Hello. Welcome to the presentation, "Correlation Analysis of Climatic Variables, Migration, and Dengue Cases in Southeast Florida." To ask questions about this presentation, join the presenter for a chat hour in the networking lounge. I would now like to introduce Brunilda Lugo.

Good day to everyone. I am Brunilda Lugo, PhD. I started my career as a microbiologist. I taught in universities and community colleges for more than 20 years. I also work with medical devices companies such as Stryker and Baxter Healthcare, for also a long period of time as a microbiologist and supervisor. I received my [Inaudible] degree recently in public health and my specialty is epidemiology. So I am going to start my presentation.

Now this presentation summarizes my study about the relationship between climatic variables and migration, with the appearance of autochthonous Dengue fever cases -- and autochthonous is also known as locally acquired Dengue fever cases -- in Southeast Florida. So I hope that with this presentation I can help better understand -- help my audience better understand how climatic factors, and other factors, can facilitate the spread of some vector-borne viral diseases.

Now in the next 35 to 40 minutes, I will summarize the study, starting with a brief background, explaining some of the aspects of the disease, the epidemiology of the disease in the mosquito. I also am going to talk about the objectives of my study, which research method and design I use for the study, how I collected the data, and what were my findings. A brief discussion of the findings of the study will follow, and in the conclusions, the interpretations of the study, of the findings. Finally, a brief discussion of the limitations of the study and my recommendations.

Now Dengue fever, a lot of people don't know what Dengue fever is, mostly in the United States. But today 40% of the world's population live in areas where there's a risk of Dengue transmission. Now Dengue fever is endemic, and as all of you know, endemic meaning is that it's mostly found in certain regions, at least in a hundred countries; in Asia, the Pacific, the Americas, Africa, and the Caribbean.

Now the World Health Organization estimates that 50 to 100 million infections occur yearly. Now Dengue is not endemic in the United States. Nearly all Dengue cases reported in the United States were acquired by travelers or immigrants from the tropic areas of the world. However, in 2009 locally-acquired Dengue fever cases were reported in Key West. Again, locally-acquired Dengue cases means that that disease was acquired in that region, in Key West, for the first time in decades. And then all those years after 2009, locally-acquired Dengue fever were reported. In 2010, '11, '12 and '14, Dengue case were reported in southeast Florida.

Here you can see a map. This slide shows a map of the geographic spread of Dengue fever. You can see some dots and those dots indicate the appearance of locally-acquired Dengue fever cases in those areas where it was fiercely absent and has shown up recently. And if you look at it carefully you can see that those dots are in southeast Florida, Hawaii, Galapagos Islands, Easter Island in the Pacific Ocean, and in the Atlantic Ocean Cape Verde in Africa.

Now the lines that you see, the undulated lines, these are very broad geographic distribution of the Aedes aegypti mosquito that is the vector of Dengue fever. And they're mostly limited by cold temperatures in the northern and southern hemispheres. Now several scientists argue that the mosquito may expand its geographic range when conditions are favorable. And the potential for expansion of the mosquito was demonstrated when the Aedes aegypti mosquito recuperated lost territories when, after that Pan American Health Organization ceased the campaign to eliminate the mosquito.

Now, Dengue fever is a viral disease and it's caused by four closely-related viruses. And this is the slide where I explain what Dengue fever is. So it's a viral disease, and there's four viruses that can cause Dengue fever. And these are classified as BNV, ENV, Dengue virus one, Dengue virus two, three, and four.

Now the classic symptoms of Dengue are high fever, severe headache, severe joint and bone pain, severe muscle pain, and sometimes a rash. Now these symptoms are self-limiting; that means that they

will go away. And the duration of the primary infection -- and primary infection is first infection with this virus -- is around seven days. So the only treatment for this viral disease is pain relievers, fluid replacement therapy, and rest, until the disease takes its course.

Now the problem with Dengue fever is a reinfection. The reinfection with any of the four Dengue fever viruses may cause Dengue hemorrhagic fever. And the symptoms of this one are very scary, because the symptoms include high fever, hemorrhagic manifestation, skin bleeding, mucosal bleeding, gastrointestinal bleeding, and decrease of platelets. Now this reinfection is fatal unless the patient is hospitalized. And then they will monitor and they will replace the fluid, et cetera, et cetera.

Now there are no vaccines for Dengue fever. There are no vaccines for Chikungunya fever. I'm sorry. For Chikungunya fever there's vaccines either. And Chikungunya fever is more like Dengue fever. And there's no vaccine for the new emerging disease called Zika. There is however a vaccine for Yellow fever.

