West Nile Encephalitis or Neuro-Invasive Disease (WNV-NID)

WNV is a Class B Disease. It must be reported to the state within one business day.

West Nile virus (WNV) is a flavivirus belonging taxonomically to the Japanese encephalitis subgroup that includes the serologically closely related Saint Louis Encephalitis (SLE) virus, Japanese Encephalitis virus, Murray Valley encephalitis virus and others. These viruses commonly infect birds in nature. Yellow Fever and Dengue viruses are also in the flavivirus group.

WNV infection is naturally spread from bird-to-bird by mosquito bites. Most reported WNV in the wild has occurred in crows, but 150 species of birds have been found positive for WNV. The species more apt to be found positive among dead birds are crows, blue jays, grackles, house sparrows, cardinals, birds of prey and seagulls.

Like the SLE virus, WNV is transmitted principally by Culex species mosquitoes, but may be transmitted by Aedes, Anopheles and other species. Most of these are not very competent vectors.

In Louisiana *Culex quinquefasciatus*, also named the Southern House Mosquito, is the main vector of WNV. The females lay a single raft of 140 to 340 eggs on heavily polluted, small water collections after each blood meal. The eggs hatch in one to two days and become adults in eight to12 days. Preferred breeding places are all types of large man-made containers, collections of ground water, storm sewer catch basins, ground pools, ditches, run-off from sewage plants, small artificial containers, cesspits, drains, septic tanks, unused wells and storm water canals. The flying range of the adult female Culex is limited, up to 3,600 feet (1,200 m) at night. They prefer feeding on birds and poultry; however, they also readily bite humans, and usually bite humans towards the middle of the night, indoors and outdoors.

The role of other potential vectors such as *Aedes albopictus*, also named the Asian Tiger Mosquito, and other Culex, is still to be determined. A lesser vector is *Culex salinarius* which lives mostly in Louisiana coastal areas and breeds in fresh and brackish water in marshes, ponds, pools, ditches, barrels, bilge water from boats, and sometimes artificial containers around homes. They bite mostly outdoors, occasionally indoors and preferably at dusk, during the first hours of darkness.

Occasionally humans or other mammals are bitten by an infective mosquito and they get infected. Dogs, cats, cattle, horses and other domestic mammals get infected, but their role in transmission is minimal because of low viremia. Most of these animals do not present obvious illness, except for horses which also suffer from WN encephalitis.

WNV was introduced in the U.S., in New York in 1999. The first cases were diagnosed in Louisiana in 2001 among one human in Jefferson Parish, along with several birds (crows and blue jays), and a few horses. The year 2002 was marked by an epidemic of 204 cases of neuro-invasive disease (WN-NID). The total number of persons infected was estimated at 30,000 to 40,000. The disease was very unevenly distributed in foci appearing in successive waves.

The incubation period for West Nile virus invasive disease is three to 14 days.

<u>Infectivity period</u>: In birds the virus is present in blood for several days to a week. Humans will have viremia for a few days before onset of disease. Humans are not infectious for mosquitoes

because of low viremia, but may be infectious by transfusion, organ transplant, transmission in utero and breast milk.

The majority of those infected are completely asymptomatic (80% to 90%).

A small proportion have West Nile Fever (10% to 20%) presenting with febrile, influenza-like illness with abrupt onset of moderate to high fever, headache, sore throat, backache, myalgia, arthralgia, fatigue and a mild and transient rash, and lymphadenopathy.

A minority of infected people have acute aseptic meningitis or encephalitis (0.2% younger than 65 years of age, 2% older than age 65). While some cases can easily be differentiated between encephalitis or meningitis, some are more difficult to classify. These cases should be classified as WNV Neuro-Invasive Disease (WNV-NID) and not as meningo-encephalitis which is a term reserved for those who have both meningeal and CNS cortical involvement. Encephalitis is diagnosed by the central nervous system (CNS) involvement, including altered mental status (altered level of consciousness, confusion, agitation, or lethargy), or other cortical signs (cranial nerve palsies, paresis or paralysis, parkinsonian signs, tremors, ataxia or convulsions).

Some individuals have severe muscle weakness or complete flaccid paralysis, which is mostly due to axonal degeneration (poliomyelitis) rather than demyelinating syndromes like Guillain-Barre syndrome.

Long term sequelae are very common. One year after illness, patients reported the following symptoms: fatigue (67%), memory loss (50%), difficulty walking (49%), muscle weakness (44%), and depression (38%).

The case fatality rate is elevated among the elderly, particularly among those 75 years of age and older.

Human Surveillance

This report focuses on human surveillance. The main goal of human surveillance is to describe the disease burden in different population groups, annual trends and use the data to disseminate information to the medical community, and provide the public at large and the vector control programs information useful to guide prevention measures.

Limitations of human surveillance: Human data have very limited usefulness for mosquito control purposes. Only 2% of all WN infections are reported (because most WN infections are asymptomatic, or WN fever cases do not get medical care; they never get diagnosed nor are reported). The reporting of those cases is delayed.

From the time a mosquito bites a bird infected with WN viruses, it takes one to two weeks, depending on temperatures and other environmental conditions, for the virus to multiply in the mosquito vector (extrinsic incubation period); then it takes three to 14 days for the virus to multiply in the human host (intrinsic incubation period); it then takes several days from onset of disease to seeking medical care; then a few more days for a physician to order a confirmatory lab test and get the result back (one week from onset, if all goes well); then anywhere from a few days to a week or two to get the report to the Louisiana Department of Health (LDH), Office of Public Health (OPH). All in all, from the initial mosquito infection to the reporting of the infection it may take from three to six weeks.

In summary, human data are too little, too late to be of major use for mosquito control. To provide a mosquito control program with data on location of human cases that may be of limited use for correlating infection rates in mosquitoes and human cases, and of use to address public and media concern, general geographical location of cases and weeks of onset are provided to those mosquito control programs who request the information. This information must remain strictly confidential.

The LDH OPH Laboratory is a reference laboratory used for epidemiologic purposes. Its role in diagnosis of cases is limited since the great majority of physicians and hospitals use private laboratories for their diagnosis.

Diagnostic testing for WN fever was restricted in the early years of the WN invasion throughout the United States. As time went by, diagnostics became widely available and physicians became accustomed to look for WN as a cause for meningitis or encephalitis during the transmission season. Therefore the number of WN fever cases is expected to increase as years go by.

When PCR screening for blood banks was implemented, cases at the early stage of viremia became diagnosed and were reported. These cases are initially classified as asymptomatic infections. As they are followed-up, they become re-classified as WN-Fever or WN-NID as the case may be.

The cases of WN-NID are the main indicator used to evaluate WN disease burden. Most cases of WN-NID are severe enough to cause hospitalization and diagnosis by some laboratory testing. Hence the reporting is assumed to be fairly complete. However, a small fraction of the cases may be missed in persons who already have pre-existing neurologic conditions. Among these people, an aggravation of neurologic symptoms may be attributed to their prior condition and not be recognized as a new WN infection.

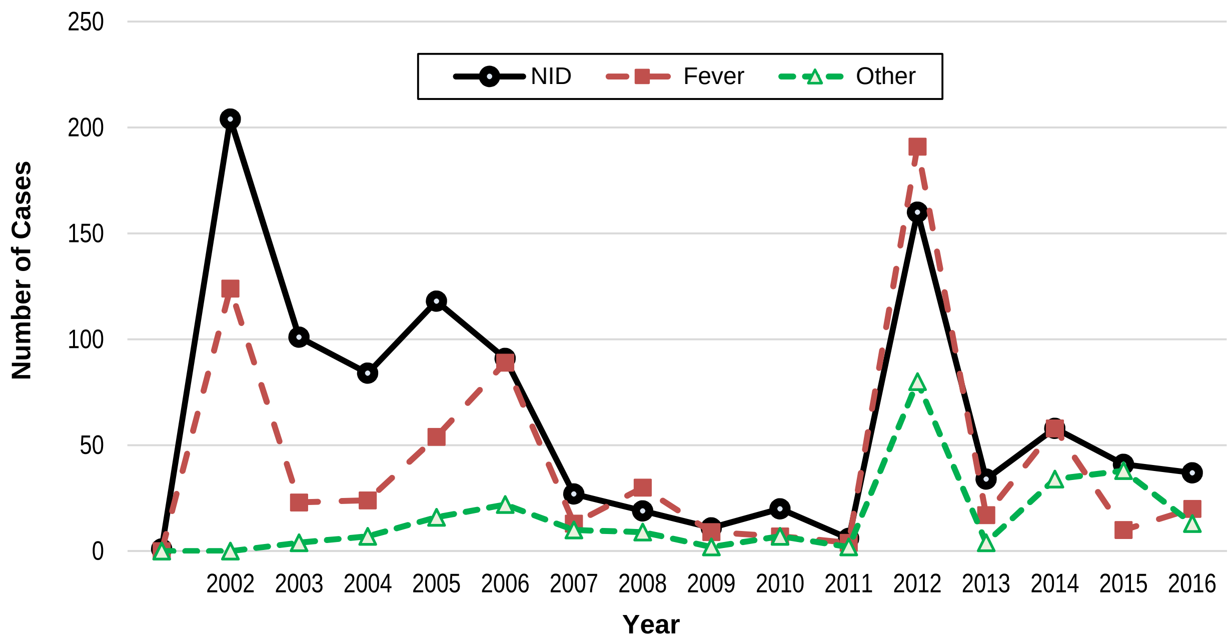
Trends

This section presents a summary of the entire surveillance period, from 2001 to present data. In the following sections, yearly data of importance are described (Table 1, Figure 1).

