a mosquito "attractant" that entices blood feeding females ready to lay eggs, these females are drawn into a collection chamber by an air current. Another type of trap that does use light and CO2 is available through the Centers for Disease Control.

Larvaciding

Michigan Department of Agriculture and the Michigan Mosquito Control Association recommend seeking legal counsel before beginning a mosquito control program so that all requirements for a mosquito control program are "in accordance with state and local laws." One of the first steps in a mosquito control program is larvaciding, the biological control of immature mosquitoes. This may take place after conducting mosquito surveillance or it may proceed following the identification of dead birds. Knowing that there are positive dead birds allows one to assume that there are Culex mosquitoes in the area. Larvaciding may involve "dipping" for

larvae. This is similar to a large ladle, and it is used to sample the number of larvae in an area. It has been recommended that treatment should begin in early-mid June and continue to September.

Treatment begins with a larvacide concentrated on breeding sources i.e. storm inlets, catchment basins, edges of retention ponds, sewage lagoons, and other sources of ponded water (in relation to population density). Local entomologists recommend bacillus sphaericus (Bs), trade name VectoLex, because of the safety of this insecticide (it has been approved for use by the Environmental Protection Agency). Another insecticide, bacillus thuringiensis (Bti) occurs naturally in the environment and is found in soil, insects, and plant surfaces. Bacillus thuringiensis (BTI) is sold under trade names such as VectoBac, Aquabac, and Teknar. Bti can be used elsewhere, but not in catch basins. Both Bs and Bti contain bascilluses, microbial insecticides that are insect specific. Ferndale, Michigan, implemented a larvacide control program last summer. The program involved larvacide control of 2,000 catch basins at a material cost of $800.

Other Methods

Other control measures involve mosquito growth regulators, such as methoprene, a chemical which is commercially marketed under the trade name Altosid. Methoprene targets mosquitoes specifically and is not toxic to other mammals. However, the monetary cost has prohibited commercial development. Sterilization of male mosquitoes is a technique that has been used in other countries, however costs are also prohibitive.

Adulticiding

Another approach to mosquito control involves “adulticiding”, or controlling adult mosquitoes. The U.S. Environmental Protection Agency and Michigan Department of Agriculture regulate insecticides, as well as persons that apply the insecticides. The E.P.A studies pesticides and conducts a variety of tests in order to examine effects on humans, wildlife, fish, and plants. Chemicals registered for use in adult mosquito control programs are: Malathion (Fyfanon and Atrapa), Permethrin(Biomist), Sumithrin(Anvil), Chorpyrifos, Resmethrin(Scourge), and Fenthion. Permethrin, Resmethrin, and Sumithrin are pyrethroids. Pyrethroids are synthetic chemical insecticides. Some entomologists recommend nighttime spraying of tree canopies in open spaces in urban areas (e.g. parks and cemeteries), especially at the onset of dead bird kills. These experts believe ultra-low volume sprayings of synthetic pyrethroids are effective and very safe. These experts believe this is safer than the EPA’s recommendation of applying DEET based repellants more than one time before going outdoors during mosquito infestation periods.

The Saginaw County Mosquito Abatement Commission begins their control program with aerial spraying for nuisance species such as the Aedes in the spring. They also do periodic larval and adult control spraying programs throughout the summer. Larvacide control begins by “dipping” for larvae at regular intervals. When larvae are present in at least 25 of the basins, larvaciding begins and 66,000 catch basins are treated.

Whereas biological controls for larvae are less controversial, there is more controversy about the wide scale application of synthetic pyrethroids, Chorpyrifos, and Fenthion. The Health Department will be forming a task force to explore the use of all mosquito control options, as well as their effects on humans and animals.

County/Municipal Measures

Other control measures include: impounding water and ditching, draining swamping mosquito breeding areas, removing road kill, enclosing garbage, and keeping vegetation mowed around edges of ponds and wetlands.

Personal Measures

Personal protection is very important since city and county measures will still not ensure that people will not be bitten. These include: wearing protective clothing, keeping home areas tightly screened, cutting down weeds adjacent to the home and in the yard, wearing DEET based insect repellants -- 10-35% DEET for adults and 10% or less DEET for children -- and staying indoors the during twilight hours. Citronella is a plant-derived insect repellant but a very large amount of it is required to achieve the same effect as DEET. Garlic is also known to have insect repellant properties. Additionally, many good suggestions for personal protection, elimination of standing water (larval control) and adult mosquito control are made in the *The Michigan Mosquito Manual* (Pages 45-49) available from the Michigan Department of Agriculture (www.michigan.gov/mda) and the Michigan Mosquito Control Association (www.mimosq.org). A few suggestions for larval control include: eliminating items from the yard that store water, changing the water in birdbaths weekly, empty and clean children's wading pools at least weekly and store boats upside down. A few suggestions for adult control include: keeping grass cut short, trim trees and shrubs to allow light and air underneath and or between plants and structures, keep firewood 10-12 inches above the ground or at least 12 inches away from any structure. Most electronic devices (bug zappers and ultraviolet light) have been found to be ineffective.

The Future

This year's (2003) rainfall and temperature will likely have an impact on this year's incidence of WNV. It is also questionable as to whether last year's epidemic will have an impact on the immune system of birds that were infected last year but did not die. In other countries such as Egypt where WNV has been found, crows and sparrows show high antibody prevalence. In the Middle East, western Asia, and Europe, WNV has not been documented to cause epizootics in birds. Crows and other birds with antibodies to WNV are common, suggesting that these birds may show no symptoms or mild infection usually occurs among birds in those regions. Dr. Pollack from Harvard has stated, "…at a certain point the survivors are essentially immune, and they will moderate the infection in the future. Once the immune birds in an area get old and die, and are replaced by other birds that are not immune, another outbreak becomes more likely." Information from the Autobahn Society suggests there may have been a large bird die off between 2001 and 2002. With the combination of over wintering mosquitoes and new bird hatchlings (called naïve hosts because they have never had the infection before and are susceptible) we may see a West Nile Cycle in the early part of the season. The birds will serve to infect more mosquitoes, which may spread the virus to people again and cause a second disease onset later in the season.

It is hoped that new vaccines will emerge in the near future. At this writing, there are no known commercially available human vaccines for WNV. However there is a vaccine for

Japanese Encephalitis, and a WNV vaccine is currently in development. West Nile Virus can be prevented in two major ways: personal protective measures and public health measures to reduce the population of infected mosquitoes. WNV offers the rare opportunity in public health to detect the risk of a disease before it occurs and to intervene to reduce the risk.