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Dengue and Dengue Virus in Florida[1]

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Introduction

The purpose of this publication is to introduce dengue (sometimes called dengue fever) the disease and its causative agent, dengue virus, to stakeholders, including the general public, mosquito control professionals, medical practitioners, and public health decision makers. Dengue is a viral disease that spreads from person to person via mosquito bites. Most people who contract dengue experience no symptoms or only mild, flu-like symptoms. In rare cases, severe dengue may result in hospitalization or even prove fatal if left untreated. Dengue is a major global health concern with around 390 million infections annually, a quarter of which show clinical signs (Bhatt et al. 2013; Yang et al. 2021). Endemic in over 100 countries (Figure 1; Yang et al. 2021), dengue imposes an estimated US$9 billion per year due to medical expenses and loss of productivity (Shepard et al. 2016).

Over the past several decades, dengue has become a major global concern. Its spread is exacerbated by urbanization, economic inequality, and climate change, all of which foster mosquito breeding (Murray et al. 2013). Additionally, globalization accelerates the rapid movement of both people and goods such as used tires, a favored mosquito larval habitat, allowing both the mosquitoes and the virus to spread. Together, these factors drive increased transmission of dengue. With no specific treatment for dengue and limited availability of vaccines, controlling *Aedes* mosquito populations is crucial to help reduce dengue risk (Deng et al. 2020; Silva and Fernandez-Sesma 2023).

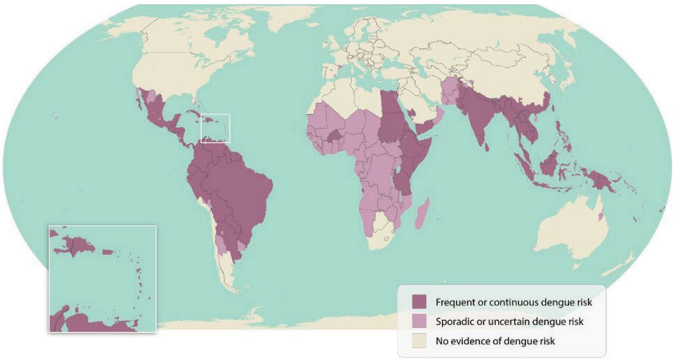

Figure 1. World map highlighting regions where there is available evidence of risk of dengue virus infection.
Credits: Centers for Disease Control and Prevention; https://www.cdc.gov/dengue/areas-with-risk/?CDC_AAref_Val=https://www.cdc.gov/dengue/areaswithrisk/around-the-world.html

Mosquito Vectors of Dengue

A disease vector is an organism (such as an insect) that transmits infectious diseases to other living organisms (such as humans). There are two main mosquito vectors responsible for spreading dengue: the yellow fever mosquito, *Aedes aegypti,* and the tiger mosquito, *Aedes albopictus* (Figure 2). They also transmit Zika, chikungunya, and yellow fever viruses. These mosquitoes lay their eggs in both natural and artificial water containers. Buckets, flowerpots, and discarded tires, as well as natural reservoirs like tree holes and coconut shells can all support larval mosquitoes. Mosquitoes undergo a four-stage life cycle. They hatch

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from eggs into larvae, which live in water, and go through several molts before turning into pupae, a non-feeding aquatic stage. Then, they emerge as flying adults, ready to mate. Female mosquitoes seek blood meals necessary for egg production. The preference of both species for human blood and their close association with human habitats facilitate their reproduction and the spread of viruses.