Table 1: Number of West Nile Cases – Louisiana, 2001 to 2016

Year	NID	Fever	Asymptomatic	Blood	Death	Ratio: (Fv+As)/NID	Case Fatality Rate
2001	1	x	x	x	x	x	x
2002	204	124	x	x	24	0.61	11.8%
2003	101	23	4	x	7	0.27	6.9%
2004	84	24	7	x	7	0.37	8.3%
2005	118	54	16	x	11	0.59	9.3%
2006	91	89	22	x	9	1.22	9.9%
2007	27	13	10	x	2	0.85	7.4%
2008	19	30	9	x	1	2.05	5.3%
2009	11	9	2	x	0	1.00	0.0%
2010	20	7	7	x	0	0.70	0.0%
2011	6	4	2	x	0	1.00	0.0%
2012	160	191	46	34	21	1.69	13.1%
2013	34	17	4	0	4	0.62	11.8%
2014	61	59	20	15	6	1.30	10.3%
2015	41	10	18	20	5	0.68	12.2%
2016	37	20	7	6	2	0.72	5.4%
Total	**1015**	**673**	**173**	**75**	**99**	**0.83**	**9.8%**

Figure 1: Number of West Nile Cases - Louisiana, 2001 to 2016



Which Factors Influence the Number of Cases?

The steady decline of WN in Louisiana from 2007 to 2011 cannot be attributed to herd immunity acquired by those who had WN infection. The majority of WN infections is asymptomatic (80%); about 19% are fever cases and only 1% are NID. From 2002 to 2016 there were 1012 cases of NID; assuming that this represents 80% of all WN-NID, the total number of WN-NID in Louisiana has been 1,000 NID cases. If this represents only 1% of all WN infections, then there were approximately 100,000 persons infected. Out of a population of 4.5 million Louisiana residents, this represents only 2% of total population, definitely a proportion much too small to confer herd immunity to a population.

The variations from year-to-year seem to be influenced more by meteorological conditions, particularly rainfall and temperature. It appears that cool springs are linked to low intensity WN transmission years.

The Four Phases of Transmission of WN in Louisiana

Maintenance Phase (January-March) is when arboviruses survive the winter. Culex mosquitoes spend the winter hibernating in protected structures such as root cellars, bank barns, caves, abandoned tunnels and other subterranean locations. Overwintering adult mosquitoes do test positive for WNV. It is difficult to document virus transmission or isolate virus during the Maintenance Phase.

Amplification Phase (April-June) corresponds with a major portion of the avian nesting season. During this period, mosquitoes and non-immune nestling birds come into contact and initiate the first rounds of avian and mosquito infections. This is called "arboviral amplification.”

The Early Epidemic Phase (July-September) is the hot, wet, humid period that includes the worst of the Atlantic hurricane season. During this phase, arboviral transmission increases dramatically, human cases appear and arboviral transmission to humans rapidly increases with epidemics usually peaking in late September.

Finally, during the Late Epidemic Phase (October-December) the number of new human cases gradually declines as epidemics burn themselves out.

Of the four phases, the Amplification Phase is the most important in determining the relative risk of human infection and the intensity of an arboviral epidemic later in the year.

Full-blown arboviral epidemics require large numbers of infected mosquitoes. WN outbreaks have typically reported mosquito infection rates ranging from 1:1,000 to 1:200. To realize mosquito infection rates of this magnitude, extremely efficient viral amplification must occur between local avian populations and vector mosquitoes. The Amplification Phase corresponds with the avian nesting season. This is particularly important because nestling birds provide a relatively easy source of blood for infected mosquitoes and also provide a large population of non-immune birds that can efficiently amplify virus.

Epidemic arboviral amplification requires more than just an unusually productive avian nesting season. Large numbers of adult birds also need to be non-immune. Once a bird is infected with an arbovirus and survives, that bird is immune to re-infection for life. If, for example, 75% of the birds in a population have been infected with an arbovirus and are immune, then three out of four mosquito blood meals are wasted relative to arboviral amplification.

Infective mosquitoes feeding on immune birds do not re-infect that bird. Likewise, uninfected mosquitoes feeding on previously infected immune birds do not become infected. In order to have efficient amplification, a large population of non-immune birds must encounter infective vectors. When this happens in the presence of increasing vector populations, explosive amplification will occur.

The most important factors contributing to explosive arboviral amplification are:

1) an extensive source of non-immune wild birds and
2) a steady supply of infective vector mosquitoes.

There are three major sources of birds:

1- Exotics birds that are imported into the state and include pets, zoo animals, breeding animals in colonies, and birds used as agricultural commodities.

2- Wild migrants that pass through or take up temporary residence during autumn and spring migrations to and from wintering grounds in the Caribbean and Central and South America.

3- Resident birds that remain in the state throughout the year.

Exotic birds probably play only a minor role in arboviral amplification, mainly because they are so focal (flamingos and parrots in zoos, emus and ostriches in farms), and patchy in their distribution.

Huge numbers of migrant birds pass through, or overwinter. Obligate insectivores, such as swifts and swallows, pass through during southward migrations starting in August. Other migrant species follow, with the peak autumn migration occurring between September and October. This places large numbers of migrant birds in the south during the Early and Late Transmission phases of the arboviral transmission cycle. The non-immune portions of these migrant populations thus have the potential of adding to epidemic amplification. During spring migration, birds move through heading north between February and May with peak activity in March and April. This places spring migrants in Louisiana when mosquitoes are relatively rare. It is unlikely that the spring migrants contribute significantly to arboviral amplification that will result in epidemic transmission later in July - September.

Resident avian populations are therefore the most likely source for the arboviral amplification. Resident populations can be divided into those that are rare, focal, or widespread.

Rare birds may become infected and, in turn, infect vector mosquitoes. However, because these birds are rare and very patchy in their distribution, it is unlikely that they are responsible for infecting large numbers of vector mosquitoes.

Focal bird population: Some avian populations are extremely focal in their distribution. For example, common grackles are focally distributed geographically and temporally. Common grackle populations are also very cyclic. During some years, these birds are extremely abundant and produce huge numbers of offspring. The populations usually build slowly, peak over a two- to three-year period and then crash. During peak population years common grackles can be found nearly everywhere, but they are especially abundant around dumpsters associated with fast-food restaurants and grocery stores.

Finally, some avian populations are widely distributed both geographically and temporally. Species like mourning doves, blue jays, northern mockingbirds, and northern cardinals are found in large numbers in virtually every habitat, especially suburban residential neighborhoods. Because these four avian species are so widely distributed, they can efficiently amplify arboviruses over a large geographic area.

In summary, it appears that ecological changes caused by temperature, rainfall and other meteorological conditions influence mosquito and bird populations, and are the major factors in the trends of WN.

