

History of Mosquitoborne Diseases in the United States

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Sarah Gregory] I have Dr. Max Moreno here on the phone with me today. Dr. Moreno is an Assistant Professor of environmental health science at Indiana University. We'll be discussing the history of mosquitoborne diseases in the United States. Welcome, Dr. Moreno.

[Max Moreno] Hello, Sarah, nice to be here talking to you.

[Sarah Gregory] What's going on with mosquitos that prompted the writing of your EID perspective on mosquitoborne diseases?

[Max Moreno] There is this growing concern about the possibility that tropical mosquitoborne diseases could be established in the United States. So, in this regard, there are certain reasons that worry people. The input is those reasons or factors is what prompted Dr. Turell and me to write the article. So, as the title implies, it has a lot to do with history. So, history has a lot to teach us about why the regional factors that would cause this apprehension would be a concern.

[Sarah Gregory] Would you give us a brief history of mosquito diseases in the U.S., then?

[Max Moreno] Sure. Malaria and yellow fever were prevalent in the United States during the 18th and 19th centuries. So, several outbreaks of malaria occurred as far north as Massachusetts since the end of the 18th century, throughout the 19th century. Malaria, particularly the subtropical southern states along the Mississippi Valley, especially during the American revolutionary war and the civil war, there are records of about 1,300,000 cases of malaria and about 10,000 deaths among soldiers during the four years of the civil war. So, since 1930, the United States government conducted efforts to control mosquitos by draining mosquito larva habitat sites. Those efforts have been undertaken, but seems that it works for the population of the rural South of the United States, who have lived today at a substantial reduction in malaria. That happened by the early 1940s.

So, in 1947, the National Malaria Protection Program and the Communicable Diseases Center of the United States Public Health Service started the operation that it's assumed that resulted in the elimination of malaria from the United States. The methods they used were mainly based on the application of DDT and the drainage of mosquito larva habitats. So, by the early 1950s, malaria was considered to be no longer endemic in any given area of the continental United States. After that, there have been reported 63 outbreaks, with only 156 of locally transmitted mosquitoborne malaria. But it is believed that those were caused by mosquitos infected after biting people that had acquired the pathogen in other countries.

So still, there is a concern because the three mosquito species that spread malaria in the United States before its eradication, they are still present, along with other anophelinic species in the United States. So, it is interesting to note that this period, starting in the early 50s, was also a period of economic boom in the country. It's just that this coincided with the usage of screened windows, air conditioning, television, and other enhancements characteristic of total socioeconomic conditions. It coincided with those periods of control made by the government, so even though they had already engaged in was activated through those mechanisms of control, it

has maintained very well the experience, despite improvement in socioeconomic conditions in the society. So, that's in regard to malaria.

In regard to yellow fever, there were epidemics in the northeastern United States, commonly happening as far north as Boston and Portsmouth in New Hampshire. So, even it has been proposed that the large epidemic of yellow fever in Philadelphia, Pennsylvania, in the summer of 1793, which resulted in about 5,000 deaths, was one of the reasons for which the nation's capital was moved from Pennsylvania to the city of Washington. Then, after 1822, yellow fever epidemics occurred mainly in the more southern cities of the United States. There were major epidemics in New Orleans, Louisiana in 1853, and Savannah, Georgia. There was also a great epidemic of yellow fever in 1878 along the Mississippi River, from the Gulf of Mexico to Memphis, Tennessee and St. Louis, Missouri, with about 16 or 20,000 deaths. Overall, there were reported at least 100,000 deaths of yellow fever in the United States during the period between 1693 and 1905.

So, in 1905 were reported the last locally acquired cases of yellow fever in the United States, specifically in Burlington, Mississippi and New Orleans. This was few years after the discovery, in 1901, that mosquitos transmitted yellow fever. Again, also here in yellow fever, it's important to note that open cisterns, usually indicative of poor living conditions, were common in the homes of the Mississippi gulf coast, for, during the centuries of time that those outbreaks happened—so, it, so again the coincidence between poor sanitation conditions and the prevalence of those diseases.

So, also important to note is that some common difficulties of yellow fever epidemics were the tendency for them to quarter in summer and fall, and in those cities with active trade with the Caribbean area. And the reason it is important to know this it's because today, with our increasingly global society, we have similar characteristics, not only in poor cities, but in all cities with airports, as we have also increasing number of travelers flying from tropical areas, especially during the summer season.

[Sarah Gregory] I understand from your article that social and economic factors, and from what you have just said, had an impact on mosquitoborne diseases in the U.S. So, tell us more about that.

[Max Moreno] Indeed. As I have previously mentioned, socioeconomic factors that determine in great nature living conditions, such as quality of housing, consistency of running water, usage of air conditioning, and other enhancements that make it more likely for people to stay indoors. So, these conditions determine the opportunity of contact between mosquitos and humans, and the accessibility of mosquitos to potential breeding indoor sites. So, by the time when malaria and yellow fever were prevalent in the United States, these conditions were very precarious. There was no prevalent use of screened windows. There was no running water, so the need to store water, which created breeding sites for mosquitos. There was no air conditioning, those windows were open, allowing access in and out of mosquitos, etc.

So now by these conditions determining the likelihood of contact between mosquitos and humans, they could consequently determine the likelihood for mosquitoborne pathogens' life cycles to be completed. But this would be the case as long as such cycles can only be completed in humans. As I meant, I was trying to mention, earlier probably, did mention, there are, there are

pathogens that has a particular stages that only can be completed, completed life cycles in humans. So, by depending exclusively on humans, they cannot complete their cycles when the good socioeconomic conditions allow good quality of housing that interrupt the contact between mosquitos and humans. Those species are known as anthroponotic pathogens, those that rely only on humans to complete the cycle.