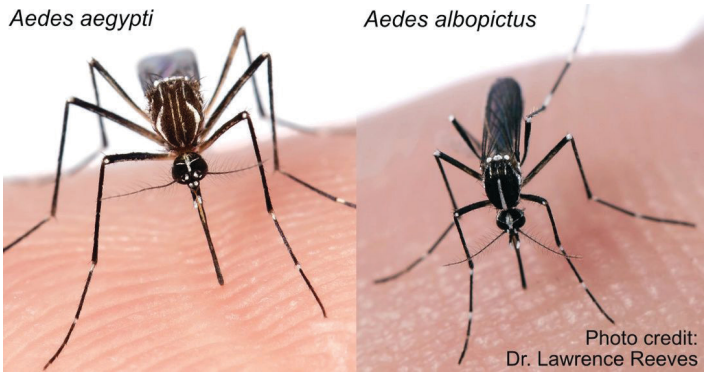

Figure 2. Two important insect vectors that spread dengue: *Aedes aegypti* (left), the primary dengue vector, and *Aedes albopictus* (right),the secondary or less important vector.
Credits: L. Reeves, UF/IFAS FMEL

Dengue Transmission Cycle

The dengue transmission cycle (Figure 3) begins when a female mosquito bites a person who is infected with dengue virus and ingests the virus. The virus then progresses through the mosquito's internal tissues, reaching the insect's salivary glands within 7–14 days. At this point, the infectious mosquito can infect new people when it bites them (Guzman et al. 2016). After a person receives an infectious bite, symptoms may develop in 4–7 days (Guzman et al. 2016) as the virus infects and multiplies within immune cells, spreading through the lymphatic system (Bhatt et al. 2021). Infected individuals can then pass the virus to new *Aedes* mosquito vectors, perpetuating the cycle.

Dengue Virus

Dengue virus belongs to a family of viruses called *Flaviviridae*. There are four different types of dengue virus, known as dengue serotypes 1 through 4, which are closely related to each other. These four dengue serotypes shape our immune response to infection. When a person is infected with one dengue serotype, that person develops lifelong immunity against that specific serotype but only temporary and partial immunity to the other three (Hussain et al. 2023). Antibodies produced after the first dengue infection can promote infection with the other serotypes, potentially leading to more serious illness, known as severe dengue (Bhatt et al. 2021). The unique interplay between the serotypes and the human immune system has made it difficult to develop an effective vaccine that simultaneously protects against all four dengue virus serotypes.

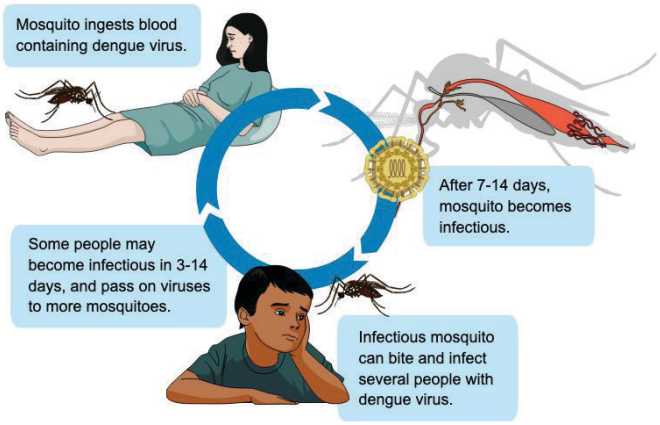

Figure 3. Dengue virus transmission cycle. The dengue virus is primarily transmitted from person to person via the bite of an infected mosquito vector.
Credits: P. Thongsripong, UF/IFAS FMEL

Signs and Symptoms of Dengue Infection

Most dengue infections are asymptomatic, but when symptoms occur, they are typically mild and include fever, headaches, body aches, eye pain, nausea, vomiting, and a rash (Figure 4; Wilder-Smith et al. 2019). Dengue can often be mistaken for other flu-like diseases. Recovery usually happens within 2–7 days. Severe dengue, although rare, can occur in patients who previously had dengue, young children, pregnant women, and those with chronic health conditions. Severe dengue manifests after the initial fever phase as abdominal pain, persistent vomiting, bleeding of the gums or nose, blood in stool or vomit, weakness of the body, rapid heartbeat, difficulty breathing, and dehydration (Wilder-Smith et al. 2019). Severe dengue requires immediate medical care.