West Nile Seasonality (Tables 2 and 3, Figures 2A, 2B and 2C)

Table 2: Percentage of NID Cases by Month - Louisiana, 2002-2016

Phase	Month	NID Proportion	Total
Maintenance	Jan	0.0%	0
Maintenance	Feb	0.0%	0
Maintenance	Mar	0.0%	0
Amplification	Apr	0.0%	0
Amplification	May	0.0%	0
Amplification	Jun	0.8%	8
Epidemic	Jul	16.0%	162
Epidemic	Aug	46.6%	471
Epidemic	Sep	24.1%	244
Late Epidemic	Oct	9.2%	93
Late Epidemic	Nov	2.9%	29
Late Epidemic	Dec	0.4%	4
	ALL Year	100.0%	1011

Table 3: WN-NID Seasonality - Louisiana, 2002-2016

WNV-NID Cases by CDC Week by Year

	Week	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
January	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25	2	2	0	0	0	0	0	1	0	0	1	0	0	0	0
July	26	11	0	0	0	1	0	0	1	0	0	1	0	0	1	0
	27	6	3	3	4	1	0	0	2	3	0	3	0	0	1	0
	28	9	5	2	5	4	0	0	0	0	1	15	1	3	2	2
	29	23	5	2	13	5	0	0	1	1	1	11	0	7	1	2
August	30	23	8	8	8	6	0	2	1	2	0	13	1	9	2	0
	31	21	10	5	21	7	1	1	0	0	0	17	3	3	5	2
	32	24	7	15	11	14	3	2	1	1	1	18	3	4	4	6
	33	21	8	7	9	13	2	1	2	1	0	16	7	8	4	0
	34	14	6	3	8	7	2	3	1	2	0	14	6	6	5	2
September	35	8	6	5	6	6	5	3	0	3	1	12	2	3	5	1
	36	13	4	5	8	9	3	2	0	1	1	4	2	8	1	1
	37	8	9	3	9	6	3	0	1	2	1	7	3	2	4	1
	38	6	4	4	2	3	1	0	0	1	0	4	0	4	0	1
	39	3	2	5	4	4	1	0	0	0	0	4	1	1	1	1
October	40	3	4	5	4	1	3	3	0	1	0	7	3	0	0	4
	41	3	2	4	3	1	0	0	0	0	0	2	1	0	0	4
	42	3	1	2	3	1	0	0	0	0	0	1	1	0	3	0
	43	0	2	0	0	0	3	0	0	0	0	3	0	0	1	2
	44	0	4	0	0	1	0	0	0	0	0	3	0	0	0	1
November	45	0	2	2	0	0	0	1	0	0	0	0	0	0	0	1
	46	0	1	1	0	0	0	0	0	0	0	1	0	0	0	1
	47	1	1	2	0	1	0	1	0	0	0	1	0	0	1	3
	48	0	2	1	0	0	0	0	0	2	0	1	0	0	0	2
December	49	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 2A: Seasonal Distribution of WN-NID - Louisiana, 2002-2006

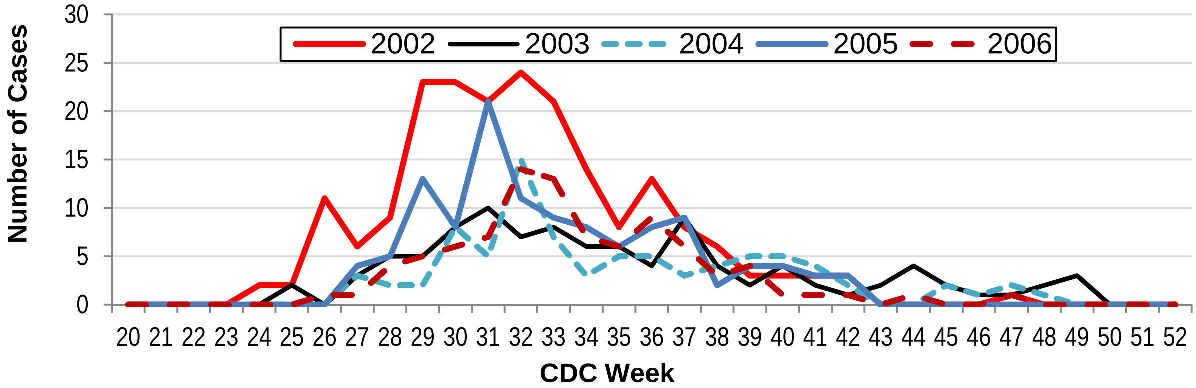


Figure 2B: Seasonal Distribution of WN-NID - Louisiana, 2007-2011

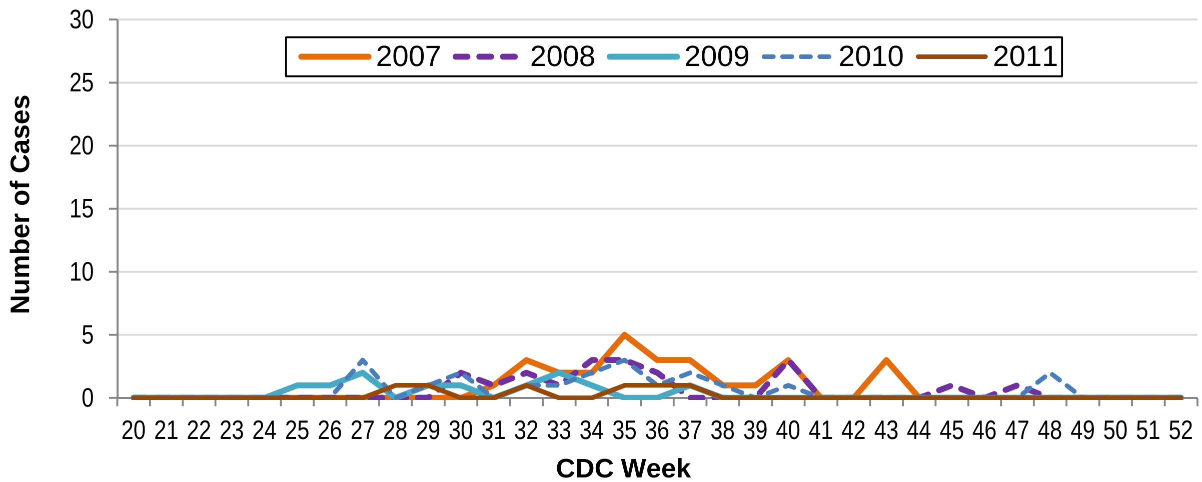
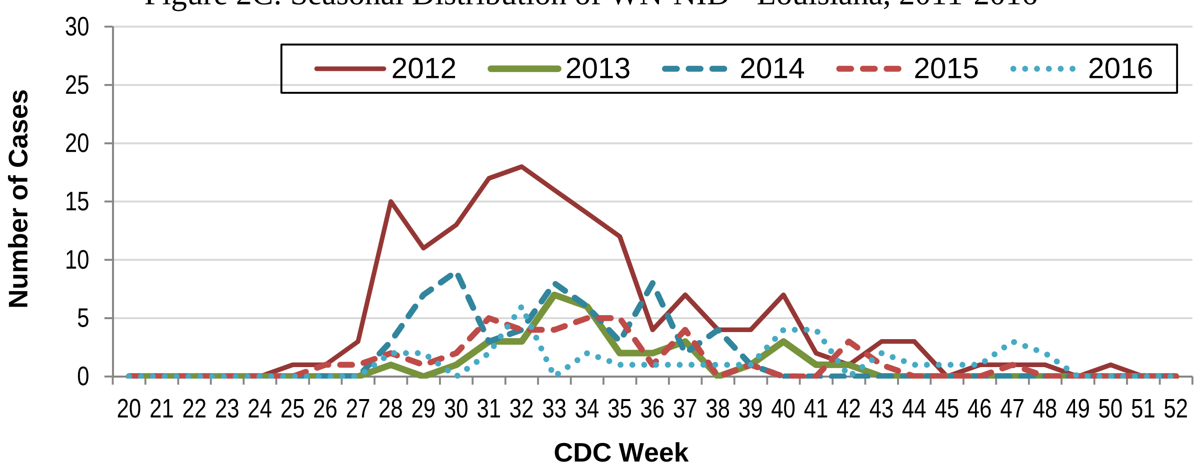


Figure 2C: Seasonal Distribution of WN-NID - Louisiana, 2011-2016



Sex, Race and Age Distribution

Sex: In 2002 the male to female ratio was 1:1 but it increased to 1.5 for the period 2003-2014. The main difference between male and female occurs at the higher age groups. For those 65 and older the male:female ratio was 1.2 in 2002 and 1.7 from 2003-2014.

