

## NEHA Mosquitoes and Mosquito-borne Pathogens

Hello and welcome to the presentation, Mosquitoes and Mosquito-borne Pathogens. To ask questions about this presentation, join the presenter for a chat hour in the networking lounge.

I would now like to introduce our presenter, Lucy Li, Assistant at Extension, Public Health IPM at the University of Arizona.

Thanks, Marissa. Hi, everyone. Welcome to the EEK Vectors and Public Health Pests Virtual Conference. My name is Lucy Li. I am the Assistant Extension for Public Health (inaudible) at the University of Arizona, and I am located at the Maricopa Education Center in Maricopa, Arizona. And thank you for your interest in mosquitoes and mosquito-borne pathogens today. And this presentation will cover basic aspects of mosquito biology and ecology and vector (inaudible) risk and the integrated (inaudible) management to control the mosquitoes.

Mosquitoes are the most dangerous insect pests on earth. And they affect the health and wellbeing of humans and domestic animals worldwide. And they can cause a variety of problems due to their ability to vector viruses and other disease-causing pathogens. Anopheles mosquitoes, also commonly known as malaria mosquitoes, in particular are the dangerest mosquitoes because they transmit malaria, which kill more than a million people every year, primarily in Africa. Although there are about 180 species of mosquitoes in the United States, and over 40 species in Arizona, only a few key mosquito species are a problem for urban residents and appear in this talk, and we will talk about these major mosquitoes. And they are beautiful here, beautiful but deadly.

Understanding the basics of mosquito biology will help to reduce mosquito problems. All mosquitoes must have water to complete their life cycle, although some species require very little water and can be (inaudible) on a very thin moisture field. Like most insects with complete metamorphosis, such as butterflies, and mosquitoes have developmental stages that look very different from one another.

So there are four distinct stages in the life of a mosquito: egg, larva, pupa and adult. At both larval and the pupal stages, are living in the water and they are aquatic. Mosquitoes belong to the family Culicidae, and females are the most vicious in this family, having long mouth parts, or proboscis, for consuming blood, so they suck blood out of their hosts. Only female adult mosquitoes bite, and they require a blood meal for egg production.

Female mosquitoes (inaudible) lay eggs a few days after acquiring a blood meal. And depending on the species, the eggs can be laid either singly, such as *Aedes aegypti*, or in rafts, and here are shown like *Culex* mosquitoes. And this is *Anopheles* species, and eggs of this, they have floats attached to each side of the egg so that it can float in the water.

And depending on the species and the eggs they lay, the eggs may be laid on the surface of water, on the side of the containers, or on damp soil.

Depending on the species, the eggs may hatch 24 to 36 hours after they are deposited. Eggs of permanent water mosquitoes where the eggs are deposited on the water surface may hatch in one to three days, and depending on the temperature, some of the mosquitoes may hatch after one to three years. And also some species will use eggs to overwinter.

And this a *Culex* mosquito laying a raft of eggs on the surface of water. As you can see, when the eggs are freshly deposited, they are pure white. But then they will be darkened to a black or black-brown within 12 to 40 hours. And we're very lucky to see those freshly-deposited eggs here.

And also a single female can lay up to five rafts of eggs in a lifetime. And also the number of eggs per raft varies based on the temperature.

The eggs hatch into squiggly little larva or wrigglers that swim in the water and feed on microorganisms or decaying organic matter.

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The larva go through four growth stages called instars in which they grow inside before reaching the relatively active pupal stage. The larva must come to the surface of the water to breathe. And they have this second structure here at the end of the body so that they can penetrate the water surface and get oxygen from the air.

And the total length of time that larvae spend in the larval stage depends on the species. And sometimes they can be four to 12 days. And some species can take weeks.

After the fourth larval instar, the mosquito pupae forms, and this is a stage between larva and adult, and also changes from larva to adult. And pupae are also called tumblers and they do not feed. Think about this as the teenager stage of the mosquito life cycle. And they are pretty active. And they need to come to the surface for air regularly. And when they come to the surface, they use the respiratory trumpets like this or known as breathing tubes to get the air – to get oxygen from the air.

Larvae and the pupae can be killed by cutting off their access to air with all use or monomolecular films. Because they are aquatic, this is a very good way to kill the larvae and the pupae stages. And the pupal stage is normally quite short, and after which the adult mosquito emerges.

