Vector-Borne Diseases of Public Health Importance

Dawn H. Gouge
University of Arizona

Definition of Vector-Borne:
- A biological association between an arthropod (insect or arachnid) and a pathogen acquired by feeding on the blood of an infected vertebrate host or through transovarial (TOT) or venereal transmission
- Arboviruses (Arthropod-Borne Viruses)

Mosquito transmitted pathogens
- Viruses
- Malaria

Flea transmitted pathogens
- Plague

Tick transmitted pathogens
- Lyme Disease
- Rocky Mountain Spotted Fever
- Tularemia

Other rare pathogens present in the US
Mosquito Transmitted Pathogens

- West Nile virus (WNV)
- St. Louis encephalitis virus (SLE)
- California group viruses (CE & LACV)
- Western equine encephalitis virus (WEE)
- Eastern equine encephalitis virus (EEE)
- Dengue virus (DEN)
- Malaria

Arboviruses

- Seasonal – typically occur in warm months
- Incidence varies with time and place because ecological factors are important
- For each of these viruses, the ratio of clinical to subclinical infection varies (number of detected cases versus number actually infected)
- With the exception of dengue virus, and yellow fever, humans are dead-end hosts.
West Nile Virus (WNV)

- Most recent mosquito transmitted arbovirus in the US
- Discovered in New York City in 1999 and has spread to every state in the continental US and most other countries south of Canada
- Basic cycle: bird to mosquito
- Bird deaths associated with infection

West Nile Virus

- Most human infection occurs by mosquito bite, May–Oct. (longer season further south)
- Blood transfusion, infected tissue donation, placental, and accidental laboratory infections
- 80% of all human infections show no symptoms – of the symptomatic 20%, most go on to develop West Nile fever

West Nile Virus

- After bite of infected mosquito, it takes 2-14 days for symptoms to occur
- Characteristics of WN Fever - fever, headache, fatigue, sometimes rash, swollen lymph glands and/or eye pain
- Severe disease occurs in up to 1% of infected individuals - meningitis and/or encephalitis and/or (sometimes) paralysis
- Approximately 10% of severe cases are fatal
West Nile Virus: Background
• First isolated in 1937 in Uganda from blood of a febrile woman
• Family: Flaviviridae
• All are transmissible by mosquitoes, many can cause febrile, sometimes fatal, illnesses in humans.

WNV Outbreak in NE U.S. 1999
• 62 confirmed human clinical cases
• 7 deaths due to West Nile Virus
• first occurrence of disease in Western Hemisphere
• majority of clinical cases and deaths were among elderly
• 70% of human cases occurred within a 10km radius of Queens

West Nile Virus in the US - Some Possible Pathways of Introduction
• Human-transported vertebrate host (mammal or bird)
  • Legal
  • Illegal
• Human-transported vector (s)
• Storm-transported vertebrate host (bird)
• Migration of infected bird less likely (virus almost identical to Middle Eastern strain)
• Infected human host from endemic area overseas
West Nile Virus in the United States, 1999-2001

Pattern indicates human cases

- 1999-2001
- 2000-2001
- 2001

West Nile Virus in the United States, 2002

Verified avian, animal, and mosquito infections during 2002, as of October 10, 2002

Pattern indicates human case(s)

Indicates human disease case(s).

Avian, animal, or mosquito infections.

2004

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2007 WNV in the United States

Indicates human disease case(s).
Arbovirus, animal or mosquito infections.

2009 WNV in the United States

Indicates human disease case(s).
Arbovirus, animal or mosquito infections.

2009 WNV in the United States

663 cases (incl. severe and mild) 30 deaths
Primary WNV Vectors

- Northeastern and northcentral US – *Culex p. pipiens*
- Southeastern US – *Culex p. quinquefasciatus* and *Cx. nigripalpus*
- Southcentral US - *Culex p. quinquefasciatus* and *Cx. salinarius*
- Mountain west and western US – *Culex tarsalis* and *Cx. p. quinquefasciatus*

West Nile Virus Severe Disease Risk Factors

- Exposure to infected mosquitoes when > 50 years of age (most fatalities > 75 years)
- *Culex* spp. mosquitoes - but over 60 mosquito spp. have been found naturally infected
- Recreational and/or occupational exposure in urban or rural setting
- Primary and secondary vectors can vary locally and regionally, so understanding local transmission is crucial

St. Louis Encephalitis Virus

- Distribution similar to WNV in New World only
- Bird – mosquito cycle; similar primary mosquito vectors (*Culex* spp.) and transmission season to WNV
- Most similar to WNV in urban situations – sparrows and other peridomestic birds important for amplifying virus
During extended spring droughts, vector mosquitoes and nestling, juvenile, and adult wild birds congregate in selected refuges, facilitating epizootic amplification of SLEV.

1975

Less than 1% of St. Louis encephalitis viral infections are clinically apparent.

