Association of Climate Factors and Dengue Case Counts in Florida

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Abstract

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Dengue fever (DENF) is a common arboviral disease globally that is caused by four serotypes of the dengue virus (DENV -1, -2, -3, and -4) and transmitted through the bite of *Aedes* genus mosquitoes. The incidence of DENF has grown substantially over time, from 505,430 cases reported in 2000 to the World Health Organization, to 6.3 million cases and more than 7,300 DENF deaths reported in 2023. Although historically DENF cases have been limited to tropical climates, new areas at higher latitudes could become at risk for DENF with the vector's habitable range changing as a result of climate change. One possible mechanism whereby changing climate could influence DENF patterns is via the reduction of extrinsic incubation period (EIP) of DENV. Our objectives were to: describe how climate in Florida affects the probability of *Aedes aegypti* mosquitos surviving the EIP, determine how mosquito survival and EPI length are related to DENF case counts in Florida, and to identify environmental conditions among states in the Southeast United States that may impact the probability of a mosquito surviving through the EIP of DENV. We created heat maps using Python code to graph the calculated probability that a

mosquito survives the EIP (PSE) against relative humidity and temperature with points representing the environmental conditions of each month in the three selected Florida counties averaged over the years between 2009-2024. Additional heat maps were produced for the five selected counties from Georgia, Alabama, southern Texas, and Louisiana using the same method as the Florida counties. We used Python to graphically display the relationship between PSE and DENF case counts for each Florida county of interest. Our results indicated that in all three Florida counties we investigated, from June to September, between 7 and 10% of *Aedes* genus mosquitoes will survive long enough to transmit DENV after becoming infected. We found that case counts in the three Florida counties appear to be closely correlated with the PSE curve. Given the average monthly PSEs over the year, every county we examined in Georgia, Alabama, Louisiana, and Texas also has the potential for yearly DENF outbreaks similar to Florida. Our findings suggest that climate factors like temperature and humidity influence mosquito survival and ultimately the time required for DENV to incubate within the mosquito. This raises serious concern about the impacts of climate change on vector-borne diseases such as DENF, and state and county health departments should be aware of how climate and travel patterns could influence the transmission of DENV amongst their state populations.

Introduction

Dengue fever (DENF) is a common arboviral disease found in the tropics and subtropics that is caused by four serotypes of the dengue virus (DENV -1, -2, -3, and -4) and transmitted through the bite of *Aedes* genus mosquitoes [1]. The incidence of DENF has grown substantially over time, from 505,430 cases reported in 2000 to the World Health Organization, to 6.3 million cases and more than 7,300 DENF deaths reported in 2023 [2]. The vast majority of DENF cases are asymptomatic or mild, leading to underreporting or misdiagnosis of the illness [2]. DENF can present with mild symptoms such as fever, headache, muscle and joint pain, nausea and vomiting, and a rash, but severe DENF may present with symptoms like severe abominable pain, rapid breathing, blood in vomit or stool, and extreme thirst, which require medical attention [2]. There is no treatment for DENF, and medical intervention typically focuses on symptom control and providing pain relief [2]. An individual may be infected with DENV multiple times, and each recurrent infection increases the risk of severe DENF [2].

Although historically DENF cases have been limited to tropical climates, new areas at higher latitudes could become at risk for DENF with the vector's habitable range changing as a result of climate change [3]. One possible mechanism whereby changing climate could influence DENF patterns is via the reduction of the extrinsic incubation period (EIP) of DENV. The EIP refers to the period of time between the acquisition of a pathogen by a vector and the vector's ability to transmit the pathogen to other susceptible hosts [3]. For DENV, the virus requires time to replicate and disseminate to the mosquito's salivary glands after being consumed through a blood meal before it may be transmitted, which indicates that both the EIP and the mosquito's survival are critical factors involved in the transmission of the virus [3]. There is evidence that warmer temperatures (above 10 degree Celsius) decrease the EIP of DENV, suggesting that the incubation period of the virus within a mosquito is temperature dependent [3]. In terms of adult *Aedes aegypti* mosquito survival, there is strong evidence that increasing relative humidity decreases the mortality hazard ratio, which compares the rate of death in adult mosquitoes exposed and unexposed to specific environmental conditions [4]. Increasing temperature is also associated with a slight decrease in the mortality hazard ratio of adult mosquitoes, but this effect only occurs until around 25 degrees Celsius. Temperatures above that show a sharp increase in the mortality hazard ratio [4]. A recent study provides further evidence that the incidence of DENF responds nonlinearly to temperature, increasing up to 27.8 degree Celsius (95% CI: 27.3-28.2) before declining at higher temperatures [5]. This evidence indicates that both high humidity and high temperatures (up to a threshold) improve the probability of survival for an adult mosquito, and potentially impacts the incidence of disease.