The last stage, and the only one that gets much public attention, the adults that fly, or specifically the adult female that bites and the vector it delivers. After a few days, the adult mosquito emerges from the pupal skin and flies away. Only adult female mosquitoes take a blood meal, and those blood will be used to produce eggs.

Male mosquitoes generally emerge first. And they want to be ready for mating when the females come out. And male mosquitoes generally feed on nectar, fruits and berry juices and from which they reuse the carbohydrates as the energy source for the mating. It's their main purpose. Male mosquitoes look similar to females but can be identified by having feathery antennae. And here is close up of the male mosquito, and these are the antennae of the male mosquito. And they mate within two to seven days after their emergences, and then they die three to five days once their job is done.

So, this is a close up of the antennae on the male mosquito. As you can see, those are feathery – quite feathery antennae of the mosquito. And the male mosquitoes can locate the females by listening for the sound of the females' wings. And generally they run about 200 to 500 beats per minute. It goes like this: whooooo. That's how they can locate the females.

And this is close up. See the hairs. They have very good recessive receptors on their antennae. And the long hairs of antennae can help them to relocate the flying females.

Because male mosquitoes travel shorter distances than female mosquitoes, and when you find male mosquitoes which means the source of water that produced them is most likely nearby.

And female mosquitoes emerge a little bit later than males. And they generally feed on the flower nectar and the fruit juice. And they (inaudible) mate only once. And only adult female mosquitoes take blood meals. And the female mosquitoes use the juice from the nectar for the nutrition, but they need the protein from blood to develop the eggs. So if you are bitten by a mosquito, another thing you can assume is that you have just become a proud new grandparent, in a way, because you know there are hundreds of grandbabies coming out because of your blood.

And generally the female mosquitoes will take one to five blood meals over a lifetime span of seven to 28 days. And here are different species of the female – different female mosquitoes of different species.

For mosquitoes, the winter survival is really important. It also determines if we're going to have a heavy mosquito infection the next year. So some mosquitoes overwinter in egg stage, such as Aedes and Psorophora. And some mosquitoes, like Anopheles, will overwinter as larvae. Culex and Anopheles also use adults to overwinter. And generally, the mated female, they will rest in the protected, cool location, for

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example, the cellar, sewers, crawl spaces, and the well pit. So when the spring comes, and the one warm spring day, and the female will come out to seek a blood meal.

However, in Arizona we generally have warm, you know, generally mild winter, so we're expecting we're going to have mosquitoes all year round. Actually last time when we had a talk about mosquitoes, early December, and unfortunately at the same time, yeah, we were in the classroom, got bitten quite a few times.

So, are those looking familiar? I'm sure some of you have seen or maybe done some of those stuff like here, the tires, piled up tires. That's why it's recommended that we dispose of tires properly. So when you pile up the tires here, think about after a heavy rain what will happen. All those spaces, like those areas, they will stock water. And it's a very good reservoir for mosquitoes to lay eggs in.

And recycling is a good idea, and we always recommend people to recycle all those soda cans. But this is not the way we're going to do it. Because once you leave it open after rain, and it's impossible to empty all the water in those containers.

And same thing. Bird bath? Yes. We thought the birds would use bird bath, but how often are they going to use it and you just have that standing water there sitting in the water bath attracts mosquitoes to lay eggs in it.

Pools. This is a swimming pool. You know, foreclosed house. I'm sure nobody wants to swim in this pool here, our audience here. So yes, we don't like it. But mosquitoes, that's ideal place for them to lay eggs in.

And roadside ditches here have all this water, and lots of mosquitoes are going to stay there.

And also flat irrigation. This is a (inaudible) site, and they have the flood irrigation, but however the field is not even. So we always find these puddles of water after the irrigation. They're going to stay there. It will take three to seven days for them to dry out. And those, you may be surprised how many mosquito larvae you're going to find from that pool.

And this one is from Phoenix. I'm not sure how many of you have ever come to Arizona before, and in Arizona, our rivers generally don't have water. But after a heavy rain in the monsoon season, this is what it looks like for our river. This is the Salt River right next to Phoenix Airport after rain in the monsoon, and this is how much water we get. And mosquitoes are happy to have larvae living there.