Now the mosquito is the main vector of all these four viral diseases. Here is a photo of the Aedes aegypti mosquito. And this mosquito is a very effective vector. The domestic variety has evolved to live in close proximity with humans and their dwelling. The close association with humans have provided opportunities for the mosquito to adapt and exploit a variety of sites for the oviposition. The oviposition is the egg laying. And the development of the larvae. Now this adaptable vector, as I mentioned before, also transmits the new emerging viral disease, Zika.

Now you can recognize the Aedes mosquito in this photo with the white markings on its legs. Now only the females bite for blood, and they feed at dusk and dawn, indoor or outdoors. So you can see that this mosquito is very adaptable and very effective. Now the female will require a blood meal from the host to produce from 100 to 200 eggs. In her lifetime she can produce five batches. And the eggs resist desiccation for six or more months. So these eggs can stay inside until the necessary environmental conditions are available. And these will undergo a lifecycle that can take more or less one to two weeks, depending on the temperature, water, and nutrients. If the female is infected with the virus, it will infect a host every time it requires a blood meal, increasing the probabilities of infecting different individuals in a short period of time.

So, for example, the female may get infected with the virus from a carrier of the Dengue virus with a blood meal. It will lay eggs. It will rest. It will go for another blood meal, infecting the other hosts. It will lay eggs. It will rest, and so on and so forth.

Now so the factors that need to be there for the emerging of Dengue fever in non-endemic regions, in regions where the disease was not there, climate conditions, rapid growth of relation through migration, and the migration -- the people that migrate are infected carriers, increase in the mosquito population, and lack of control of that population of mosquitoes, all these factors can contribute to facilitate the emergence of new vector borne diseases.

Now I found few studies about climate variables in Dengue cases in non-endemic regions. One of the studies I found was done in Taiwan, in non-endemic Taiwan. And the results indicated that without the appropriate weather conditions, no locally-acquired Dengue fever will emerge, even though the presence of imported Dengue fever cases. Other similar studies in non-endemic regions, such as China and Australia also found positive associations between temperature and effectiveness on locally-acquired Dengue fever cases.

So, as you can see, the purpose of this study was to find a correlation between temperature, precipitation, and migration, with the geographic expansion of Dengue fever in a region, and the region that the study was focusing on was southeast Florida. Now I will utilize the locally acquired Dengue fever cases as indicators of the geographic expansion of the disease.

The most appropriate study defined for this research was the Ecological Design. And I use a quantitative manner, and also I used archival secondary data for this study. The Ecological Design study, the population not the individual, and some ecological factors are variable. So in this study, the ecological

factors are obviously temperature precipitation. And there is also a social variable in its migration, and also known as imported Dengue fever cases.

I'm going to explain now the variables, so the dependent variables, and I have mentioned this before, it's a geographic expansion of Dengue fever. How I am going to measure that would be using the locally acquired Dengue fever cases. Those are going to be the indicators that Dengue fever is expanding geographically, so the appearance of locally acquired diagnosed Dengue fever cases in the areas where it was previously absent.

The independent variables are two climatic variables, temperature and precipitation, and then the social variable of migration; that is, diagnosed Dengue fever cases that were originated in other regions that are endemic, where Dengue fever is endemic. So if you hear in the presentation "imported Dengue fever," that is the same thing as migration.

Now, about the collection, the data of the Dengue fever cases, locally acquired or imported, was collected through the Florida Department of Health Website. Now these cases were diagnosed by a physician and corroborated by laboratory testing. Only these cases were used for my data collection, and they were also classified as imported or locally acquired. And I took all of those cases from these specific counties or regions. Monroe County in Key West was where locally acquired Dengue fever began, in 2009; Miami-Dade County, Broward County is Fort Lauderdale, Palm Beach County where is West Palm Beach, and you can understand those are the cities that know more; and then the Treasure Coast Region, and that particular region consists of three small regions; Martin County, St. Lucie, and Indian River.

Now the climatic data collection was mean monthly temperature, total monthly precipitation for 34 years. I used 34 years, or more than 30 years, because NOAA suggests and recommends, for studies of this caliber, in order to see differences in weather, you need to have more than 30 years of data, of climatic data. So I collected this data from the NOAA NCDC website, and I began to look for land-based stations in each of the counties, and they needed to fulfill my requirements of having data precipitation and temperature and more than 30 years of data. And it needed to be as close as possible of where they found the locally-acquired Dengue fever cases.

So the period of the study was from 1980 to 2013. After I collected all the data and had the okay of the reviewers, I used the SPSS statistical problem to run the data. And the first analysis I did was a bivariate analysis, and of temperature and locally acquired Dengue fever cases. Oh, and the result was a statistically significant relationship, statistically significant between the temperature and autochthonous Dengue fever cases. It was a weak correlation, but it still was significant.