To date there has been little research on how the EIP and adult mosquito survival relates to case counts of DENF, particularly in the southern United States. Given higher than average numbers of DENF reported in the United States in 2023, alongside recent data from Morin et al. (2022) demonstrating that southern Florida is suitable for DENV transmission for a majority of the year (42 weeks) [6], there is an urgent need to better understand how climate could impact the burden of DENF in the southern United States.

This study will expand on the research conducted by Morin et al. (2022) by applying the models used to calculate the EIP, daily mosquito survival, and probability of adult mosquito survival through the EIP, to the state of Florida using contemporary climate data. Our specific objectives are to: describe how climate in Florida affects the probability of *Aedes aegypti* mosquitos surviving the EIP, determine how mosquito survival and EIP length are related to DENF case counts in Florida, and to identify environmental conditions among states in the

Southeast United States that may impact the probability of a mosquito surviving through the EIP of DENV.

Methods

Study Setting and Design

This is a descriptive study examining how climate affects mosquito survival, EIP, DENF case counts, and potential DENV circulation.

To assess the relationship between climate and mosquito survival and cases of illness, we used data from three counties (Martin, Monroe, and Miami-Dade) in Florida from 2009-2024. These three counties were chosen because they have the highest DENF case counts in the state, and they had reported cases during multiple years of the study period. Martin county was specifically included because in 2013 the county had a sudden surge of cases over multiple months, which was unique to that year alone.

To examine the potential for DENV circulation in other states, we chose five counties within Georgia, Alabama, southern Texas, and Louisiana based on the presence of major international airports. Since DENV is not endemic to the United States, outbreaks can occur due to travel from areas where DENV is endemic, such as Puerto Rico and South America. We selected Fulton County, Georgia, because it contains the capital city of the state (Atlanta) and Hartsfield-Jackson Atlanta International Airport is located in the adjacent county. We focused on Jefferson County in Alabama, because it contains Birmingham-Shuttlesworth International Airport. We selected Cameron County, Texas, because it has the southernmost airport in the state (Brownsville South Padre Island International Airport) and shares a border with Mexico, therefore experiencing a high volume of travel by vehicle and foot. Additionally, Cameron

County includes Brownville, Texas, which is adjacent to Matamoros, Mexico, which experienced a DENF outbreak in 1995 [7]. We selected Harris County, Texas because it contains George Bush Intercontinental Airport, which serves the greater Houston area. In Louisiana, we focused on Jefferson Parish, where Louis Armstrong International airport is located and neighbors the city of New Orleans.

Data Sources

We obtained data on DENF case counts from the Florida State Department of Health (DOH)'s electronic surveillance database Merlin, which hosts all data on cases of reportable disease, except for sexually transmitted infections. In Florida, all health care providers and laboratories are required by law to immediately report (within 24 hours) suspected or laboratory-confirmed DENF cases to local health authorities [8]. Lab confirmation of DENF can be either via polymerase chain reaction (PCR) or IgM antibody test [9]. Florida's disease surveillance system tracks both locally acquired cases (acquired in Florida) and imported cases (acquired outside of Florida). This distinction is determined through interview and examination of an individual's medical records to investigate if the case had traveled outside of the state two weeks before symptom onset. If the case had traveled outside of Florida in the incubation period for DENV (4-10 days) [2], the case is considered imported, and the county in which the individual sought medical care is recorded. For locally-acquired cases, the county where an individual was likely exposed to DENV is recorded.

We obtained average monthly temperature and relative humidity data for Florida and other states of interest from gridMET, which combines the spatial attributes from gridded climate data in PRISM with the temporal attributes of climate data from NLDAS-2 [10]. The data is updated and managed by the Climatology Lab at the University of California, Merced [10].

Analysis

Relationship between Florida climate and probability of Aedes aegypti mosquitos surviving the EIP

To calculate the probability of *Aedes aegypti* mosquitoes surviving the EIP, we used the following equation previously developed by Morin and colleagues:

$$\text{PSE} = \text{MSP}^{\text{EIP}}$$

where PSE is the probability that a mosquito survives the EIP, and MSP is the daily mosquito survival probability. We calculated the MSP using a set of equations developed by Schmidt and colleagues, which utilizes temperature and relative humidity. We calculated the EIP using a cubic spline fitted to the data presented in Tjaden et al. [3], which provides the length of the EIP measured at various temperatures using a collection of previous studies.

We used gridMET data to calculate the average monthly temperature and relative humidity within the three selected Florida counties for the years 2009-2024 to impute into the above-referenced equations.

We created heat maps, using Python, to graph the calculated PSEs against relative humidity and temperature with points representing the environmental conditions of each month in the three selected Florida counties averaged over the years between 2009-2024.