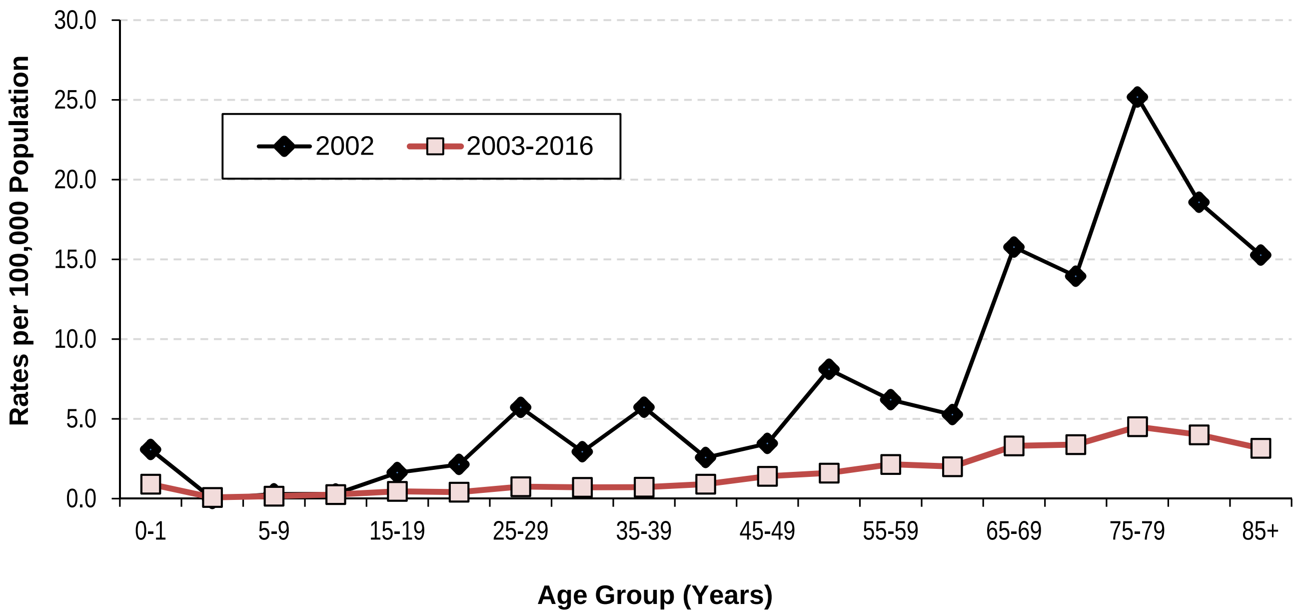
Race: The proportion of African-Americans is around 30% of WNV-NID cases, a proportion not significantly different from the proportion of the African-American population in Louisiana (Table 4).

Table 4: Race Distribution/Ethnic Proportion of WNV-NID Cases - Louisiana, 2002 and 2003-2016

	Number		Proportion	
Ethnic Group/ Race	**2002**	**2003-2016**	**2002**	**2003-2016**
European	111	407	66.9%	70.8%
African-American	55	163	33.1%	28.3%
Asian-Pacific	0	1	0.0%	0.2%
Am Indian	0	1	0.0%	0.2%
Other	0	3		
	166	**575**		
Unknown	37	155		
	203	**730**		

Age group: In 2002, the incidence of new cases of NID remained between 0.1 to 5 per 100,000 population from infancy to age 50, then increased sharply to 15 and up to 25 per 100,000 population. The older age group (75 and over being the highest). For the period 2003 to 2016, the pattern is similar but with rates topping around 5 per 100,000 population (Figure 3).

Figure 3: Age Group Distribution of WNV-NID - Louisiana, 2002 & 2003-2016



Death

Overall the case fatality rate was 8% to 9% in 2002 to 2014. The case fatality rate was strongly associated with age ranging from 2% in the younger ages to 10% in age groups for those in their 60s and 70s and then to 25% in the elderly older than 85 years of age (Table 5).

Table 5: Case Fatality Rate by Age Group for WNV-NID - Louisiana, 2002 and 2003-2016

Age Group (Years)	2002			2003-2016		
	Cases	Deaths	CFR	Cases	Deaths	CFR
0-29	34	1	2.9%	101	2	2.2%
30-39	23	0	0.0%	62	1	1.9%
40-49	20	0	0.0%	102	2	2.1%
50-59	35	1	2.9%	142	13	9.2%
60-69	23	0	0.0%	118	11	10.4%
70-79	46	10	21.7%	132	15	11.4%
80-84	13	4	30.8%	42	8	19.0%
85+	9	2	22.2%	30	7	25.9%
Total	**203**	**18**	**8.9%**	**729**	**52**	**8.2%**

Geographical Distribution (Tables 6A and 6B)

Table 6A: Distribution of WN by Parish - Louisiana, 2002-2014

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total	% Yr with WN
Jefferson	24	3	1	6	8	2	2	0	0	0	13	0	0	1	0	60	60.0%
Orleans	10	2	1	6	12	2	2	0	0	0	11	0	0	1	0	47	60.0%
Plaquemines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
St Bernard	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	13.3%
Ascension	6	2	1	3	10	0	0	0	2	0	3	0	4	2	0	31	60.0%
East Baton Rouge	37	1	22	17	6	0	0	2	9	0	17	0	21	3	4	139	73.3%
East Feliciana	2	1	1	0	0	0	0	0	0	0	2	0	0	0	2	8	33.3%
Iberville	2	0	0	2	0	0	0	0	0	0	0	0	1	1	0	6	26.7%
Pointe Coupee	6	0	0	2	0	0	0	0	0	0	0	0	2	1	0	11	26.7%
West Baton Rouge	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	4	20.0%
West Feliciana	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	3	13.3%
Assumption	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	3	20.0%
Lafourche	0	2	0	1	1	0	0	0	0	0	1	0	4	1	0	10	40.0%
St Charles	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	13.3%
St James	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6.7%
St John	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	13.3%
St Mary	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6.7%
Terrebonne	0	3	0	0	0	0	0	0	0	0	1	0	1	0	0	5	20.0%
Acadia	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	16.7%
Evangeline	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	3	26.7%

Iberia	2	1	0	4	0	0	0	0	3	0	1	0	0	0	0	11	33.3%
Lafayette	4	0	1	1	1	1	0	0	0	0	2	9	0	0	1	20	53.3%
St Landry	1	0	3	0	0	0	0	0	0	0	0	0	0	2	0	6	20.0%
St Martin	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	13.3%
Vermillion	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	3	13.3%
Allen	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	3	20.0%
Beauregard	0	0	1	1	0	1	0	0	1	0	1	0	0	0	1	5	40.0%
Calcasieu	8	1	3	2	5	0	1	0	0	2	8	1	0	0	5	36	66.7%
Cameron	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6.7%
Jeff Davis	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	4	13.3%
Avoyelles	2	0	0	0	1	1	1	0	0	0	1	0	0	1	0	7	40.0%
Catahoula	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	13.3%
Concordia	1	0	0	0	1	1	0	0	0	0	2	0	0	0	0	5	26.7%
Grant	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	4	16.7%
Rapides	14	2	8	7	7	2	0	1	0	0	11	4	0	8	2	66	73.3%
Lasalle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Vernon	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2	13.3%
Winn	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3	20.0%
Bienville	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	6.7%
Bossier	3	8	9	6	2	0	0	0	0	0	6	0	2	1	1	38	60.0%
Caddo	5	38	8	16	3	7	3	1	0	0	19	0	16	5	10	131	80.0%
Claiborne	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6.7%
DeSoto	0	1	0	0	0	0	0	0	0	0	3	0	0	0	1	5	20.0%
Natchitoches	1	1	0	2	0	0	0	0	0	0	2	0	1	0	0	7	33.3%
Red River	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	6.7%
Sabine	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	13.3%
Webster	0	0	1	0	1	0	0	0	0	0	4	0	0	1	0	7	26.7%
Caldwell	0	0	1	0	0	0	0	0	0	0	1	3	0	0	0	5	20.0%
East Carroll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Franklin	0	0	1	1	0	0	0	0	0	0	1	0	1	0	1	5	33.3%
Jackson	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6.7%
Lincoln	0	2	0	1	0	0	1	0	0	0	1	0	0	0	0	5	26.7%
Madison	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2	13.3%
Morehouse	0	2	2	1	0	1	0	0	0	0	1	0	0	0	0	7	33.3%
Ouachita	6	2	5	15	3	1	1	0	0	0	3	14	2	6	3	61	80.0%
Richland	2	1	1	0	0	0	0	0	0	0	1	0	0	0	0	5	26.7%
Tensas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Union	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	4	26.7%
West Carroll	0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	5	20.0%
Livingston	12	5	6	11	1	1	1	0	1	0	6	1	2	0	2	49	80.0%
St Helena	0	2	0	2	0	0	0	0	0	1	2	0	0	0	0	7	26.7%
St Tammany	27	4	0	3	14	0	3	4	1	1	10	1	2	2	0	72	80.0%
Tangipahoa	12	6	1	2	6	1	3	1	0	1	12	0	0	1	0	46	73.3%
Washington	6	2	0	3	4	2	0	1	0	1	1	0	1	0	0	21	60.0%
Total	204	101	84	118	91	27	19	11	20	6	160	34	61	41	37	1010	100.0%

There is no simple explanation in the differences between these parishes. One would have to understand the micro-ecological conditions (human habitat, drainage, sewage, surface waters, forest, type of trees, other type of vegetation, bird species, seasonal meteorological conditions etc.).