And we also, you know, got a call from a senior lady before, and she complained she keep having those mosquitoes in her yard. And she said she didn't have any water sources around her yard. So we went and had the investigation. Guess what happened? This beautiful flower pot, beautiful flower there, right in front of her yard. And like most people, they're always afraid their plants will get thirsty, they need water, so this flower pot always have water in it. And see those, even count 30 black colored – yeah, not surprisingly there were lots and lots of mosquito larvae living in that flower pot.

So all this, it may happen. It may happen around your home. It may happen in your community. Or somewhere you have visited and then you found this. All this provides a reservoir for the mosquitoes. The water collecting in those natural and unnatural reservoirs provide mosquitoes with ideal areas to lay eggs.

Some mosquitoes lay their eggs on the surface of a water reservoir, like we showed earlier, while others lay their eggs on damp ground. Or some of them lay eggs on the insides of the discarded tires, cans, tree house, or other containers which can hold water.

So, mosquitoes, there are so many ways to category mosquitoes, but generally mosquitoes are classified based on their larvae habitat. So there are three groups here: floodwater mosquitoes, permanent water

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mosquitoes, and the container mosquitoes. That's how we group the mosquitoes together, and we're going to talk about them detail.

Floodwater mosquitoes includes *Aedes* and *Psorophora* species. And some genera in this group are important pest species. And they bite humans, livestock, pets, birds. And they can have very large populations in spring and early summer. And they also vector some other diseases.

Floodwater mosquitoes can survive in egg stage for several years until flooded. And they deposit their eggs on moist soil or another wet substance, and have a wide variation in incubation period. Eggs are laid on soil surface and/or standing pools of water that are left from rains or floods. These eggs will not hatch until submerged by running water caused by rainfall, melting snow in the spring, or other floodwater. Depending on the species and the conditions, these eggs may hatch the next time they are flooded, as soon as ten days, or may not hatch until they are flooded a year or more later.

Adult populations generally peak in the late spring, like April, May and June, and some species like to hatch with late summer with the fall rains. And in the hot weather, adult mosquitoes can die very quickly because the floodwater usually dries up. It dries up too fast so they cannot support the larvae at the hot weather. And generally female mosquitoes, they are most active around sunset or in shady areas when they are disturbed. And some of them are active day biters, too.

*Aedes vexans*, or the inland floodwater mosquito, is one of the most wet (inaudible) mosquitoes in the world, and it spans throughout the United States. And these mosquitoes are vicious biters, and they are responsible for most mosquito (inaudible). And they are recognized as the most serious pest mosquitoes due to their abundant wetland distribution and the breeding potential in floodwater habitats. And this mosquito is most active at sundown, when they attack humans and animals in swarms. And in this picture you can see this group of mosquitoes generally show up in green space like parks, soccer games, fields or lawns.

And *Psorophora* is another species or the dark ricefield mosquito. It has a broad range of warm-blooded animal hosts but appears to have a preference for bovine blood. It has been reported to kill livestock when they are in large numbers. And also the females are furious biters during day or night.

Dark ricefield lay their mosquito larvae over here in this water pond. That's probably thousands of them.

So they also vector diseases. *Aedes vexans*. They are known vectors of dog heartworm, and occasionally probably West Nile Virus in humans. And *Psorophora* is the known vector of West Nile Virus in humans and also other pathogens as well.

So permanent water mosquitoes include *Anopheles* and some *Culex* species. And generally this group of mosquitoes are found in quiet bodies of freshwater with sunlight. And also the surface vegetation and a little wave action go with the fresh water. And they can also be found in shallow edges of ponds, and sometimes usually can be found in lakes, wet waters, backwaters of rivers or slow-moving streams. But in the lakes with wave action, it's really seldom to find this group of mosquitoes.

*Anopheles*, or commonly known as the malaria mosquito, is the most important vector of malaria. Malaria is a mosquito-borne disease caused by parasites. People with malaria often experience fever, chills, and a flu-like illness. If they are left untreated they may develop severe complications and die. In 2013, an estimated 198 million cases of malaria occurred worldwide. And 500,000 people died, and mostly children, in African regions.

About 1,500 to 2,000 cases of malaria are diagnosed in the United States each year. And the vast majority of cases are in travelers or immigrants returning from countries or areas where malaria transmission occurs. And many of them from sub-Saharan Africa and south Asia. And they can be found in the mismanaged ponds because of the excessive vegetation, stagnant water, and most times those kind of ponds are lack of predators of mosquitoes.