Relationship between mosquito survival and the EIP length and DENF case counts in Florida

We used Python to graphically display the relationship between PSE and DENF case counts for each county of interest. We calculated PSEs of each month over each year between

2009-2024 and aggregated monthly case counts between 2009-2023. Case counts for 2024 were not included due to the numbers not yet being finalized by the Florida State DOH. We used the graphical data to make qualitive assessments of the relationship between PSE and DENF case counts.

Southern states' climate and impact on mosquito survival through the EIP of DENV

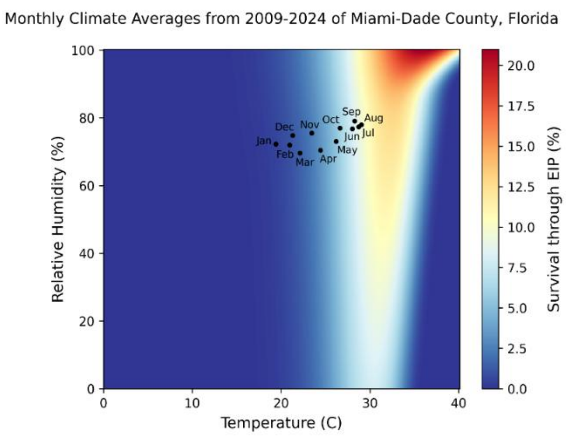
The existing model used to calculate PSE was also applied to the five counties we selected from Georgia, Alabama, Texas, and Louisiana with 2009-2024 climate data from gridMET. Each additional state had a heat map generated in Python, similar to Florida, to graph the calculated PSEs against relative humidity and temperature with the environmental conditions of each month averaged over 2009-2024.

Results

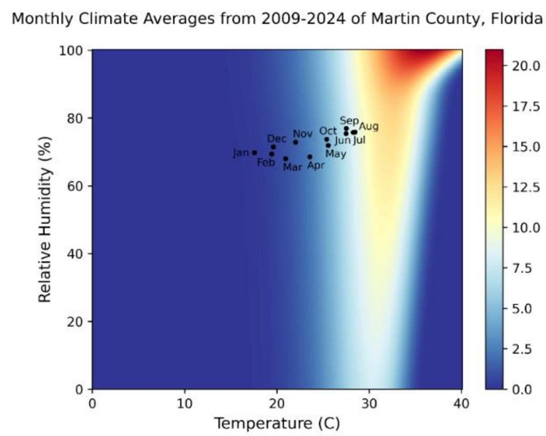
From 2009-2023, there were 3,435 reported cases of DENF in the state of Florida, with 502 cases being classified as locally acquired. Miami-Dade had a total of 1,904 cases of DENF, and 277 (14.5%) of these were locally acquired. Martin County had a total of 28 cases of DENF, with 25 (89.2%) being reported as locally acquired. Monroe County had a total of 177 cases, with 161 (90.9%) of those being locally acquired. For all three Florida counties, temperatures throughout the year ranged between 17 and 29 degrees Celsius on average, and between 68 and 80 percent relative humidity. August had the highest average temperature for all three counties, but September had the highest average relative humidity. PSE generally appears to increase with temp and humidity, although not exclusively.

Florida Heat Maps

Figure 1 displays the heat maps depicting average monthly temperature (Celsius) and percent relative humidity from 2009-2024 in each of the three Florida counties. The points representing the average monthly temperature and relative humidity of the three counties form a cluster in each figure, indicating that climate variations throughout the year in these Florida counties are not as extreme. Each counties' climate is also very similar to one another, which is to be expected given their geographical proximity in southern Florida.



A.



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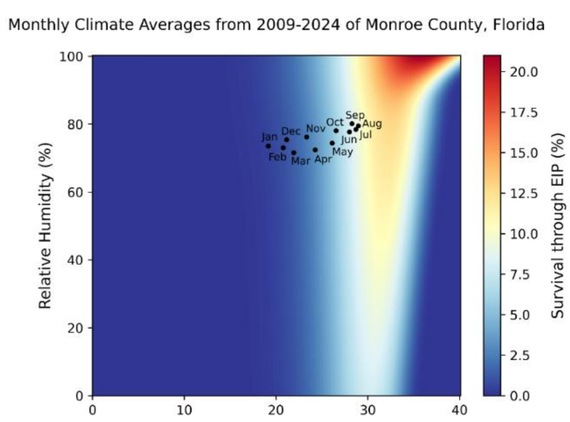