Figure 4. The most common symptom of dengue is fever. Other symptoms such as eye pain, headaches, body aches, rash, and nausea/vomiting may also occur.
Credits: P. Thongsripong, UF/IFAS FMEL

Dengue in Florida

While dengue is not common in the continental United States, it is endemic in some US territories such as Puerto Rico, the US Virgin Islands, and American Samoa (Ryff et al. 2023). In the continental United States, most dengue cases are associated with travel, although sporadic cases resulting from transmission by local mosquitoes does occur in Florida, Texas, and other southern states (Rivera et al. 2020). Between 2010 and 2023 there were 2600 travel-associated dengue cases in Florida (Figure 5 and Table 1; the Florida Department of Health's Mosquito-Borne Disease Surveillance page at https://www.floridahealth.gov/diseases-and-conditions/mosquito-borne-diseases/surveillance.html). Most of these cases were detected in Miami-Dade County, but other hotspots include Broward, Hillsborough, Palm Beach, and Orange Counties. There was a total of 437 cases of local dengue transmission in Florida between 2010 and 2023. These local cases occur when a person is bitten and infected by an infectious mosquito while the person is in Florida. Local transmission of dengue occurred across 12 different counties. Most cases occurred in Miami-Dade and Monroe Counties, where conditions are favorable for the primary dengue vector *Aedes aegypti*. Notably, 217 of these cases occurred in Miami-Dade County between 2022 and 2023.

Since 2010, Florida recorded more than 200 dengue cases in 2019, 2022, and 2023 (Figure 6; Table 3). More than 50 local cases were recorded during 2010, 2020, 2022, and 2023. The local transmission season in Florida occurs between June and November, with a peak occurring between August and October. Low numbers of dengue cases have been observed in most other months. The vast majority of imported dengue cases detected in Florida have resulted from travel to the Caribbean, particularly Cuba and Puerto Rico, where dengue is endemic (Table 2). All four dengue serotypes have been detected in Florida since 2022, but which of the four is the most prominent dengue serotype fluctuates regularly. This is normal for dengue virus; it is common for multiple viral serotypes and genotypes to circulate simultaneously and for the circulating viruses to change over time (Alagarasu et al. 2021). Since 2012, dengue virus 3 has been the most commonly detected dengue serotype in Florida, accounting for about half of all cases. However, before 2022, both dengue 1 and dengue 2 were more common in Florida.