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So the population is generally low in spring but they build up through the summer. And they peak in the summer, like July to October. And it depends on the temperature and the location. And many of those mosquitoes prefer birds as hosts, and they also feed on mammals including humans. They are vicious biters at night.

So mosquitoes of great concern in the United States are Culex mosquitoes. There's Culex tarsalis, also commonly known as Western Encephalitis mosquito. Or the Culex quinquefasciatus, southern house mosquitoes.

All these mosquitoes are permanent water mosquitoes, and their population peaks in the summer at the same time as the virus activity peaks as well. As Culex mosquitoes feed on birds and mammals, including humans.

Here this is a Culex quinquefasciatus. And as we mentioned earlier, these are freshly-deposited eggs, so after 12 to 24 hours, the eggs will be darkened to a black or dark brown color. But they're still as a raft.

Culex quinquefasciatus, more commonly called the southern house mosquito, is found throughout the southern half of the United States. And it can be identified by the five lines that can be seen on the abdomen. See the five lines here.

It is an annoying pest at night, not only due to its bite, but also its distinct high-pitched (inaudible) announces its presence. Because it's oohoo.

Culex tarsalis has a prominent white span across the piercing mouth part (inaudible) and two white spans across all lower legs. It's a very distinct species here. They feed on birds and mammals, including humans. And Culex tarsalis spreads encephalitis to people and horses west of the Mississippi and occasionally is found in the east, too.

Culex mosquitoes lay their eggs on a raft and float on quiet pools of water as big as lakes or as small as buckets or as stinky as sewage pools. They prefer the nasty, smelly water such as the roadside ditches – the water in the roadside ditches or the water in wastewater treatment pools. And adults usually bite in evening or at night, and have been blamed on disease outbreaks in several places.

So Culex mosquitoes, a vector in West Nile Virus, St. Louis encephalitis in birds and humans, and West Equine encephalitis in horses. And also because of the new emerging Zika virus, Brazilian scientists are investigating if Culex is transmitting Zika virus. It is ongoing. Hopefully not.

So the third group of mosquitoes are container mosquitoes. And these mosquitoes live in close association with human habitations and appears to disperse much like most other mosquitoes. And they live in man-made containers or materials that hold water, like all the ones we talked about earlier, the tires, cans, buckets, bird baths, gutters, pet water dishes, and anything that you can think about that can hold water and they can be in it.

This is probably based on availability of egg-laying site and availability of tender human blood. So they like to live close to us.

We call this group of mosquitoes you breed them, you feed them.

So, the question is, how much containers do you have in your yard. And you want to get rid of them as much as possible. Those are the typical container mosquito habitats, like tires, piled up tires, bird bath. After picnic, people forget to take away their stuff so mosquito can stay. A bucket with water. And sometimes when the temperature is warm and they can lay eggs in as little as three days once you have water there so they can find. So carry off those containers.

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These two mosquitoes are the key species in this group. And the left one is *Aedes aegypti*, or the yellow fever mosquito. And the right one is *Aedes albopictus*, also known as Asian tiger mosquito.

So *Aedes aegypti*, this one here, can be identified by the white bands on the hind legs and the distinct white (inaudible) shape marking on the body on the thorax like that. This is *Aedes aegypti*. It is from the tropics, and it is responsible for transmitting several diseases in humans and dog heartworm.

And *Aedes albopictus*, characterized by its black-and-white-striped legs and small black-and-white-striped body. And they are native to the tropical and subtropical areas of southeast Asia. However, in the past couple of decades this species has spread to many countries through the transport of goods and international travels.

Asian tiger mosquito, *Aedes albopictus*, arrived in the U.S. as eggs or larvae in cargo and now is established throughout the east and mid-west of the United States. It is a possible vector for dengue, dog heartworm, and encephalitis, and it can breed in small water containers like *Aedes aegypti*, which it is out-breeding in some areas. And they can utilize containers in any sizes. And they are also active during the daytime. Astonishingly beautiful mosquito here.

So here is image with a bucket of water and some black dots in the water. And people will see that as dirt. So here is verification. No, it's not dirt. It is eggs of the mosquito. It's eggs of *Aedes albopictus*. So they're everywhere in this little container. On the sticks, on the surface of the water, and on the sides of the containers. They are very good container breeders. And also some of the eggs were hatched. Some of them were delayed for a while based on the temperature.