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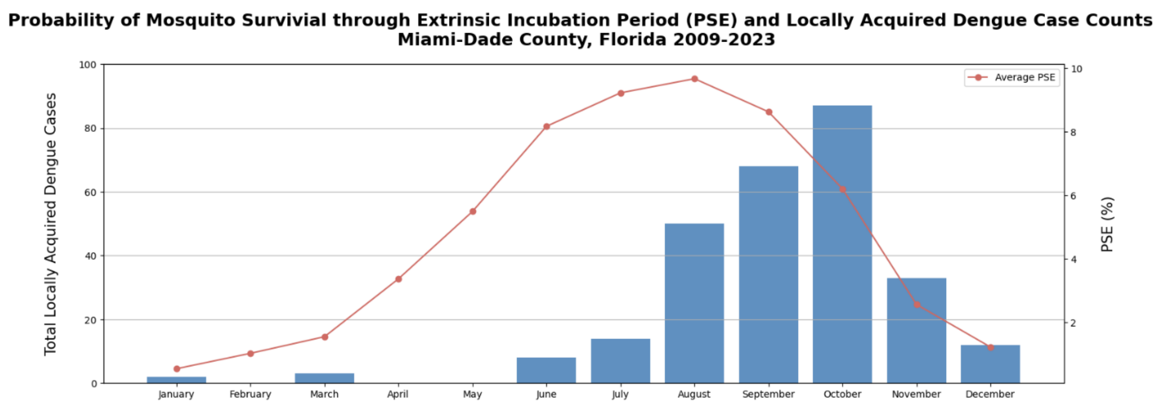
Figure 1. A. Heat map depicting average monthly temperature (Celsius) and percent relative humidity from 2009-2024 in Miami-Dade County, Florida to estimate PSE. B. Martin County, Florida. C. Monroe County, Florida.

When averaging monthly PSEs and aggregating cases across all three Florida counties, we found that 95% of the DENF cases occurred during a time when the PSE was above 2.2%. Based on these data, we considered a monthly PSE above 2.2% to be an "elevated PSE" for our study.

Figure 1A shows that Miami-Dade County has an eight-month window of elevated PSE (April-November), ranging between 2% and 10%. August had the highest PSE of this range with 9.67%, and November had the lowest at 2.56%. While some months had extremely low PSE, such as January with 0.54%, none of the months within the year had 0%. This indicates that while during some months the probability of a mosquito surviving the EIP is exceptionally low, it is never actually zero. This is true for every county that we investigated. Martin County (Figure 1B) has a seven-month window of elevated PSE from April to October, ranging between 2 and 9%. Similar to Miami-Dade County, August had the highest PSE at 8.81%, while October had the lowest at 4.48%. Monroe County (Figure 1C) shares the same eight-month window of elevated PSE as Miami-Dade from April to November, ranging between 2 and 10%. Like the other two counties, August had the highest PSE at 9.63%, and November with the lowest at 2.50%.

PSE and Case Counts

Figure 2 displays the probability of mosquito survival through the EIP overlaying locally acquired DENF case counts. The line depicting the average PSE for each month followed a similar standard curve for each county, as noted in Figure 1. This outcome was to be expected given Miami-Dade, Martin, and Monroe have few differences in their climates between each county.



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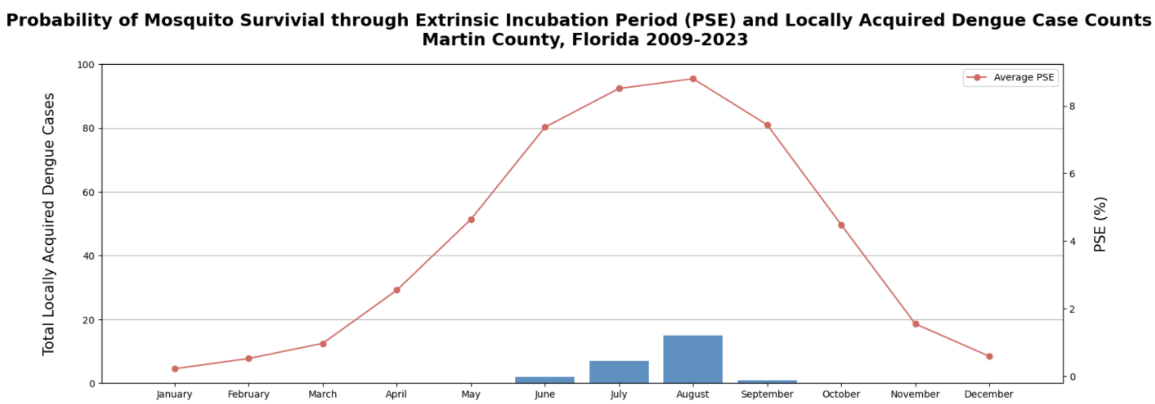