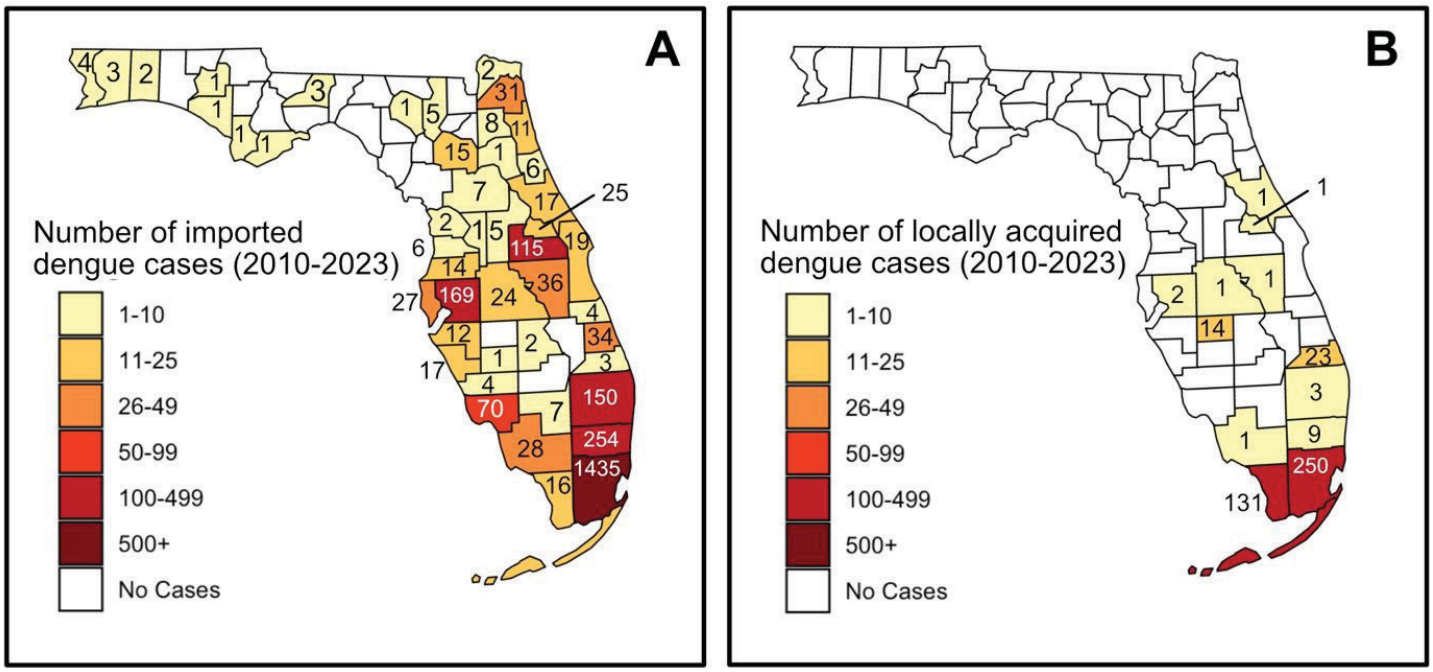

Figure 5. Map showing the number of imported (A; contracted while overseas) and local (B; contracted while in Florida) cases of dengue that have occurred in Florida, by county, between 2010 and 2023.
Credits: The figure was created using R (version 4.4.0, released 2024-04-24; R Core Team 2024) and RStudio (version 2024.04.1+748; Posit Team 2024), utilizing the usmap (Di Lorenzo 2024) and sf (Pebesma 2018; Pebesma & Bivand 2023) packages.