**SLE Symptoms and Risks**

- 0 – 2,000 cases/year (1975), but usually smaller outbreaks; average of ~ 130 cases/yr
- Most infections asymptomatic or mild, with case-fatality ratio of 5 to 15%
- Severe disease – meningitis, encephalitis, coma, death
- Similar risk to WNV – increasing age, outdoor exposure in urban or periurban areas
California Group (La Crosse) Encephalitis

• Distribution in Eastern US and Canada – highly focal association with mosquito distributions
• Aedes triseriatus mosquito and chipmunk/squirrel transmission cycle – also TOT
• Vectors are woodland/suburban container inhabiting species
• Likely secondary or locally important vectors are Ae. albopictus and Ae. japonicus

LACV Symptoms and Risk

• Approximately 70 cases/year
• Most infections asymptomatic or mild, with <1% case fatality ratio
• Severe disease – encephalitis, seizure, coma, sequelae are common
• Children <16 years - most severe disease
• Woodland areas with containers (natural or manmade); rural poor
Western Equine Encephalitis Virus

- Distribution in Western US, Canada, Central and South America
- *Culex tarsalis* – bird transmission cycle
- Vector tends to be associated with irrigation or other farming practices
- Rural or periurban transmission most common
- Also infects horses – 50% mortality in unvaccinated animals

WEE Symptoms and Risk

- 640 confirmed cases since 1964, but less than 0-2/year in past 10 years
- ~13% of infections show disease (30% of infants) with 3% case fatality ratio
- Severe disease - encephalitis, coma, death; seizures common in infants
- Rural areas where the vector is common
**Eastern Equine Encephalitis Virus**

- Distribution in the Eastern US, Canada to Central and South America
- Bird – mosquito cycle maintained by bird feeding mosquito, *Culiseta melanura* in swamp/wetland areas
- Transmission to humans and horses by “bridge” vectors, *Aedes, Culex* and *Coquillettidia* spp.
- High equine mortality if unvaccinated

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**EEE Symptoms and Risk**

- 257 cases confirmed since 1964, with ~5 cases/yr
- Rare infection, but 30% mortality rate
- Severe disease (*encephalitis, coma, death*) most common in <15 or >50 years
- 50% of severe disease survivors have permanent neurological damage
- Risk assoc. with age and residence near endemic areas

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**Dengue Virus**

- Distribution worldwide *(50-100 million cases with ~200,000 severe)* – not common in US, but recent S. Texas cases
- Human – mosquito transmission, *Aedes aegypti* vector
- Vector develops in containers and feeds during the daytime
- Typically urban transmission in overpopulated tropical/subtropical areas

**Dengue Virus**

- More than one-third of the world’s population live in areas at risk for transmission
- Dengue infection is a leading cause of illness and death in the tropics and subtropics.
- As many as 100 million people are infected yearly.

**DEN Symptoms and Risk**

- There are 4 serotypes *(DEN 1-4)* and all can cause classical dengue *(sudden fever, headache, severe aches and rash)* known as “breakbone fever”
- Following sequential infection with different serotypes, severe hemorrhagic manifestations known as dengue hemorrhagic fever *(DHF)* can result
- DHF risk highest for <15 years of age
• 1950 Pan American Health Organization begins eradication campaign to prevent urban yellow fever.
• Dengue declines.
• Eradication program discontinued in the US in 1970.
• Geographic distribution of Aedes aegypti in 2009 is much wider than before eradication.

2008

• No dengue vaccine is available.
• An effective dengue vaccine for public use will not be available for 5 to 10 years.
**Recent Dengue in the US**
- Texas – endemic transmission 6 times between 1980 and 2004
- First local DHF case in south Texas in 2005 and studies show undetected local DEN
- Hawaii – 88 cases in 2001-02 (*Aedes albopictus* vector)
- Low but increasing risk for local transmission, since 1977, ~ 4000 cases imported to US (100-200 cases/year)

**Dengue Risk**
- Areas in the southern and southeastern US where both one or both vectors are present (*especially Aedes aegypti*) are at risk for sporadic outbreaks
- Increased influx of residents from dengue endemic regions outside the US (as currently occurs in New Orleans following Hurricane Katrina) further adds to the risk of introduction and local transmission

**Yellow Fever**
- The last epidemic of yellow fever in North America occurred in New Orleans in 1905.

*Approximate Global Distribution of Yellow Fever, by State/Province, 2007*
Malaria

- Distribution worldwide in tropics and subtropics (700,000–2.7 million deaths annually—75% in African children)

- Plasmodium parasites (5 Plasmodium spp.) transmitted from human to human by Anopheles spp. mosquitoes

- 41% of the world’s population lives in malarious areas—so risk of importation to US from endemic areas is constant
Malaria in the US

- 1,337 cases of malaria with 8 deaths, were reported in the US in 2002
- 5 of those cases were locally acquired
- Between 1957 and 2003, 63 outbreaks of locally transmitted malaria have occurred
- Two species of *Anopheles* mosquitoes have been implicated
- About 1200 cases of malaria are diagnosed in the United States each year
Malaria in the US

- "Airport malaria" is a term coined by researchers to explain the more recent spread of malaria to areas such as the United States and Europe, which some scientists credit to warmer climate changes.

