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Tracking the spread of dengue fever: Domestic networks drive rapid transmission of human infection

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The mosquitoes that spread dengue fever tap into the domestic networks of humans, along with their bloodstreams, finds a study recently published in the *Proceedings of the National Academy of Sciences* (*PNAS*).

The data from Iquitos, Peru, shows that the trail of the most rapid transmission of human infections does not lead through large, public gathering places, as might be expected, but from house-to-house, as people visit nearby friends and relatives.

"It's common in a dengue fever outbreak to first treat public places like schools for mosquitoes, but our results show the focus needs to be on residential networks," says disease ecologist Gonzalo Vazquez-Prokopec.

Vazquez-Prokopec and Uriel Kitron, both from Emory University's department of environmental studies, conducted the spatial-temporal analysis as co-authors of the study, led by Steve Stoddard and Thomas Scott from the University of California, Davis. The research is part of a major, ongoing dengue project that also includes scientists from the U.S. Navy; the University of Iowa; Tulane University; San Diego State; and researchers in Peru.

"On a global scale, human air travel is known as a driver of dengue virus circulation, but this is the first time we've quantified the powerful

impact of human movement on the small scale of neighborhoods," Vazquez-Prokopec says.

The tropical disease is caused by a virus that is passed from the blood of one person to another through the bites of mosquitoes. Also known as "break-bone fever," dengue causes debilitating pain leading to the hospitalization of many sufferers. Severe cases can be fatal.

"It is vicious, and rapidly growing as a threat," Vazquez-Prokopec says.

During the last 50 years, the incidence of dengue has increased 30-fold and more than half the world's population is now at risk. The World Health Organization estimates that 50-100 million dengue infections occur each year. That number is expected to rise as the climate warms and the trend toward urbanization continues.

During 2009 and 2010, dengue fever emerged for the first time in decades in the contiguous United States, when an outbreak in the Florida Keys led to 93 cases.

The dengue virus is complex and has at least four different serotypes. Each time a person is infected with one serotype, it raises the risk that they will become more severely ill if infected by a different serotype.

"There is no vaccine for dengue. The only way to control outbreaks is to kill the vectors – mosquitoes," Vazquez-Prokopec says. Many of the places affected have poor public health infrastructure, he adds, so it's critical to identify the most effective places to spray for the insects.

A 2009 outbreak of dengue in Iquitos killed at least 24 people and drove almost 1,000 sufferers to the hospital, where cots had to be set up in stairwells and hallways to handle the flood of patients.

A city of 400,000 located deep in the Amazonian rain forest, Iquitos is essentially an island, only accessible by boat or plane. The city has high unemployment, and the housing is often substandard. Water is stored in open containers in crowded homes that lack air-conditioning, or even window screens. These factors make the homes havens for *Aedes aegypti* mosquitoes, the primary vector for the dengue virus. These mosquitoes feast almost exclusively on human blood, bite during the day, and have a limited flight range of about 100 meters.

To study how the dengue virus spreads through Iquitos, the researchers tracked and mapped outbreak patterns of two large neighborhoods, encompassing hundreds of homes, over several years. When a case of dengue was confirmed through a blood test, social workers would interview the patient, recording all the places the patient went during the 15 days leading up to the onset of fever. Mosquitos were collected from as many of these locations as possible and tested to determine if they carried the virus.

The data from interviews of 2,000 people was plotted over time and space using geographic information systems (GIS) technology.

"People appear to be getting infected most often in homes, but not necessarily their own homes," Vazquez-Prokopec says. "The main driver is people visiting friends and relatives in nearby homes."

Interviews with dengue patients revealed that two-thirds of them had visited the same location.

"We suspect that the importance of human movement that we observed in Iquitos will hold in other populations and for other pathogens transmitted by the mosquitos that spread dengue," Vazquez-Prokopec says. "The findings provide a different way for thinking about how a vector-borne pathogen may spread through a population, and have

implications for better disease surveillance and control."

Provided by Emory University