So this is *Aedes aegypti*, yellow fever mosquito. Originally from Africa, it's now found throughout most of the southeast United States, and their larvae will thrive in any stagnant water around cities or homes from old tires to gutters. And they are really sensitive to cold, and overwinters by leaving eggs to hatch when warm weather returns. So they can go from egg to adult in ten days when temperatures are hot. Think about Arizona, and think about *Aedes aegypti*.

It prefers to bite in the morning or late afternoon rather than at night. And also they will choose people over animals. And they are the vector for dengue and chikungunya.

So this is a comparison between those two *Aedes* mosquitoes. *Aedes aegypti* prefers hot, dry environment, and they are more desiccation resist and they also like to live in urban area. *Aedes albopictus* prefers rural, suburban and a vegetated urban habitat, for example parks. And they also they like the new low nutrient natural resource in our midst.

For both mosquitoes, their larva breeding and adult resting sites are typically outdoors. So in that case the screen and the air conditioning can prevent the indoor breeding, so that's a very good way to prevent mosquitoes inside.

And they vector chikungunya, dengue and Zika virus. So because those virus are pretty new new virus, so the best way is to prevent, detect and respond. So work with your state department of health services when you have diseases like this.

Mosquito-borne diseases impact the health of Americans every year. So this year brings additional concerns due to relatively new, such as Zika, and also reemerging disease issues.

So first let's talk about West Nile Virus. West Nile Virus was first detected in North America in 1999, and now it's the most commonly occurring mosquito vectors affecting humans in the United States. And West Nile Virus is a mosquito-borne virus contracted through mosquito bites, and primarily the *Culex* mosquitoes. And the bites generally happen at dusk and dawn, indoors, in shady areas, or when the weather is cloudy. People of all ages can contract the virus. About 20% of those who contract West Nile Virus will come down with what is called West Nile fever. And the other 20% of those really only show

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mild symptoms of the virus. And less than one percent of infected people develop a serious, sometimes fatal, neurologic ailment.

So this is a map of West Nile Virus activity by state. As of January 2016, a total of 48 states and the District of Columbia have reported a West Nile Virus infection in people, birds or mosquitoes in 2015. And overall, 2,060 cases of West Nile Virus disease in people have been reported to CDC. And of this, 66% were classified as neuro-invasive disease, such as encephalitis, and 34% were classified as non-neuro-invasive disease.

So, chikungunya. First we have to clarify chikungunya is not a chicken disease. When that first came out on the radio people were wondering, it was like, oh, yeah, there's a new chicken virus coming out. No, chikungunya means (inaudible) up generally associated with the pain of your joints. It's a arthropod-borne virus transmitted by *Aedes* mosquitoes. And it is relatively new to the United States.

Outbreaks have occurred in countries in Africa, Asia, Europe and the Indian and the Pacific Oceans. In late 2013, chikungunya virus was found for the first time in Americas Island in Caribbean, and there is a risk that the virus will be imported to new areas by infected travelers. So the CDC and the Pan America Health Organization have developed a preparedness and a response plan available at its website. So if you would like to know more information about chikungunya, check the website.

The most common symptoms of chikungunya virus infection are fever and joint pain. Other symptoms may include headache, muscle pain, joint swelling or rash. So generally there are two phases for chikungunya infection, and acute phases generally last a few days to a couple of weeks. And the symptoms are fever, chills, vomiting, nausea, headache. They generally can last five to seven days. In chronic phase, also when the case is really severe, the joint pain may last up to two years. And also 90% of infected adults are symptomatic and most become disabled for weeks to months.

Thus because chikungunya is rare, the serious complications include encephalitis may happen.

So this map shows the countries and territories where chikungunya cases have been reported. And this happened in 2015. So there is no vaccine to prevent or medicine to treat chikungunya virus infection. And as you can see, all those areas have chikungunya infection – active chikungunya infection. So when travelers go to those areas, they can protect themselves by preventing mosquito bites. So when traveling to countries with chikungunya virus as shown on this map, the most important thing to use is insect repellent. And when you go outdoors, wear long sleeves and pants. And also stay in places with air conditioning or places that use window and door screens. They can lower your chances for chikungunya infection.

And this is a map for the United States. And this is 2014 map, and a total of 2,811 chikungunya virus cases were reported. And 12 – here's 12 locally-transmitted cases were reported from Florida. And all other cases occurred in travelers returning from the affected areas.