  All but one of these cases were acquired outside of the United States; one was acquired through a blood transfusion.

Malaria Symptoms and Risk

- Classic symptoms: fever, chills, sweating, headaches, muscle pains
- Severe symptoms: cerebral malaria, anemia, kidney failure
- *Plasmodium falciparum* causes most severe disease and death
- Night time biting mosquitoes in rural areas of southeastern US and southern California

Tick Transmitted Pathogens

- Lyme Disease
- Rocky Mountain Spotted Fever
- Tularemia

Lyme disease, Babesiosis, Ehrlichiosis.
Takes 24-48 hours for a tick to transmit bacteria - Rapid removal is important

- Using a pair of pointed (fine-tipped) tweezers, grasp the mouthparts of the tick as close to the skin as possible.
- Pull the tick straight out with a firm and steady force.
- Wash the area of the bite with soap and water.
- Place the tick in a jar of alcohol for ID and testing.
- Contact your physician.
- Watch the bite for signs of a rash.

Lyme Disease – *Borrelia Spp.*
**Lyme Disease Symptoms and Risks**

- First sign is usually a circular rash. A distinctive feature of the rash is that it gradually expands over a period of several days.
- Loss of muscle tone on one or both sides of the face, severe headaches and neck stiffness, shooting pains that may interfere with sleep, heart palpitations and dizziness, and pain that moves from joint to joint.

**Rocky Mountain Spotted Fever (RMSF) - *Rickettsia rickettsii***

- Rocky Mountain spotted fever was first recognized in 1896 in the Snake River Valley of Idaho and was originally called "black measles" because of the characteristic rash.
- Most severe and frequently reported rickettsial illness in the US, Mexico, Central and South America.
Initial symptoms include fever, nausea, vomiting, severe headache, muscle pain, lack of appetite.

- The rash first appears 2-5 days after the onset of fever and may be very subtle.
- Often it begins as small, flat, pink, non-itchy spots (macules) on the wrists, forearms, and ankles.
- Later signs and symptoms include rash, abdominal pain, joint pain, diarrhea.
Tularemia - *Francisella tularensis*.

- Tularemia, also known as “rabbit fever,” bacterial disease.

- Typically found in animals, especially rodents, rabbits, and hares. Usually a rural disease and has been reported in all U.S. states except Hawaii.

- People become infected through the bite of infected arthropods (most commonly, ticks and deerflies), by handling infected sick or dead animals, by eating or drinking contaminated food or water, or by inhaling airborne bacteria.

Tularemia Symptoms and Risks

- The signs and symptoms depend on how you are exposed to tularemia:

  - skin ulcers, swollen and painful lymph glands, inflamed eyes, sore throat, mouth sores, diarrhea, pneumonia.

  - If inhaled: abrupt onset of fever, chills, headache, muscle aches, joint pain, dry cough, and weakness.
Tularemia can be fatal if the person is not treated with appropriate antibiotics.

Lone star tick (Amblyomma americanum)

American dog tick (Dermacentor variabilis)

Chrysops spp.

3000-4000 eggs

Rare Vector-Borne Infections with Recent US Human Cases

- Chagas Disease (riatominette bugs)
- Leishmaniasis (sand flies)
- Murine Typhus (fleas)

Cases of cutaneous leishmaniasis have been reported in Texas and Oklahoma.

Chagas Disease vector in Louisiana, Triatoma sanguisuga

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Arthropod-borne Diseases of Public Health Importance
Chikungunya fever
- Chikungunya fever is a disease caused by an Alpha virus spread to people through the bite of infected mosquitoes, primarily primate reservoir species.
- Symptoms can include sudden fever, joint pain with or without swelling, chills, headache, nausea, vomiting, lower back pain, and a rash.
- Chikungunya mainly occurs in areas of Africa and Asia.
- In 2007, limited transmission of chikungunya virus occurred in Italy.
- Aedes aegypti, and Aedes albopictus
- Biological weapon

Links for Additional Information:
http://www.cdc.gov/ncidod/dvbid
(CDC’s NCID/DVBD Home Page)
http://www.cdc.gov/malaria
(CDC’s Malaria Home Page)
Also search CDC A-Z listing for Chagas, Leishmaniasis, etc.

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Last 20 years there has been a dramatic global resurgence & emergence of epidemic arboviral diseases affecting humans and domestic animals.

Viruses thought to be under control (dengue, Japanese encephalitis, yellow fever, and Venezuelan equine encephalitis).

Viruses that have expanded their geographic distribution such as West Nile and Rift Valley fever.
Bedbugs may be a vector for hepatitis B1 and in endemic areas for American trypanosomiasis – Chagas disease2. Of note, reports have indicated the risk of insect transmission of HIV, if any, is extremely low and likely nonexistent3,4.