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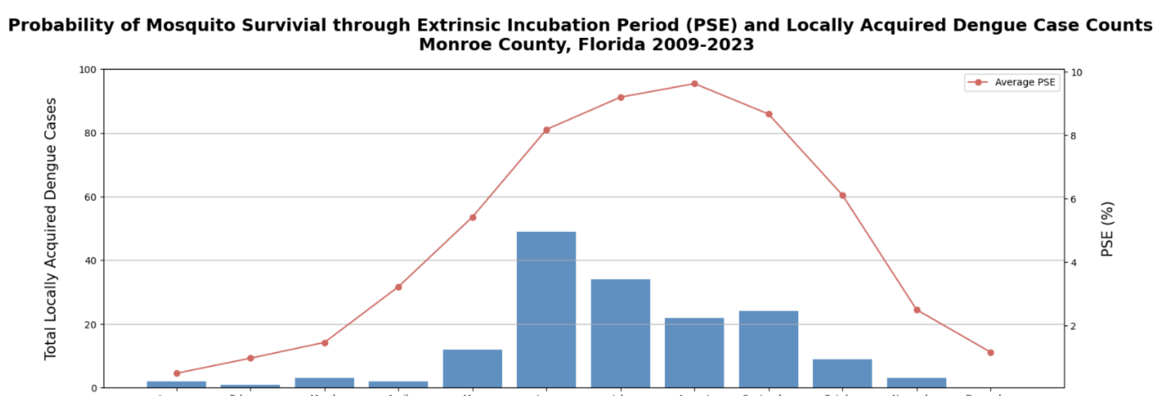

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Figure 2. A. Bar and line graph visualizing relationship between average monthly PSE and locally acquired DENF case counts in Miami-Dade County, Florida from 2009-2023. B. Martin County, Florida from 2009-2023. C. Monroe County, Florida from 2009-2023.

Miami-Dade had the highest total locally acquired cases of the three counties, with the month of October having the largest number of aggregate cases at 87 between 2009-2023 (Figure 2A). The case counts follow a standard curve shape with negative skew, with the peak DENF case counts occurring two months after the PSE peak in August.

Martin County (Figure 2B) had the lowest total case count of the three counties, with August being the month with the highest number of reported local DENF cases, acquiring a total of 15 cases from 2009-2023. There is no lag time in case counts peaking as observed with Miami-Dade, for the cases peak in August at the same time as the average PSE. Every recorded case within Martin occurred in 2013, with the exception of one case in July of 2011.

In Figure 2C, cases in Monroe County occurred more consistently throughout the year compared to Miami-Dade. We observed the most cases occurring in June with a total of 49 from 2009-2023, two months before the average PSE peak in August. This is opposite of the relationship we observed in Miami-Dade, where the cases peaked two months after the average PSE.