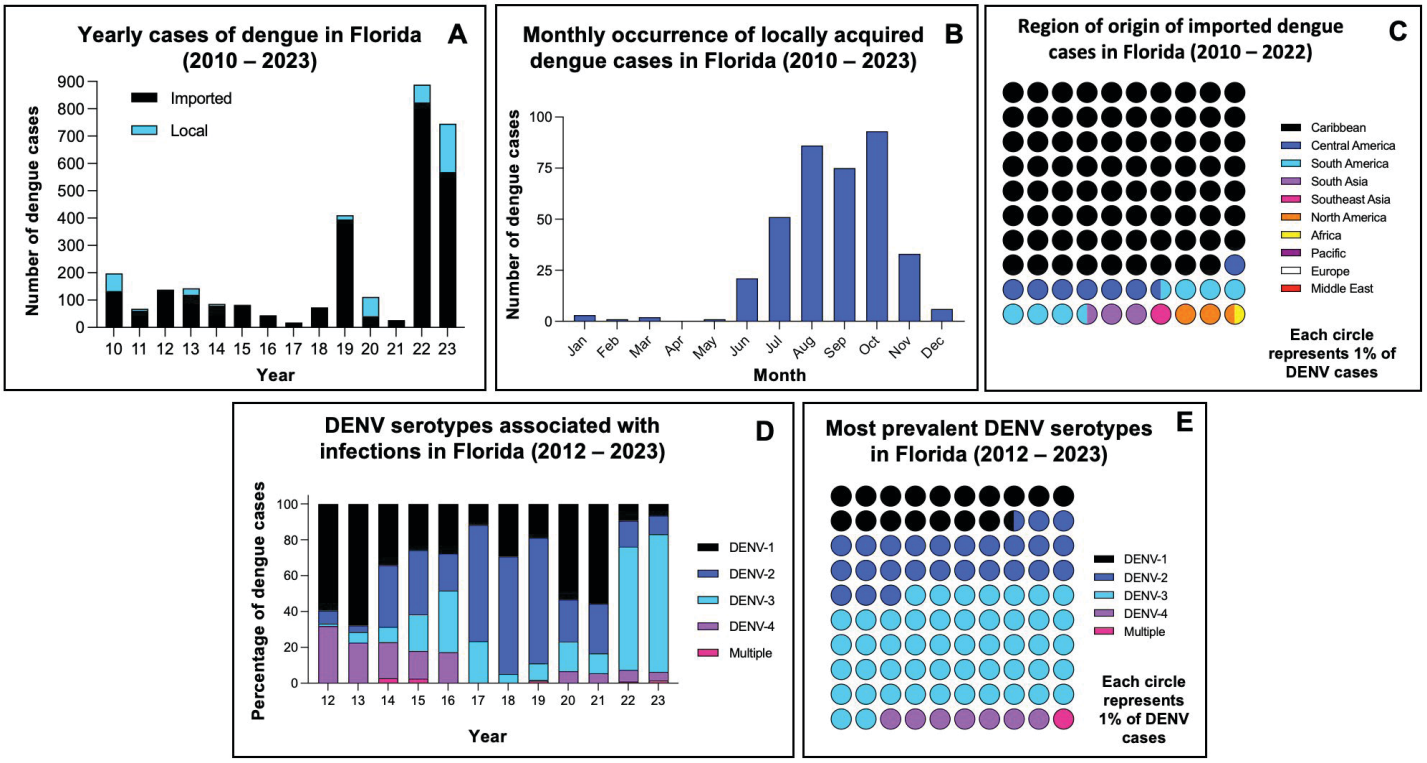

Figure 6. Descriptive information about dengue cases in Florida between 2010 and 2023. (A) The yearly number of imported (black) and local (blue) dengue cases in Florida (2010–2023). In most years, imported cases outnumbered locally acquired cases. Additionally, the combined number of dengue cases (imported and local) in 2022 and 2023 was much higher than in other years, exceeding 700 cases each year, whereas case numbers in other years ranged from under 100 to approximately 400. (B) The month of detection of local dengue cases (2010–2023) indicating that peak risk occurs between late summer and spring. (C) The origin of imported dengue cases in Florida (2010–2023) indicating that most cases are associated with travel in the Caribbean. (D) Yearly breakdown of dengue cases in Florida by dengue serotype (2012–2023). The distribution of dengue serotypes varied over time. For example, serotype 1 was predominant in 2012 and 2013, serotype 2 dominated from 2017 to 2019, and serotype 3 was most common in 2022 and 2023. (E) Breakdown of total dengue cases in Florida by dengue serotype (2012–2023). Overall, serotype 3 was most common. "Multiple" indicates that more than one dengue serotype was detected in that patient.
Credits: E. P. Caragata, UF/IFAS FMEL

Diagnosis and Treatment

Clinicians should test for dengue in patients showing clinical symptoms compatible with dengue illness and who have recently returned from regions where dengue is endemic. The choice of diagnostic assay depends on the timing of sample collection. Early on (e.g., less than 5 days after the onset of fever), dengue can be diagnosed via direct detection of the virus or its components such as viral RNA or NS1 antigens. Later, diagnosis typically involves a combination of tests to detect the NS5 antigen and IgM antibody (Guzman and Harris 2015). Cross-reactivity with other flaviviruses occurs when the patient has been exposed to other flaviviruses or vaccinated against flaviviruses such as yellow fever or Japanese encephalitis. Cross-reactivity can complicate results (Wilder-Smith et al. 2019). In such cases, further molecular and serological diagnostic testing for dengue and other flaviviruses may be warranted.

There are currently no antiviral drugs specific for dengue. Patients experiencing mild dengue are advised to remain well hydrated, to stay at home, and to avoid mosquito bites. Patients with fever and pain should avoid aspirin (acetylsalicylic acid) and nonsteroidal anti-inflammatory drugs, such as ibuprofen, because of their anticoagulant properties (CDC 2024). Severe dengue cases require close monitoring and medical assistance. Although there is no treatment for severe dengue, early detection and prompt medical care can lead to improve outcomes.