Table 6B: Distribution of WN by Parish - Louisiana, 2002-2016

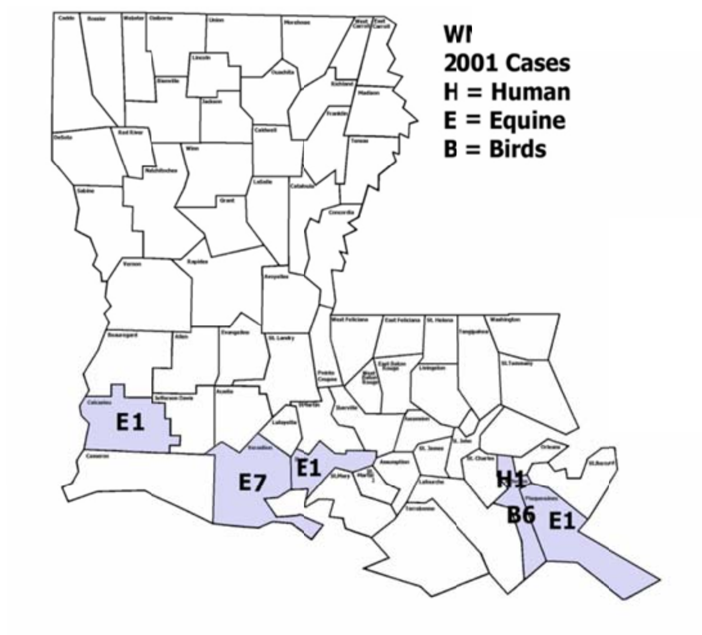
Region	Parish	Cases 2002-16	Average Number of Cases /Yr	% Years with WN	Average Rate /100,000 /Year	Region	Parish	Number of Cases	Average Number of Cases /Year	% Years with WN	Average Rate /100,000 /Year
1	**Jefferson**	**60**	4.0	**60.0%**	0.9	**6**	**Avoyelles**	6	0.4	**40.0%**	0.9
1	**Orleans**	**47**	3.1	**60.0%**	0.9	**6**	**Catahoula**	2	0.1	**13.3%**	1.2
1	**Plaquemines**	0	0.0	**0.0%**	0	**6**	**Concordia**	5	0.3	**26.7%**	1.5
1	**St Bernard**	2	0.1	**13.3%**	0.3	**6**	**Grant**	4	0.3	**16.7%**	1.2
2	**Ascension**	**31**	2.1	**60.0%**	1.9	**6**	**Rapides**	56	3.7	**73.3%**	2.7
2	**E.Baton Rouge**	**139**	9.3	**73.3%**	2.0	**6**	**Lasalle**	0	0.0	**0.0%**	0
2	**East Feliciana**	**8**	0.5	**33.3%**	2.4	**6**	**Vernon**	2	0.1	**13.3%**	0.2
2	**Iberville**	**6**	0.4	**26.7%**	1.2	**6**	**Winn**	3	0.2	**20.0%**	1.3
2	**Pointe Coupee**	**11**	0.7	**26.7%**	3	**7**	**Bienville**	1	0.1	**6.7%**	0.4
2	**W.Baton Rouge**	**4**	0.3	**20.0%**	1.2	**7**	**Bossier**	36	2.4	**60.0%**	2.0
2	**West Feliciana**	**3**	0.2	**13.3%**	1.2	**7**	**Caddo**	116	7.7	**80.0%**	2.9
3	**Assumption**	**3**	0.2	**20.0%**	0.8	**7**	**Claiborne**	1	0.1	**6.7%**	0.4
3	**Lafourche**	**10**	0.7	**40.0%**	0.7	**7**	**DeSoto**	4	0.3	**20.0%**	1.0
3	**St Charles**	**2**	0.1	**13.3%**	0.2	**7**	**Natchitoches**	6	0.4	**33.3%**	1.0
3	**St James**	**2**	0.2	**6.7%**	0.9	**7**	**Red River**	1	0.1	**6.7%**	0.7
3	**St John**	**3**	0.1	**13.3%**	0.2	**7**	**Sabine**	2	0.1	**13.3%**	0.5
3	**St Mary**	**1**	0.1	**6.7%**	0.2	**7**	**Webster**	6	0.4	**26.7%**	0.9
3	**Terrebonne**	**5**	0.3	**20.0%**	0.3	**8**	**Caldwell**	5	0.3	**20.0%**	3.2
4	**Acadia**	**2**	0.1	**16.7%**	0.2	**8**	**E.Carroll**	0	0.0	**0.0%**	0
4	**Evangeline**	**3**	0.2	**26.7%**	0.6	**8**	**Franklin**	4	0.3	**33.3%**	1.2
4	**Iberia**	**11**	0.7	**33.3%**	0.9	**8**	**Jackson**	1	0.1	**6.7%**	0.4
4	**Lafayette**	**20**	1.3	**53.3%**	0.6	**8**	**Lincoln**	5	0.3	**26.7%**	0.7
4	**St Landry**	**6**	0.4	**20.0%**	0.5	**8**	**Madison**	2	0.1	**13.3%**	1.1
4	**St Martin**	**2**	0.1	**13.3%**	0.2	**8**	**Morehouse**	7	0.5	**33.3%**	1.6
4	**Vermillion**	**3**	0.2	**13.3%**	0.3	**8**	**Ouachita**	52	3.5	**80.0%**	2.2
5	**Allen**	**3**	0.2	**20.0%**	0.8	**8**	**Richland**	5	0.3	**26.7%**	1.6
5	**Beauregard**	**5**	0.3	**40.0%**	0.8	**8**	**Tensas**	0	0.0	**0.0%**	0
5	**Calcasieu**	**36**	2.4	**66.7%**	1.2	**8**	**Union**	4	0.3	**26.7%**	1.1
5	**Cameron**	**1**	0.1	**6.7%**	0.8	**8**	**W.Carroll**	5	0.3	**20.0%**	2.8
5	**Jeff Davis**	**4**	0.3	**13.3%**	0.8	**9**	**Livingston**	47	3.1	**80.0%**	2.3
						9	**St Helena**	7	0.5	**26.7%**	4.0
						9	**St Tammany**	70	4.7	**80.0%**	1.9
						9	**Tangipahoa**	45	3.0	**73.3%**	2.4
						9	**Washington**	21	1.4	**60.0%**	2.9
							Total	**1010**	**67.3**	**100.0%**	**1.4**

Given that there were a total of 875 cases of WN-NID since 2002, it is estimated that there are about 875 times 100 persons who have been infected with the WN virus in Louisiana = 87,500.

WNV 2001

In August 2001, a crow infected with West Nile virus was identified in Kenner (Jefferson Parish), the first indication of WNV transmission within Louisiana. By the end of the year, five additional birds (crows and blue jays) in Jefferson Parish, eight horses from Calcasieu, Vermillion and Plaquemines Parishes and one human case in a homeless man from Kenner were reported (Figure 4).

Figure 4: West Nile Virus Cases - Louisiana, 2001

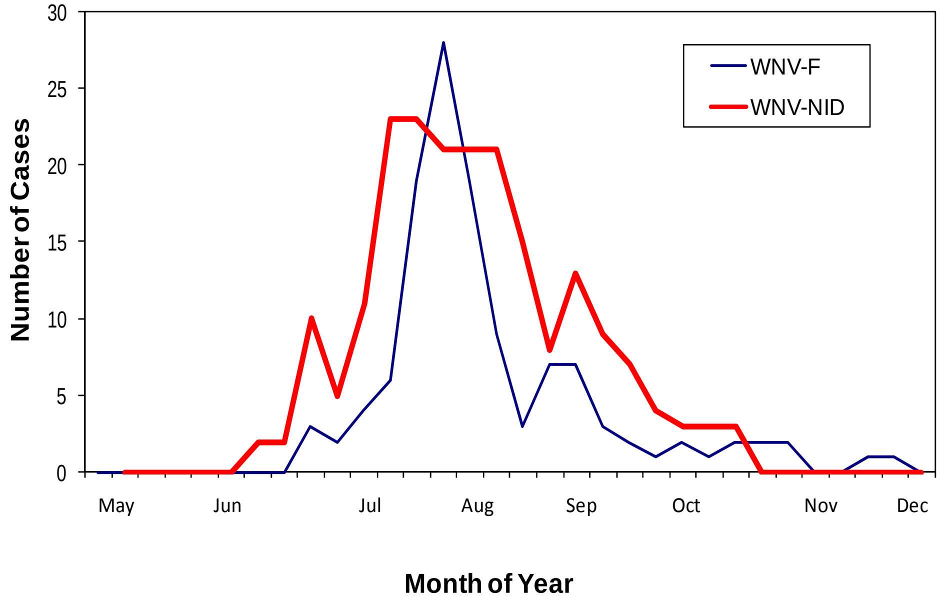


WNV 2002

There were a total of 328 cases of West Nile diseases in Louisiana in 2002: 204 cases of WNV-NID and 124 cases of WNV-F. The term WNV-F (fever) is the preferred designation of the mild, self-limited disease, characterized by fever, headache, weakness and sometimes a macular rash.