Georgia, Alabama, Louisiana, and Texas Heat Maps

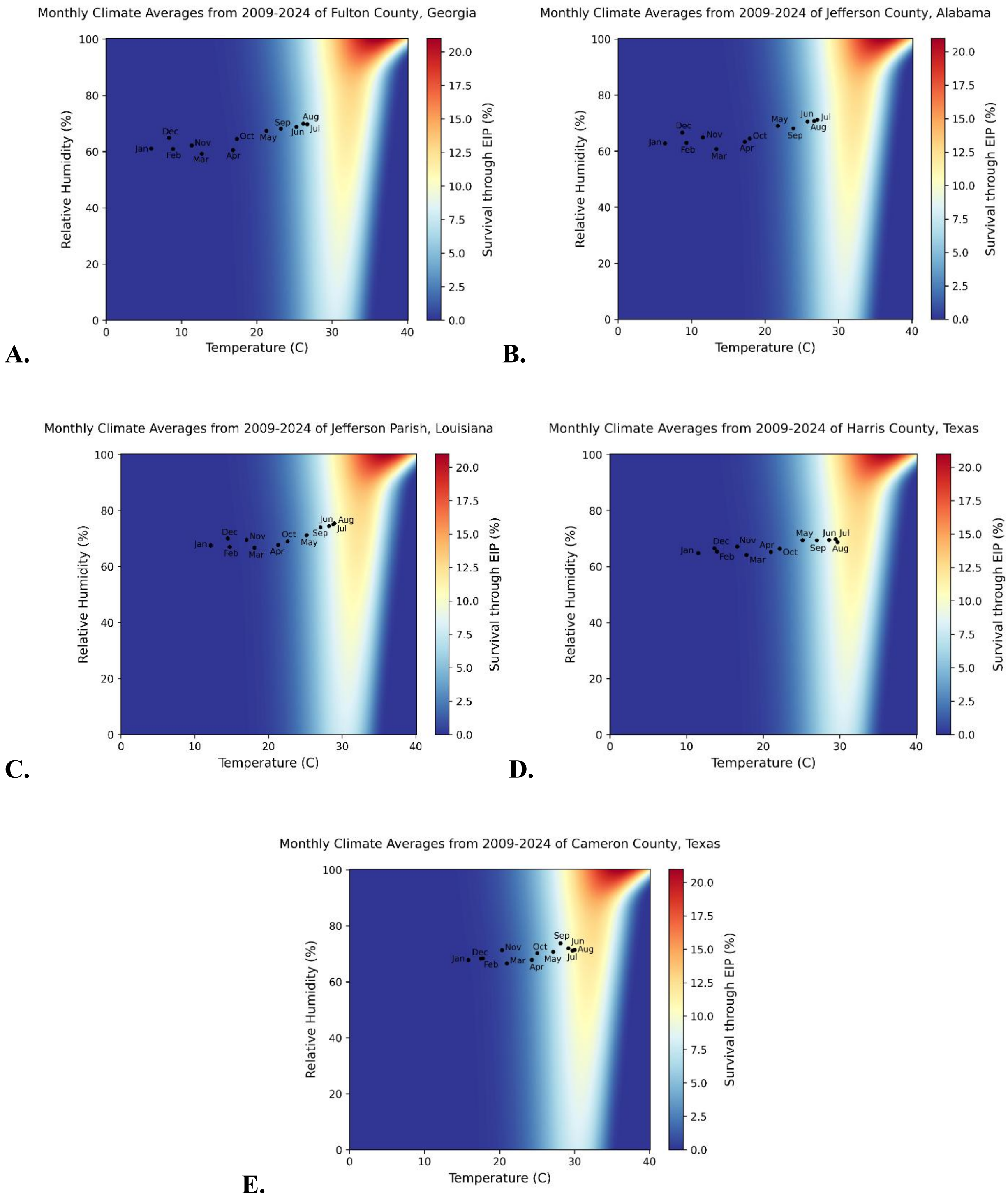

Figure 3. A. Heat map depicting average monthly temperature (Celsius) and percent relative humidity from 2009-2024 in Fulton County, Georgia to estimate PSE. B. Jefferson County, Alabama. C. Jefferson Parish, Louisiana. D. Harris County, Texas. E. Cameron County, Texas.

The heat maps depicting average monthly temperature and percent relative humidity for counties in four states outside of Florida are shown in Figure 3. Fulton County (Figure 3A) has a four-month window of elevated PSE relative to the other months in the year (noted by a PSE above 2.2%), three to four months shorter than Florida's counties, with the PSE percentage reaching a maximum of around 6.15% in July. However, August still had a relatively high PSE compared to the rest of the year at 5.44%. The climate variation throughout the year is also much more extreme than Florida, with the points resembling a line rather than a cluster. Like Florida, July and August are the months with the most elevated mosquito survival probability. We noted more extreme weather variation throughout the year in Jefferson, Alabama (Figure 3B) like Fulton, also with a four-month window of elevated PSE with the PSE being highest in July and August. The average PSEs of these two months are slightly higher than in Fulton, but July's PSE only reached a maximum of 6.77%. Jefferson, Louisiana (Figure 3C) has a five-month window of elevated PSE from May to September, with August's maximum PSE reaching 9.46%. We also observed slightly less extreme weather variation throughout the year compared to Fulton, Georgia and Jefferson, Alabama. Compared to all three Florida counties, we observed a higher average PSE in July and August for Harris (Figure 3D) and Cameron Counties (Figure 3E) in Texas. There is a seven-month window of elevated survival probability in Cameron County from April to October, with a maximum PSE 10.75% in August. This is the only county we investigated that had a PSE above 6% in May. Harris County had a five-month window of elevated PSE between May and September with a maximum of 10.32% in August. While these two counties still have more climate variation throughout the year than the Florida counties, we saw less variation throughout the year compared to the counties in Georgia and Alabama. The climate variation we see in Texas more closely resembles the one in Jefferson, Louisiana.

Discussion

In this study we used climate data and DENF surveillance data from Florida to describe how climate in Florida affects the probability of *Aedes aegypti* mosquitos surviving the EIP and to determine how mosquito survival and EIP length are related to DENF case counts. We found that there is potential in August for nearly 1 in 10 *Aedes* mosquitoes to survive long enough in the climate of Miami-Dade and Monroe counties to transmit DENV after being infected. Case counts in the three Florida counties appear to be closely correlated with the PSE curve, with Miami-Dade County's cases experiencing a two month-lag time where cases peak two months after the PSE. We also examined environmental conditions in other states to determine how climate conditions may affect the probability of a mosquito surviving through the EIP of DENV. Cameron County in Texas had a seven-month window of elevated PSE from April to October with the most similar PSE range to the Florida counties. Our results indicate that climate conditions such as temperature and humidity are related to a mosquito's probability of survival and the length of time for DENV to incubate. Understanding how PSE differs by location and changes over the course of a year may also be helpful information for state governments when making decisions on how to combat mosquito populations during the warmer months, as well as how early to start and how long those interventions should continue.