And this is a map for the 2015, the distribution of chikungunya, and a total of 679 chikungunya virus disease cases have been reported from 44 U.S. states. And all reported cases occurred in travelers returning from affected areas. And no locally-transmitted cases have been reported from the United States, which is good.

So dengue. Dengue is caused by any one of four related viruses transmitted by mosquitoes. Every year there are as many as 400 million people are infected. Dengue has emerged as a world-wide problem only since the 1950s. although dengue rarely occurs in the continental United States, it is endemic in Puerto Rico and in many popular tourist destinations in Latin America, southeast Asia, and the Pacific Islands. And *Aedes aegypti*, this mosquito is the most important vector for dengue virus.

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So this is a global dengue map. Here it says almost 1,500 alerts for the past three months. So as you can see, with more than one-third of the world's population living in areas at risk for infection, dengue virus is a leading cause of illness and death in the tropics and the subtropics.

So, for the United States, this map shows areas at risk of dengue outbreaks in the United States based on the distribution map of the two primary mosquito vectors, *Aedes aegypti* and *Aedes albopictus*. So as you can see, half of the U.S. are in the potential dengue outbreak areas.

So dengue fever, generally, if you are infected, dengue fever includes high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, and mild bleeding. And also those symptoms can vary individually. Another severe symptom is dengue hemorrhagic fever, called DHF, and this can be fatal. And generally you'll see the symptom of fever lasts from two to seven days. And also when the fever declines, the patients will suffer persistent vomiting, severe abdominal pain, or the difficulty to breathe. So when infected with dengue, early recognition and prompt supportive treatment can dramatically lower the risk of medical complications and even death.

So Zika. Zika is a viral disease transmitted by mosquitoes and first isolated in Uganda in 1947. The Zika virus is related to dengue and the West Nile viruses. Prior to 2015, Zika virus outbreaks occurred in areas of Africa, southeast Asia, and the Pacific Islands. In May 2015, the Pan American Health Organization issued an alert regarding the first confirmed Zika infection in Brazil when an outbreak in Brazil was linked to a dramatic increase in cases of babies born with microcephaly and the currently Zika cases occurring in many countries.

Zika virus is transmitted to people primarily through the bite of an infected *Aedes* mosquitoes, like *Aedes aegypti* and *Aedes albopictus*. And these are the same mosquitoes that spread dengue and the chikungunya virus. And they are day biters and they live near people, and only the female mosquito will bite. And they can also bite at night. And the confirmed cases also proved that Zika virus can also be transmitted from mother to her fetus during pregnancy. Also through blood transfusion and through sexual contact. And this case has been confirmed from the traveler in Texas.

And generally about one in five people infected with Zika virus will become ill. And the most common symptoms are fever, rash, joint pain, and/or red eyes or conjunctivitis. And other symptoms include muscle pain and headache.

And the illness is usually mild with symptoms lasting for a few days to a week. And severe disease symptoms requiring hospitalization are very uncommon, and death due to this virus is really rare. But the main health concerns are related to pregnant women and the impacts on the developing fetus. So the question is, does Zika in pregnant women cause birth defects? So Brazilian communities have experienced a significant number of Zika cases since May 2015. And officials also noticed an increase in the number of babies with microcephaly. Microcephaly is a neurological condition in which the brain develops abnormally in the womb and the infant's head is smaller than the head of other babies of the same sex and age. But additional studies are needed to determine the degree to which Zika might be linked with microcephaly.

Because of the possible association between Zika infection and microcephaly, pregnant women should take steps to prevent mosquito bites. And pregnant women should also minimize their exposure to pesticides. And the CDC has guidance for healthcare providers caring for pregnant women and the women of reproductive age at this website. So if you would like to know more about Zika and microcephaly, go check the website.

This is a map of areas with active Zika infection. And it is really important for pregnant women to see a doctor if they develop a fever, rash, joint pain, or red eyes during or within two weeks of traveling to a country where Zika has been reported.

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So this is a comparison of those four pathogens. As you can see the virus for West Nile is flavivirus, and the Culex mosquito are the primary mosquito, and they're incidental, the human hosts are incidental because they prefer birds and mammals. And also less than 20% of the people were showing symptoms and less than one percent that would develop chronic symptoms. And less than one percent fatality. So for West Nile virus, fever, headache, body aches, skin rash, and swollen lymph nodes.