So, pathogens such as West Nile virus, which life cycle can also be completed in animals, so these are also known as zoonotic pathogens, will then be less restricted by good living conditions, because they can, the mosquitos can have contact with animals and the cycle can be completed, even in conditions where humans are very, are well protected or more isolated from the mosquitos. The other diseases, the anthroponotic, those that depend on humans, they will be limited, if the opportunity of contact between humans and mosquitos, which is the only host where they can complete the cycle, can be done.

[Sarah Gregory] So, what's opening the door for zoonotic viruses? And maybe you can tell us here what zoonotic viruses are.

[Max Moreno] Ah well, zoonotic viruses are those who can be completed in animals other than humans, could be in humans, but also in other animals. The increasing globalization and the limited resources in developing and underdeveloped countries, the needed resources to control and prevent outbreaks caused by these type of pathogens, are windows that open specifically for the inclusion of zoonotic viruses. So, those conditions in developing countries are very important, and more important since the globalization, because the fact that those diseases are more prevalent in developing and underdeveloped countries, and those countries have not the resources to control or to prevent the outbreak of these diseases, then they could act as a likely source for the introduction of those pathogens into nonendemic regions, such as in the United States. Therefore, the more resources there are to prevent the spread of these diseases in the source, there will be consequently less chance for these pathogens to ever reach the nonendemic regions, such as in the United States. And those are more of a concern, as compared to anthroponotic pathogens, because they are not as limited for the good living conditions that are more prevalent in the United States. So they could stay, because they could be completed, their cycle could be completed in, in the wildlife.

[Sarah Gregory] Okay, so what's going on with new or novel viruses?

[Max Moreno] These viruses may have been known locally for a while, but the isolation of the communities more exposed to them has kept those viruses from reaching other regions. All this is changing with our increasingly global society. An example of this, the recent outbreak of chikungunya which was able to spread very quickly once introduced in new regions because of the lack of immunity in the receiving local populations. These pathogens are anthroponotic, as I described before, which explains why they were not able to establish in the United States, in spite of numerous introductions of cases into the United States. Because here the living conditions are good, generally good, then the contact between the mosquitos and humans was not enough to guarantee the establishment of those viruses.

The situation is more concerning when considering the potential neozoonotic pathogens because the transmission cycle of those pathogens could be completed in animals easily accessible in nature. As it was the case with West Nile virus, that even these mosquitos don't have much

access to bite humans, because they live under good housing conditions, they still can bite birds, so the cycle can be completed in this environment and the transmission cycle can keep going on. So, eventually if humans get out for a jogging or a hiking, they could get bitten and they could get the disease.

[Sarah Gregory] So would this also be true for chikungunya and dengue and. . .?

[Max Moreno] No, that would not apply to chikungunya and dengue because those are anthroponotic viruses. So it means that where in the natural environment where they were originally, in Africa, those cycles might have been able to be completed in primates, but since here in the states, there are not primates in the wild, those pathogens are limited to only humans as a source where they can be completed. So, if humans have good conditions of housing, because they have screening windows, because they have air conditioning so they don't open the windows, they have running water constantly, so they don't need to store water, so there is no pit inside for mosquitos. So, those mosquitos are not in contact with humans, or are in limited contact with humans, so then the cycle cannot continue. The cycle is stopped when they don't reach humans to be transmitted. In the other case, the cycle doesn't stop, because even if humans are not accessible to the mosquitos, still, birds are accessible to the mosquitos.

[Sarah Gregory] I see. So, putting all of this together, are there any conclusions and next steps?

[Max Moreno] Well, the emphasis should be placed on the design and implementation of the septic preparation plans, and even assuming that good living conditions could be maintained, then preparation plans to avoid the introduction of zoonotic diseases, such as Japanese encephalitis and Rift Valley fever viruses, because those show similar propensity as has been demonstrated already by the West Nile virus, which has been established already. So, history demonstrates, not only the already accepted importance of maintaining good living conditions has to be, it has to be kept in mind, but also the potential threat for the development of new pathogens from tropical origins, and also, in general, the risk of globalization. Therefore, the importance of paying attention to the public health of developing countries as a way to ensure the safety of local public health everywhere. So, it's not just looking at our public health, but looking at the public health of the potential sources of the spread of new viruses, which is developing countries most of the cases.

[Sarah Gregory] Well, Dr. Moreno, would you care to tell us about your job and your interest in mosquito diseases?

[Max Moreno] Yeah, sure. I am an assistant professor in the department of environmental health sciences at the Fairbanks School of Public Health at Indiana University in the IUPUI campus in Indianapolis. I teach classes related to whatever specific diseases, such as vectorborne diseases, and also teach classes on the use of technologies, such as geographical information systems and remote sensing in public health. And I do research, too. For my research, I apply those technologies, geographical information systems and remote sensing, in the study of the determinants of mosquitoborne diseases—not just schematic determinants, but lately, even more focus on physical characteristics that could be used as a proxy of cultural and socioeconomic conditions. In fact, my interest in these technologies, geographic information systems and remote sensing, came as a result of my interest in studying what created public health issues, such as vectors and other main active diseases.

[Sarah Gregory] Well, thank you so much, Dr. Moreno, for taking the time out of your busy day to talk to me. I've been talking with Dr. Moreno about his May 2018 article, History of Mosquitoborne Diseases in the United States and Implications for New Pathogens. Listeners can read the article online at cdc.gov/eid.

I'm Sarah Gregory for *Emerging Infectious Diseases*.

[Announcer] For the most accurate health information, visit cdc.gov or call 1-800-CDC-INFO.