Our results indicate that in all three Florida counties we investigated, from June to September, between 7 and 10% of *Aedes* genus mosquitoes will survive long enough to transmit DENV after becoming infected. Given that mosquito populations can grow to staggering numbers, this could contribute to a significant number of potential vectors for the virus in Florida. A previous study conducted by Morin et al. [6] discovered that a 1.2% probability or above of an *Aedes aegypti* mosquito surviving the EIP was associated with a greater than 50%

probability of DENF being reported in a Brazil municipality [6]. Although the PSE in Florida tends to fall off outside of the June to September window, the PSE remains above 1.2% for the majority of the year. The impacts of climate change and the warming of temperatures could produce a climate in Florida where the PSE remains above 1.2% for the entire year, and continues to increase every month. This value is close to the 2.2% PSE we found in the three Florida counties where 95% of cases had occurred, and indicates that DENV can persist and transmit to humans in detectable levels within the population even with a much lower PSE.

While we found that the average relative humidity does not very greatly between the months in each of the states we investigated, the average monthly temperature makes a substantial difference in the PSE. A previous study reported that the incidence of DENF increases up to 27.8 degrees Celsius (95% CI: 27.3-28.2) before declining at higher temperatures [5], and we observed the PSE also increase with an increase in temperature, which could align with a higher DENF incidence. Research focused on geographic transmission risk for DENV in Florida discovered that transmission potential was higher for *Aedes aegypti* mosquitos exposed to DENV-1 in Miami-Dade compared to Manatee County [11], located in Southwest Florida and further north than Miami-Dade. There was also a significantly higher transmission potential for DENV-4 in both Miami-Dade and Manatee County compared to St. Johns County in Northern Florida [11]. Southern Florida may be particularly vulnerable to outbreaks of DENF due to a multitude of factors such as climate, geographical location, lifestyle, as well as the volume of travel [12].

Florida typically sees a seasonal pattern of DENF outbreaks, with a peak in cases during the summer and declining during winter. DENV is not endemic to the state; therefore, the virus must be reintroduced to the state through travel of individuals from locations where DENF is endemic during a time where the climate allows vectors to sustain transmission. This indicates that along with climate, travel is also an important factor for local DENV transmission in the state of Florida. Miami-Dade County had significantly more cases than both Monroe and Martin counties, which could be due to Miami-Dade County having the largest population size of the three counties, and Miami city being a prominent travel hub with the presence of a large international airport. This latter hypothesis is also supported by the fact that Miami-Dade County was the only county out of the three in Florida we investigated where the majority of DENF cases were imported rather than locally acquired.

Travel may be related to the pattern of DENF cases that we observed. In all three counties, the DENF cases appear to follow closely to the PSE curve; however, Miami-Dade County demonstrates a two-month lag time from the peak of the PSE in August to the peak of the cases in October. This lag time in Miami-Dade could be due to several reasons. One hypothesis is that travel to the county was beginning to increase over the summer and allowed more potential for the virus to be introduced to the mosquito population. The virus would then need time to circulate and amplify within the mosquito population, then spread to humans. There is also additional time necessary for the infection to become symptomatic (unless the individual remains asymptomatic, and the likelihood of them being caught as a case decreases) and be diagnosed by a medical professional and recorded by the state health department. Martin does not have a lag time (the cases and PSE both peak in August). Monroe county's cases peak in June, two months before the PSE peaks in August. This pattern might also be attributable to when travel volume is increasing to the county, just a different travel pattern than Miami-Dade. There is also the potential that large outbreaks could result in a high mosquito control response, which would reduce the cases. A peak of cases in may induce an increase in mosquito control efforts in July and August, resulting in fewer cases. It is important to note that while PSE typically peaks in August, June and October both have average monthly PSEs that would be supportive of DENV transmission. Limitations of our data may also be affecting the case count curves, especially if one or two years contribute significantly more to the aggregate case counts (e.g., 2013 in Martin County and 2023 in Miami-Dade County). Aggregating the case count data does not provide a direct relationship between climate data and dengue fever, and monthly case counts do not provide information on if the cases were reported mostly at the beginning, end, or throughout the month. These limitations of the data can potentially obscure our results.