And the chikungunya. Aedes mosquitoes are the primary vector for chikungunya. And humans are the first primary host. And 72 to 97% of the people who are infected will show the symptoms, in which 30 to 40% would develop to a chronic condition. But the fatalities are really low for chikungunya. So the symptoms are headache, muscle pain, joint swelling and rash.

So here are very important for West Nile Virus. Less than 20 will show symptoms. But chikungunya, once you get it, chances are you will show symptoms and half of the chance will develop to the chronic condition.

Here is dengue. Dengue virus, Zika virus and the West Nile virus are the same virus. And they are transmitted by Aedes. And the humans are the primary host. But for dengue, it can be 50% of people will show symptoms. And also the chronic condition are variable and less than one to 50% may become fatality, it depends on whether you are treated or not. And the symptoms are headache, eye pain, joint pain, muscle and a bone rash, nausea.

And for Zika, it's still investigating because it's a new disease, so we'll see how it goes. But because the potential association between Zika and the microcephaly, it really cause people have to be aware of it. And this is a comparison to know that.

So few mosquito-borne diseases have a vaccine, so the best method of avoiding illness is to protect yourself and your home from mosquitoes. So here are some tips, integrated pest management methods for mosquitoes.

So what is integrated pest management, and short for IPM. IPM is a sustainable, cost-effective and risk-reduction strategy that would be used to solve the pest problem with the least possible risk to people, property and the environment. So IPM is a patient and effective and safe way to manage mosquitoes. It's generally utilizes many techniques like the ones listed here instead of pesticides alone.

So the surveillance are very important. The goal of surveillance is to have overall understanding of the types of mosquitoes in order to properly address the pest concerns. It's good to know what are there, how many mosquitoes are there, and what species they are.

And the second one is source reduction. Source reduction is to eliminate mosquito breeding sites. Like we show the pictures earlier, the general public can do a great deal to eliminate artificial water reservoirs such as wash out the bird bath and pet water dishes, do not allow tires and cans to pile up, and rain buckets and ponds can be covered with insect screen or treated with BT tablets which kill the larvae. Here is an example called MosquitoDunks. It's a BT rinse. You can put it in the small water.

Also the larvicide are used to suffocate or kill the mosquito larvae while they are still in the water. So when they become adults, generally we use adulticides, and those are used to kill adults because mosquitoes can fly, and generally adulticides most times are pesticides, can be sprayed, either using the fogger or the particle mist blowers. And also biological control agents have been used to control the mosquito larval and the pupal stages, such as mosquito-eating fish or Gambusia can be used in the (inaudible) consumed water resources.

And in the end, finally, public education is most important because mosquito control also is community-wide control and needs to educate the public to reduce the conducive condition, eliminate containers that hold water in your yard or in your neighbor's yard, or in anybody's place you can see, and also recommend people to use repellent.

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So here is the key point of the mosquito management. You can avoid being bitten by infected mosquitoes, such as minimize mosquito numbers by eliminating breeding habitats around the home, by using the larvicide, or you can kill the adults by using adulticide. And also use a barrier treatment against the ones you miss. And some people always use repellent no matter where you go even though you go out for a very short time, remember to use the repellent. And also this is an item you want to share with all your friends, family, every people you know who forget the repellent, that's a very good thing to share.

So here are some useful resources you can use. CDC is great resource. Anything you would like to know more about those disease vectors, mosquitoes, check out the CDC website. And the USGS also have those map about those mosquitoes. It's good to know. And also your state universities or your state department of health services or extension offices, you can find all the materials about mosquitoes. This is an example. This is our University of Arizona website. We have mosquitoes. We have (inaudible) extension publications and any you can find on those websites. And also as to how to choose a repellent that fits your needs, go to the EPA website, and they have a page that kind of introduce all kinds of repellents that are good for your use. Check out the EPA website.

And I would like to thank my (inaudible) agencies, EPA and the USDA and also Arizona Pest Management Center for their support. And I'd also like to thank all the people here, Claudia, Jennifer, Nicole, for providing all the information in this presentation.

And this is my email address, so if you have any questions, please drop me a email and I will be glad to answer them.

Thank you so much, and don't forget to go to the chat room later if you want to talk with me.

Thank you.

Thank you, Lucy, and thank you, everyone, for attending today's presentation, Mosquitoes and Mosquito-borne Pathogens. On behalf of the National Environmental Health Association and our presenter, thank you for joining us today.