And here you can see that I made a graph. This is a line graph. You can see in the Y axis of autochthonous Dengue cases, and in the X axis you can see the temperature. And here you can see how that the warmer it gets, the higher the number of locally-acquired Dengue fever cases. So there is a relationship between those two. So there was an increase of Dengue cases with increase of temperature.

Now I also did bivariate analysis with precipitation and locally acquired Dengue fever cases, and there was no statistically significant correlation between those two numbers, as you can see the numbers. And finally, a bivariate analysis between migration and imported Dengue fever cases, or imported Dengue fever cases with locally acquired Dengue fever cases. There was a statistically significant relationship these two variables, with a weak correlation, too.

Finally, I did my multivariate regression analysis. I wanted to find the predictors of the geographic expansion of Dengue fever, so I included imported Dengue fever. You can see it there on the graph, total precipitation and the monthly temperature, monthly mean temperature. So the appropriate analysis for the type of data that I have was the negative binomial regression analysis. So this regression analysis for modeling account variables, usually for overdispersed count outcome variables.

So the negative binomial regression can be considered as a generalization of the Poisson regression, because it has the same structure as the Poisson, but with an extra parameter to model the dispersion of

outcome variable. And the Poisson model was a very good model to use because it can deal with a lot of zeros, and that's what I really was facing, there was a lot of zeros because the outcome variable did not show up on until recently, so there was all these years of zero. So the Poisson was also okay to use it. But because this has a parameter for overdispersion, I decided to use the negative binomial results.

So according to the findings after I ran the negative binomial result analysis was that temperature, again, had a positive relationship between -- with locally acquired Dengue fever cases. And after the calculations, the results were that for every one unit of celcius increase in temperature, the rate of locally-acquired Dengue fever cases in southeast Florida increased by a hundred percent. However, when I look at the precipitation, and after I did the calculations for the precipitation results, there was a negative relationship between precipitation and Dengue fever, locally acquired Dengue fever cases.

And after the calculations, the results were that for every one unit of millimeters, "mm," increased in precipitation the rate of autochthonous, or locally acquired, Dengue fever cases decreased by .9%. These results were very interesting, very interesting, and the temperature was not as surprising, because, according to a lot of studies, temperature has a relationship with locally acquired Dengue fever. But here the precipitation -- the precipitation was related to relationship. The precipitation was related to the relationship.

Now the migration on imported Dengue cases was not a predictor. It was not statistically significant, so we cannot use imported Dengue cases as a predictor for southeast Florida. Now to better visualize the results of the multivariate analysis I produced this three-dimensional graph. And if you can look at the three-dimensional graph and think that it's like an open book, you see, with the XY axis having the autochthonous cases from 1 to 17, then in the floor you can see the monthly mean temperature going from 18 Celsius to 30+ Celsius. And then by its side, more or less, you can see the total precipitation. And the zeros are the farthest away from the temperature, and it will increase in hundred units, 100, 200, 300, and 500.

If you can visualize that as an open book, then you can see that in the 100 and 200 mm's of precipitation is the highest number of autochthonous Dengue case. And if you look at the temperature, you can see that that is true with the warmer temperature of 27 here, and 30-plus. So, here, what the data is telling you, that the increase of temperature and the decrease of precipitation results in an increase of Dengue -- autochthonous Dengue fever cases.

So we found in this study that an optimal range of temperature and precipitation is the perfect combination for the mosquito to thrive and for the virus to replicate. This range will predict the geographic expansion of Dengue fever in southeast Florida. Again, temperature, being the main determinant for the survival of the mosquito, and the optimal temperature will reduce the time of the lifecycle of mosquito to half. The mosquito will live longer with optimal range of temperature. The mosquito will bite more hosts, will infect more hosts, and will lay more eggs, increasing the population on the mosquito, increasing the Dengue transmission.

So the optimal range of temperature also will reduce the time of replication of the virus inside the mosquito. And because the mosquito lives longer, it will have time not only to replicate but to then, when the host is bitten, go to the host and infect the host. So this will increase, again, the Dengue transmission.

Now, precipitation we saw also a good range of 100 mm's to 500 mm's. We need precipitation because the precipitation will create breeding grounds, will increase the mosquito population, and also enhance the risk of Dengue fever transmission. So precipitation is needed.

Now in this study the main determinants for the geographic expansion of autochthonous Dengue fever cases were favorable weather conditions, the favorable range of temperature and precipitation. Imported Dengue fever cases is not a predictor. Predictors are temperature and precipitation in the optimal range. Again, so an optimal range was present in southeast Florida for the survival and the thriving of the Aedes mosquito. The optimal temperature also was there, and that permitted the fast replication and transmission of the virus.

Now the effects of precipitation -- in this case it's rainfall -- was complex. Precipitation events can increment vector abundance by increasing the availability of the breeding sites. However, heavy precipitation episodes can reduce mosquito abundance by washing away the larva from the breeding sites, by the site, by disrupting those breeding sites and washing away the eggs, so the locally acquired Dengue fever cases decreases.