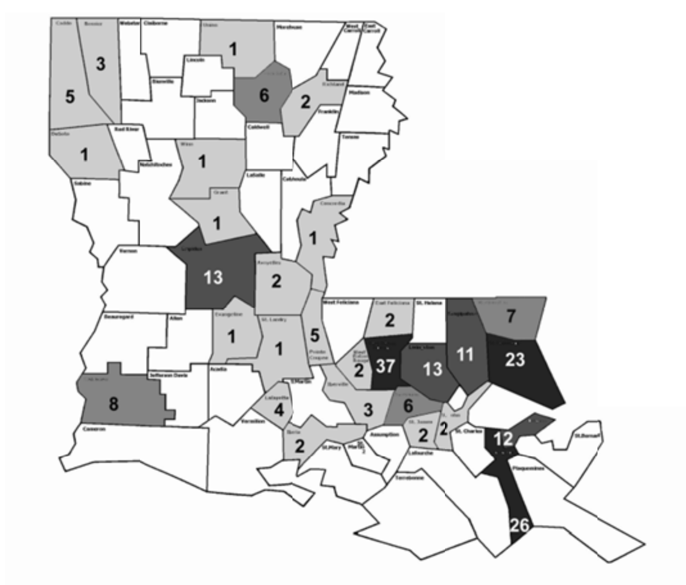
The first cases were diagnosed during the second week of June in St. Tammany and Tangipahoa Parishes. The weekly number of cases increased rapidly to plateau from mid-July to mid-August. The weekly number of cases then decreased very progressively until the first week of December. The red curve representing WNV-NID cases in Figure 5, was, and continues to remain the most accurate and reliable tool in tracking the epidemic because specimens from these suspects were more likely to be submitted. Testing and confirmation of WNV-F cases was discouraged in order not to overwhelm laboratory capacity. However, sera that were submitted for West Nile fever suspects were tested, their results reported and integrated into the surveillance system (Figure 5).

Figure 5: WNV Cases - Louisiana, 2002



WNV human cases were identified in 61% of Louisiana parishes (39 out of 64). WNV infections were found among horses and birds in 94%, or 60 of the 64 parishes. WNV exhibited a very focal distribution - 11 parishes reporting ten cases or more comprising 265 of 328 cases (81% of cases). Within these parishes and/or separated by NID or fever infections, the distribution was also very focal (Figure 6).

Figure 6: WNV-NID Cases - Louisiana, 2002



This West Nile epidemic was characterized by a combination of small foci concentrated within cities and limited rural areas and also of sporadic cases in rural areas. These foci were staggered over time. The first outbreaks occurred north of Lake Pontchartrain in St. Tammany, Tangipahoa and Livingston Parishes during June. At the end of June, foci appeared to the west in East Baton Rouge and Ascension Parishes. In July, new foci appeared in Calcasieu and Ouachita Parishes (southwestern and northeastern corners of the state). In mid-July, foci were initiated south of the Lake in the New Orleans metropolitan area (Orleans and Jefferson Parishes), and west of Baton Rouge in Pointe Coupee Parish. In mid-August, a focus began in the central Louisiana parish of Rapides (Figures 7, 8 and 9).

Figure 7: WNV Cases by CDC Week - Southeast Louisiana, 2002

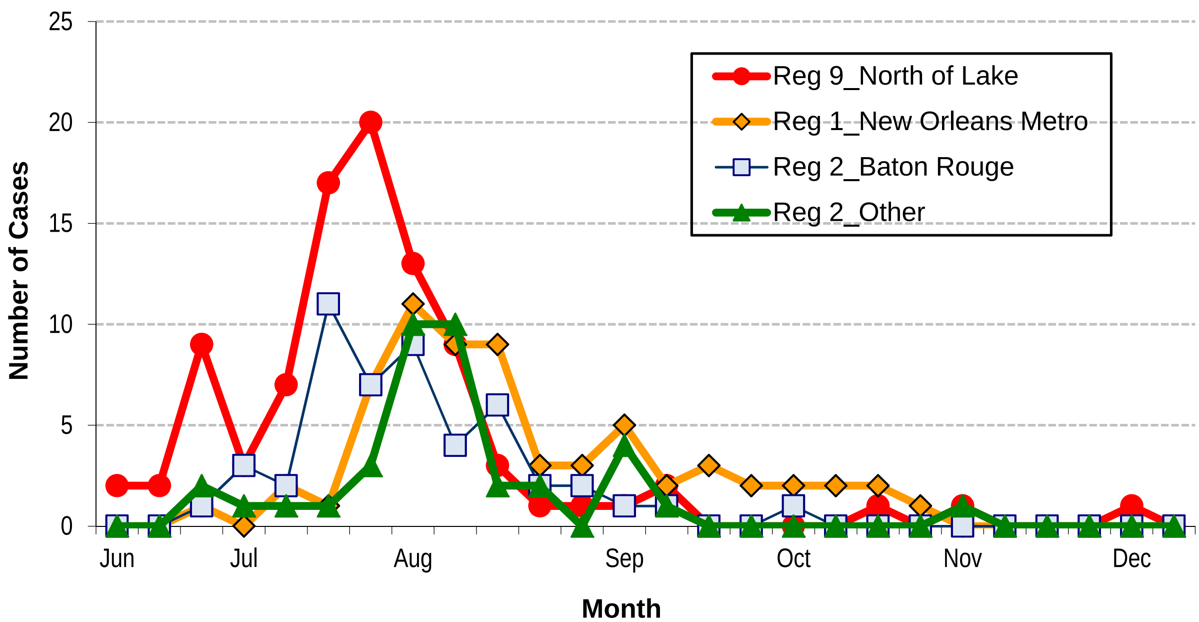


Figure 8: WNV Cases by CDC Week - Southwest, Central and Northern Louisiana, 2002