DENV is not endemic to the United States and requires reintroduction every year typically seen through travelers from regions where the virus is endemic. DENV introduced to a population through travelers is likely to result in further domestic spread and contribute to the occurrence of epidemics under suitable weather conditions [13]. Taiwan has seen imported dengue cases enter the country almost every month, which has not always resulted in a local epidemic, suggesting that the timing of imported dengue's introduction to the population has a considerable impact on local epidemics [13]. DENV is frequently imported into the coastal areas of Peru from the jungle regions where the virus is highly persistent due to environmental conditions providing suitable year-round mosquito breeding sites [14]. Although not a specific focus of our study, the 2013 outbreak of DENF in Martin County merits discussion. Very few studies have previously been conducted to investigate the origin of DENV that caused the 2013 outbreak in Martin County. A phylogenetic analysis was conducted of the E generegion from a patient diagnosed with DENV-1 in the 2013 Martin County outbreak and compared with other known sequences of DENV to determine where the strain circulating in the county had come from. The researchers concluded that the 2013 Martin County strain was distinct from a separate DENV-1 strain that was involved in the 2009-2010 outbreak in Key West, Florida [15]. The strain of DENV-1 in the 2013 Martin County outbreak was most closely related to the viruses from a recent expansion of South American DENV-1 strains into the Caribbean, and thus the 2013 Martin County outbreak was the result of a novel introduction of DENV-1 to Florida [15].

Based off of the average monthly PSEs over the year, every county we examined in Georgia, Alabama, Louisiana, and Texas has the potential for yearly DENF outbreaks similar to Florida. Each county had a window of elevated PSE at least four months long, with Jefferson, Alabama and Fulton, Georgia having the smallest windows and Cameron, Texas with the largest window at seven months. In addition to the shortest windows of elevated PSE, Jefferson, Alabama and Fulton, Georgia also had the lowest maximum PSEs. Along with the longest window of elevated PSE, Cameron County also had the highest average PSEs, higher than all the Florida counties as well, which provides some evidence that a DENF outbreak in this county could be very severe and persistent. While Harris County only had a five-month window of elevated PSE, the county had PSEs above 10% in July and August similar to Cameron. Thus, our study suggests that climate in some Texas counties could sustain mosquito survival incredibly well. The first locally acquired case of DENF in 2024 was reported in a resident of Cameron County, and there have been 40 cases of locally acquired cases of DENF in Texas since 2013 [16]. This is potentially problematic given that Harris County serves as a significant travel hub with the George Bush Intercontinental Airport. Texas also experiences high volumes of vehicle and foot travel in addition to air travel given its shared border with Mexico. Travel to the state from countries in South America with endemic DENF could create a scenario for a significant outbreak. This raises serious concern about the impacts of climate change on vector-borne diseases such as DENF, and state and county health departments should be aware of how climate and travel patterns could influence the transmission of DENV amongst their state populations.

Our study has several strengths. We visually represented how climate and PSE are related in Florida state, and took a novel approach of investigating how PSE and locally acquired DENF case counts within Florida are correlated. We used DENF case counts verified and provided by the Florida State Department of Health to ensure accuracy during this study. We also used climate data and DENF case count data from a roughly 14-year period, allowing us to calculate more accurate averages for monthly temperature and relative humidity and allowing us to incorporate more DENF cases covering a more expansive time range, increasing the external validity of our findings.

There are a number of important limitations. First, DENF case counts we received from the Florida DOH have some seasonal and yearly variation in accuracy due to changes in collection methodology, such as the increased emphasis put on PCR testing and syndromic surveillance methods by closer examination of emergency room visits, and identification of DENF cases (e.g., some providers may believe that DENV is not transmittable during the late fall and winter seasons and would not order a test). However, because we are using 14 years of DENF case count data, our study is relatively robust against this limitation. Second, the DENF case counts are likely an underestimate of the true number of DENF cases. DENF is often asymptomatic, and most people are not tested for DENV. For those who access healthcare, providers may not order laboratory tests that identify DENV. Given that we examined case counts relative to climate facts, we do not believe the under ascertainment of cases changes our findings. Third, our comparison of the PSE and DENF case counts within Florida was done visually, so there is a subjective component to interpretation due to the lack of quantification of these differences. Fourth, we used modeled climate data to represent conditions over the entire United States, but there is considerable variation in both temperature and humidity throughout the country. Fifth, DENF case counts were aggregated during our analysis of the relationship between PSE and cases in each of the Florida counties due to the small number of cases, and this prevented us from making a direct one to one comparison of dengue cases and PSE.

In conclusion, our findings suggest that climate factors like temperature and humidity influence mosquito survival and ultimately the time required for DENV to incubate within the mosquito. These factors directly affect the likelihood that a mosquito will be capable of transmitting the virus. Tracking how the PSE fluctuates throughout the year could provide valuable insights for state-level public health planning—informing when to begin mosquito control efforts, how aggressively to intervene, and how long those measures should be sustained during the warmer months. Understanding the average monthly PSE throughout the year could also help us identify the areas at increasing suitability for dengue transmission due to climate change.

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