And, again, the migration on imported Dengue fever cases are not predictors, but they are needed to introduce the virus into the ecology of the Aedes mosquito. So the carriers that come from endemic countries bring the virus and will introduce the virus to the ecology of the mosquito, and that virus will be there. With the appropriate optimal climate range, then locally acquired Dengue cases will emerge. If the climate is not appropriate there will be no locally acquired Dengue cases.

Now the data shows a movement, the autochthonous case of geographic expansion you see. You can see that in 2009 there was Dengue fever cases in Monroe County, in Key West, and then in 2010, locally acquired Dengue fever cases were recorded in Miami-Dade County. Not only in 2010, but 2011, 2012, and 2013. Locally acquired Dengue cases were also reported in Broward County, where Fort Lauderdale is, and then in 2010. And cases in West Palm Beach were reported in 2011, and locally acquired Dengue cases were reported in the Treasure Coast in 2013. So, as you can see, it began to appear that locally acquired Dengue cases in Monroe, and it went and expansion, geographic expansion to the north until the Treasure Coast.

The year 2014 was not included in this study; however there were locally acquired Dengue fever cases in Miami-Dade, and, surprisingly, 11 cases of Chikungunya in Miami-Dade County, Broward County, Palm Beach County, and Treasure Coast. This is suggesting that the Chikungunya virus had been introduced in the ecology of the mosquito.

Now the study faced limitations. The data used was secondary archival data. The ability of the Dengue cases depended a lot on the complete list and the [Inaudible] of the person that filled the report. So, and also the data of the temperature and precipitation that was collected from the NOAA NCBC website was more reliable in this case, because this agency, that its job, is to provide all sorts of valid data for researchers and other users. So the agency has quality control protocols in place, validation programs in place, validation to see that the land bases are working correcting, to see if they need to eliminate some of the land-based stations because they are obsolete. So they are always looking to have quality data available for the researcher.

Another limitation is under-reporting or over-reporting of Dengue fever cases. I mean, Dengue fever is still not very common in Florida. So the symptoms of this disease can vary from subclinical to mild flu-like disease, to a high fever hemorrhagic disease that can be fatal. The subclinical patients -- that means that they have the disease, but they don't have any signs and symptoms but they do have the virus in their system -- they don't feel sick, so they don't go and seek care from a physician. They don't. So these are not reported, but these are still carriers, and these still can provide viruses to the ecology of the mosquito. So these are not reported.

And the over-reporting can be when -- because some of the signs and symptoms of Dengue fever can be confused with other types of diseases. Other types of diseases can be confused with Dengue, so it can get an over-reporting, but this is less likely because those Dengue fever cases have to go through laboratory testing.

Another limitation was the lack of accurate data of the population or the distribution of the Aedes mosquito in Florida. The surveillance efforts of the Department of Florida is more focused on the Culex mosquito or other mosquitoes that transmit encephalitis. So they're very focused on those type of mosquitoes, not Aedes aegypti mosquito or the other type of Aedes mosquitoes. The traps that they use is mostly for other -- for mosquitoes that transmit encephalitis. So there's really not very accurate data of how the population of the mosquito is distributed in Florida.

And the last limitation is that I used an ecological design. However, ecological studies are used to explore possible relationships between available health statistics, in this case Dengue fever cases, and geographic locations, in this case southeast Florida, or environmental measures, in this case in this study it was temperature and precipitation. However, ecological analysis has a distinct advantage because of the statistical power to detect small risks, and that's what this study detected. The study detected that temperature and precipitation in the optimal range predicts locally acquired Dengue fever cases.

If the information is available to adequately assess population characteristics, relevant exposures, and the health outcome of interest, these studies can help identify potential problems. However, ecological studies are also known as correlation studies, and correlation in and of itself does not constitute a causal relationship between two or more variables. But it is one criterion for causality.

Now, to the best of my knowledge, this study is the first that explores the correlation of climatic variables, migration, and the cases in southeast Florida; however more studies are needed to research other factors that can influence the Aedes mosquito. Also, studies are needed to assess the change in population of the mosquito. It's necessary to gather data on the populations in the mosquito. This data could help assess the changes in the population of the vector and can be used to assess its relationship to the incidence and prevalence of the Dengue fever.

Studies haves found that the Aedes species are highly adaptable vectors that can thrive in diverse ecological conditions. So there is a tremendous potential for the direct expansion of the Aedes aegypti mosquitos in areas where climatic conditions are favorable, including regions in the United States. So leaving this important vector unchecked, we place multiple communities at risk.

And this concludes my summarization of my study. Thank you very much for your attention.