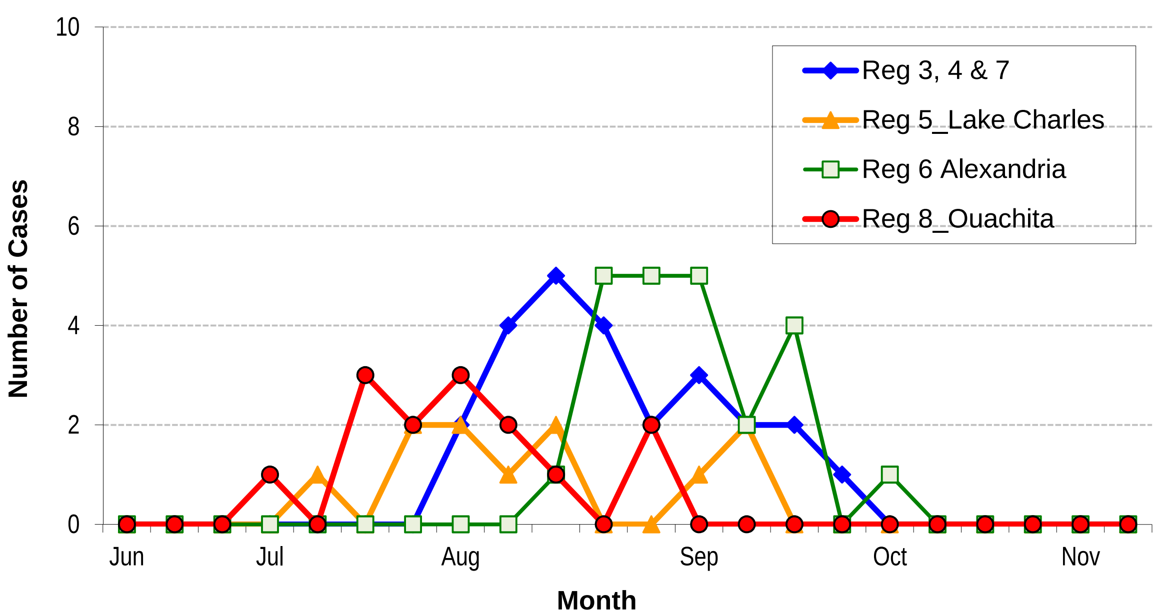
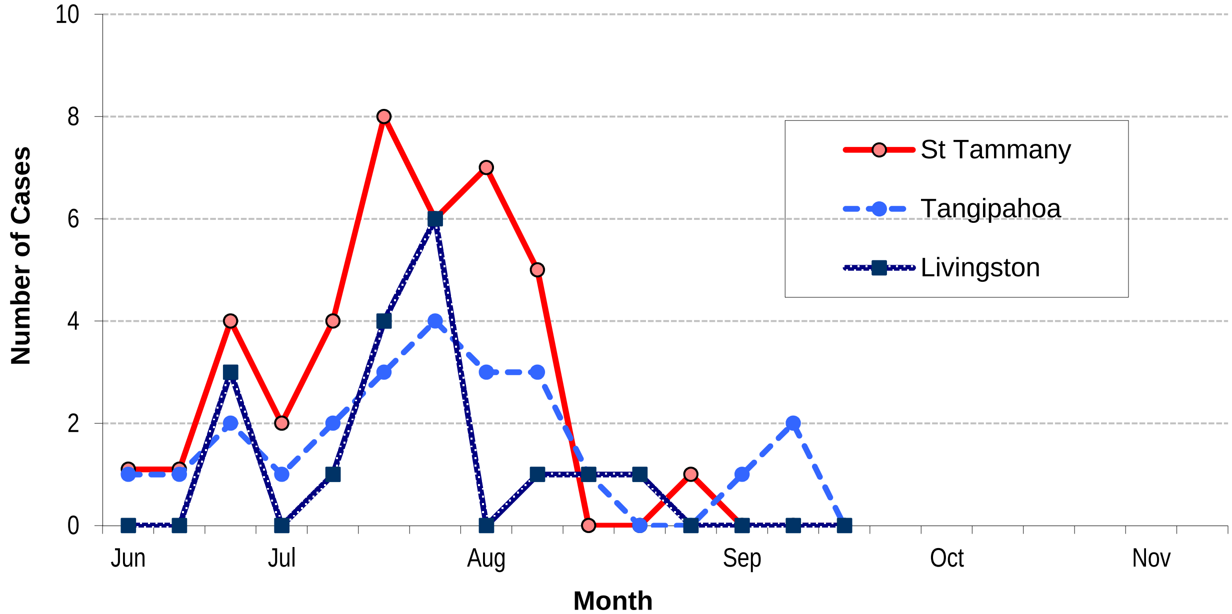


Figure 9: WNV Cases by CDC Week - Region 9 - Louisiana, 2002



Serosurvey for WNV Infection Slidell, Louisiana, 2002

In early June, St. Tammany Parish was among the first counties nationwide to report human cases. Eventually, 27 WNV-NID cases occurred between June 10th and August 29th. Due to high WNV activity, climatic and ecological factors that favor various vector species and also given the historical occurrence of other arboviral outbreaks, St. Tammany Parish was chosen as the site of several Centers for Disease Control and Prevention (CDC) investigations that aimed at characterizing WNV occurrence in the southern United States.

To establish the community-wide prevalence of recently-acquired WNV infection, a household-based serosurvey was conducted in late October, in and around Slidell (the largest city in St. Tammany Parish).

Among the 1,226 participants, 21 had serological evidence of recent WNV infection (seroprevalence = 1.7%). In spite of the warm and coastal location, the risk for WNV infection in Slidell was similar to that estimated in previous studies done in the northeastern United States. Standard WNV precautions were recommended.

In 2002, hospital-based surveillance identified nine residents of the surveyed area in Slidell with severe WNV neurological illness (cumulative incidence = 19.7 per 100,000 population). On the basis of the estimated seroprevalence, an estimated 765 (95% CI = 367-1,164) residents older than or equal to five years of age were infected with WNV in 2002. Consequently, an estimated 1.2% (95% CI = 0.8-2.5) of WNV-infected Slidell residents developed severe neurological illness.

The 1.7% seroprevalence of recent WNV infection estimated in 2002 in the Slidell area was similar to that estimated in comparable studies carried out in 1999 and 2000 in the northeastern United States. Following the 1999 New York City outbreak, seroprevalence was estimated at 2.6% (95% CI = 1.2 to 4.1) in the borough of Queens, New York City. In 2000, after a season with reportedly less intense WNV epizootic activity, seroprevalence ranged from 0.5% (95% CI = 0.2% to 1.2 %) in Staten Island, New York, to 0.1% (95% CI = 0.0% to 0.7%) in Suffolk County, New York and 0.0% (95% CI = 0.0 to 0.5) in Fairfield County, Connecticut.

From October 23 to 28, 2002, a two-stage cluster method was used to select a representative sample of households in the Slidell, Louisiana area (2000 census population = 45,672). Residents from at least ten households in each of 70 randomly selected clusters were invited to participate. Consenting participants, older than or equal to five years of age, were interviewed with a standard questionnaire. Their serum was tested for the presence of WNV-specific IgM antibodies. IgM-positive samples were further tested for WNV-specific neutralizing antibodies.

From the 758 participating households (64% of approached households where at least one adult was at home), 1,226 individuals were enrolled (70% of eligible residents who were at home). WNV-specific antibodies were detected in the serum of 21 participants. The estimated prevalence of recently acquired WNV infection was thus 1.7% (95% confidence interval [CI] = 0.8 to 2.6). Seroprevalence ranged from 3.9% among participants aged 15 to 24 years to 1.0% among those older than or equal to 65 years of age, but the differences were not statistically significant ($p = 0.31$). No difference in seroprevalence existed between female and male participants (both 1.7%). Seroprevalence was not significantly higher among African-American participants compared to White participants (4.7% vs. 1.4%, respectively; $p = 0.08$). The 21 seropositive participants lived in 20 different households; these households were distributed among 17 clusters in no discernable geographical pattern.

Nine (weighted percentage 48%, 95% CI = 22–74) of 20 seropositive participants reported a febrile illness between June and October, 2002 (one seropositive participant could not recall) compared to 212 (18%) of 1,191 seronegative participants. WNV seropositivity was thus associated with a febrile illness ($p = 0.01$), and an estimated 30% of the seropositive participants had a febrile illness attributable to a recent WNV infection (95% CI = 7-53).

Consequently, even in an area of the United States that had very high WNV activity and was located in the southeastern U.S. - with warm, coastal ecology, the risk of WNV infection was not as high as initially expected.

Most WNV infections are asymptomatic. The estimated proportions of WNV-infected individuals that developed a febrile illness (48%), and West Nile meningoencephalitis (1.2%) in the Slidell area in 2002 were slightly higher to that estimated in the 1999 Queens, N.Y. serosurvey (32% and 0.7%, respectively). In contrast, the proportion of seropositive participants who reported symptoms suggestive of West Nile fever appeared much lower in Slidell in 2002 than in Queens in 1999 (4% and 21%, respectively).

The most significant public health implication of the survey of recent WNV infection carried out in Slidell in 2002 is that it repeated (consistently and confirmed) the findings from comparable studies done in 1999 and 2000 in the northeastern United States. This means that, in spite of the elapsed time and climatic and ecological conditions that were expected to favor vectors of the infection, risk for both infection and morbidity has remained unchanged. The emerging public health burden of WNV is thus a function of the expanded geographical presence of the virus rather than changes in the host-vector-virus interaction.

In newly affected areas where the virus has become established, mosquito abatement activities and personal precautions, such as the use of DEET repellent, wearing of long sleeves and pants during the vector season, housing with mosquito-proof window and door screens and the emptying of water-holding containers in the backyard, continue to be important prevention measures.

WNV Viremic Asymptomatic Blood Donors

In 2003, the CDC reported that 80% of those infected would not have any symptoms. Due to new technological tools in 2003, Louisiana began encouraging blood collection agencies to screen all donations through WNV nucleic acid amplification tests. Four viremic asymptomatic blood donors were identified in 2003 as having present (WNV-PRE) infections. It is expected that over time, the numbers reported will increase as the virus becomes more endemic to Louisiana.

Study of West Nile and Hurricanes

The study first compared the WNV-NID cases reported for the four weeks prior to the hurricane week (“before”), and the cases reported for the four weeks following the hurricane week (“early after”). A second comparison was made between the four weeks prior to the hurricane (“before” and the four weeks starting two weeks after the hurricane week (“late after”). The reason for this second comparison was to identify a delayed effect of the hurricane on WNV transmission.