Prevention and Control

Effective prevention and control of dengue virus requires a multi-faceted approach involving both community participation and coordinated top-down public health strategies (Erlanger et al. 2008). One of the primary dengue controlling methods is to remove containers that could fill with water, thus eliminating standing water, where *Aedes* mosquitoes breed. When water cannot be removed, larvicides or biological control can be applied to kill larvae (Achee et al. 2015). Mosquito bites can be prevented through the use of insect repellents that contain EPA-registered active ingredients (e.g., DEET, picaridin, and oil

of Lemon Eucalyptus), long-sleeved clothing, mosquito nets and screens, and by remaining indoors during peak mosquito times.

Most Florida counties have mosquito control programs that implement Integrated Pest Management utilizing holistic approaches to suppress mosquito populations (Moise et al. 2020; Kondapaneni et al. 2021). These programs may apply targeted strategies like source reduction and aerial pesticide spraying to control mosquito populations during high-risk periods as warranted by surveillance data. These measures should be carefully managed to avoid environmental impacts and the development of pesticide resistance in mosquitoes. Ongoing research and development of dengue control methods offer hope for long-term prevention. Although their eligibility criteria are limited, the recent availability of the Dengvaxia CYD-TDV and Qdenga TAK-003 vaccines represent a critical step in the fight against dengue (Tully and Griffiths 2021). Biological control methods, such as the use of genetically modified mosquitoes or *Wolbachia* bacteria, are being explored as sustainable control method (Flores and O'Neill 2018; Utarini et al. 2021).

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Table 1. Number of dengue cases (imported and locally acquired) in Florida County from 2010-2023.

County	Imported cases	Locally acquired cases
Alachua	15	0
Bay	1	0
Brevard	19	0
Broward	254	9
Charlotte	4	0
Citrus	2	0
Clay	8	0
Collier	28	1
Columbia	5	0
DeSoto	1	0
Duval	31	0
Escambia	4	0
Flagler	6	0
Franklin	1	0
Gulf	1	0
Hardee	0	14
Hendry	7	0
Hernando	6	0
Highlands	2	0
Hillsborough	169	2
Indian River	4	0
Lake	5	0
Lee	70	0
Leon	3	0
Manatee	12	0
Marion	7	0
Martin	3	23
Miami-Dade	1435	250
Monroe	16	131
Nassau	2	0
Okaloosa	2	0
Orange	115	0
Osceola	36	1
Palm Beach	150	3
Pasco	14	0
Pinellas	27	0
Polk	24	1
Putnam	1	0
Santa Rosa	3	0
Sarasota	17	0
Seminole	25	1
St. Johns	11	0
St. Lucie	34	0
Sumter	1	0
Suwannee	1	0

County	Imported cases	Locally acquired cases
Volusia	17	1
Washington	1	0

Table 2. Number of imported dengue cases in Florida by region of origin (2010-2023).

Region	Cases
Caribbean	2042
Central America	190
South America	174
South Asia	65
Southeast Asia	33
North America	55
Africa	9
Pacific	4
Europe	1
Multiple countries/territories	27

Table 3 Yearly breakdown of percentage of dengue cases in Florida by dengue serotype (2012-2023).

Year	Dengue serotype 1	Dengue serotype 2	Dengue serotype 3	Dengue serotype 4	Mulitple serotypes
2012	59.42	7.25	1.45	31.88	0.00
2013	67.86	3.57	5.95	22.62	0.00
2014	34.29	34.29	8.57	20.00	2.86
2015	25.64	35.90	20.51	15.38	2.56
2016	27.59	20.69	34.48	17.24	0.00
2017	11.76	64.71	23.53	0.00	0.00
2018	29.31	65.52	5.17	0.00	0.00
2019	18.81	70.15	9.25	0.30	1.49
2020	53.33	23.33	16.67	6.67	0.00
2021	55.56	27.78	11.11	5.56	0.00
2022	9.36	14.39	68.85	6.42	0.98
2023	6.38	10.49	76.75	4.73	1.65
Overall	17.43	25.57	48.96	6.89	1.15