To control for seasonal effects, the landfall related periods described above were compared to the same time periods in identical locations during years in which these areas were not affected by tropical cyclones. These controls were referred to as “non-hurricane years” and, of course, were from the same time period, 2002 to 2005.

In summary the study compares: Hurricane year, “before” and “early after” with non-hurricane year, “before” and “early after”; and hurricane year, “before” and “late after” with non-hurricane year “before” and “late after.”

The statistical analysis consisted of t-Test for Paired Two Sample for Means, one tail test conducted on MS Excel® 2007.

Results - The hurricanes and storms studied are presented in Table 7.

Table 7: Hurricanes and Tropical Storm Dates, and List of Impacted Parishes
Louisiana, 2002-2005

Year	Dates	CDC Week	Storm	Type	Parish
2002	Aug 5-7	32	Bertha	TS	Plaquemines, St Bernard, St Tammany, Washington, Tangipahoa, St Helena, East Feliciana, West Feliciana, EBR, Iberia, St Martin
2002	Sept 26	39	Isidore	TS	Jefferson, Orleans, St Tammany, Plaquemines, St Bernard
2002	Oct 3	40	Lili	H1	Vermilion, Acadia, Evangeline, Lafayette, Rapides
2003	Jun 30	27	Bill	TS	Terrebonne, St John, Jefferson, Orleans, St Tammany, Lafourche, Tangipahoa
2004	Sept 24	38	Ivan - 2nd Landfall	TD	St Mary, Vermilion, Cameron, Calcasieu, Beauregard
2004	Oct 10	41	Matthew	TS	Terrebonne, Lafourche, St James, St John, St Charles, Jefferson, Orleans, St Tammany, East Baton Rouge, Plaquemines, Livingston, St Helena, Ascension, East Feliciana
2005	July 6	27	Cindy	TS	Jefferson, Orleans, Lafourche, St Tammany
2005	Aug 29	35	Katrina	H4	Jefferson, Orleans, St Tammany, St Bernard, Plaquemines, Washington
2005	Sept 24	38	Rita	H3	Cameron, Calcasieu, Beauregard, Vernon, Jefferson Davis, Acadia

H = hurricane, 1 to 4 = hurricane category, TS = tropical depression

A comparison of the number of cases during pre-hurricane weeks and control weeks showed respective means of 9.0 and 2.94.

The comparison of number of cases in hurricane years between before-hurricane and early-after hurricane shows a reduction in the total numbers of cases from 81 to 35, a 57% reduction while in control years there was hardly any reduction, 106 before and 105 (26.5 and 26.3 per year) early after. The t-Test for Paired Two Sample for Means, one tail test shows no statistical significance for the controls ($p = 0.49$) and a lower probability although not reaching the level of significance for the hurricane years ($p = 0.12$), (Table 8).

Table 8: Comparison of Pre-hurricane Versus Early Post-hurricane Between Hurricane Years and Controls - Louisiana, 2002-2005

Hurricane	Year	Hurricane Year		Control Years*		Statistical Analysis	
		Pre	Post Early	Pre	Post Early	Hypothesized Mean Difference	0
Bertha	2002	47	12	20	16	α	0.05
Isidore	2002	11	3	9	4	Degrees of freedom	8
Lili	2002	7	2	4	4	Hurricane Year:	
Bill	2003	1	4	8	37	t stat	1.253
Ivan	2004	1	0	4	0	P(T<=t) one-tail	0.12 2
Matthew	2004	8	1	28	6	Percent reduction	57%
Cindy	2005	0	5	5	26	Control (Non Hurricane) Year	
Katrina	2005	3	8	27	12	t stat	0.020
Rita	2005	3	0	1	0	P(T<=t) one-tail	0.49
Total		**81**	**35**	**106**	**105**	**Percent reduction**	**0.1%**
Mean/year		9	3.9	2.94	2.92		

**There are four control years for each hurricane year.*

The results of the comparison of cases before and late after the hurricanes are presented in Table 9.

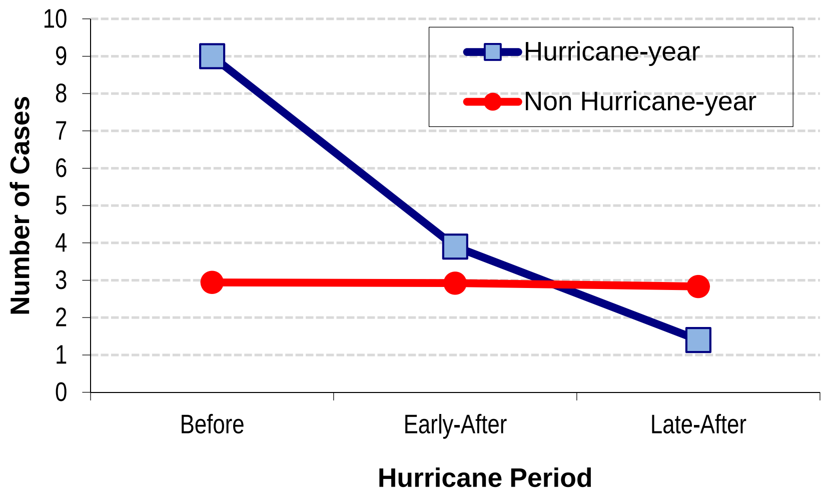
Table 9: Comparison of Pre-hurricane Versus Late Post-hurricane Between Hurricane Years and Controls - Louisiana, 2002-2005

Hurricane	Year	Hurricane Year		Control Year*		Statistical Analysis	
		Pre	Post Late	Pre	Post Late	Hypothesized Mean Difference	0
Bertha	2002	47	4	20	18	α	0.05
Isidore	2002	11	1	9	3	Degrees of freedom	8
Lili	2002	7	0	4	3	Hurricane Year:	
Bill	2003	1	4	8	36	t stat	1.617
Ivan	2004	1	0	4	0	P(T<=t) one-tail	0.072
Matthew	2004	8	0	28	4	Percent reduction	84%
Cindy	2005	0	2	5	29	Control (Non Hurricane) Year	
Katrina	2005	3	2	27	9	t stat	0.078
Rita	2005	3	0	1	0	P(T<=t) one-tail	0.47
Total		**81**	**13**	**106**	**102**	**Percent reduction**	**4%**
Mean		9	1.4	2.94	2.83		

**There are four control years for each hurricane year.*

The comparison of number of cases in hurricane years between pre-hurricane and late post-hurricane shows a reduction in the total numbers of cases from 81 to 13, a 83.9% reduction while in control years there was only a 3.7% reduction, 106 before and 102 after late. The t-Test for Paired Two Sample for Means, one tail test shows no statistical significance for the controls (p=0.47), and a lower probability although not reaching the level of significance for the hurricane years (p=0.07), (Figure 10).

Figure 10: Average Number of Cases per Hurricane per Year for Hurricane-year and Control-year - Louisiana, 2002-2005



In summary, whether the comparison was made between pre-hurricane and post hurricane, early or late, the results the similar: large reductions during the hurricane years (57% and 84%) and no reduction or minute reduction during the control years (0% and 4% reduction). It is therefore reasonable to conclude that hurricanes do depress the transmission of WNV.

Discussion

There are some limitations to this study. The number of storms studied was relatively small (nine) which may have limited reaching levels of significance.

The selection of parishes based on hurricane path and rainfall as reported in the National Hurricane Center - Tropical Cyclone Reports may introduce some uncertainties. Parish lines are arbitrary, rainfall reported may not be representative of the entire area affected by the storm. A cursory look at the number of cases in the individual parishes that were included in the analysis and the neighboring parishes does not show any salient abnormalities. Therefore it appears that the selection of parish affected was fairly reasonable.

There may be some unusual circumstances under which hurricanes may increase transmission, such as hurricanes strikingly early during the season or those involving relocation of people in areas of intense transmission (Lehman 2007).

Transmission of WNV is specific to temporal and spatial conditions. There are no consistent incidence patterns over time, no consistent patterns in an area. The only consistent patterns found are 1) a seasonal transmission starting from late June to early August and ending in late October to early December and 2) a sporadic distribution throughout Louisiana with a few foci of more intense activity. Within the foci, there are wide differences from year to year. For example East Baton Rouge Parish had large numbers of cases (15 plus) in 2002, 2004 and 2005, very low numbers of cases in 2003, 2006 and 2007; St Tammany had large numbers of cases in 2002 and 2006; Ouachita Parish had a large number of cases in 2005 only; Caddo had large numbers of cases in 2003 and 2005. Any generalization of the effect of hurricanes on WNV transmission needs to be based on comparisons made over several seasons in several locations. Comparisons based on one single event in a limited area should be viewed with suspicion.