Zeroing in on 'super spreaders' and other hidden patterns of epidemics

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A study in Iquitos, Peru, is focusing on how asymptomatic human carriers contribute to the spread of dengue fever, transmitted by the Aedes aegypti mosquito. "This information is important," says Emory University disease ecologist Gonzalo Vazquez-Prokopec, "because Latin America is more than 80 percent urban and the *Aedes aegypti* mosquito is in every town." Credit: NASA satellite image

Ebola. Chikungunya. Zika. Once rare and exotic pathogens keep popping up and turning into household names. It's the new reality as the climate warms, humans expand more into wildlife habitats and air travel shrinks the distances across the globe.

"Africa and other parts of the developing world are undergoing rapid urbanization, so we are going to keep seeing more of these explosive epidemics," says Gonzalo Vazquez-Prokopec, a disease ecologist focused on mosquito-borne diseases in Emory University's Department of Environmental Sciences.

The complex properties driving today's disease transmission—and the speed at which an epidemic can travel—call for new methods of surveillance, Vazquez-Prokopec says. He is lead author on an opinion piece proposing a novel way of developing mathematical models of infectious diseases to uncover hidden patterns of transmission, recently published by *Trends in Parasitology*.

For example, he says, disease surveillance tends to focus on people with symptoms, but in cases of many mosquito-borne viruses—such as dengue, chikungunya and Zika—many of the people infected have no symptoms. And these asymptomatic carriers have the potential to infect others. They may even play the role of super spreaders—those who contribute the most to the transmission of the pathogen.

"There is a gradient in the manifestation of disease, from no symptoms at all to death," Vazquez-Prokopec says. "And during an epidemic of mosquito-borne disease, that spectrum of disease manifestation is coupled with variable factors such as the movement of people and mosquitoes and whether individual people are more attractive to the mosquitoes and get bitten more often."

The so-called 80-20 rule—80 percent of disease transmission events in

an epidemic are caused by 20 percent of people—is a well-established phenomenon. "We know this pattern is prevalent across disease systems," Vazquez-Prokopec says, "but we don't know the variations that combine to make someone a super spreader. We need to determine if each variable is just noise or is contributing to transmission in a predictable way, so that we can target interventions that have more impact."

The uneven contribution of certain individuals, locations or reservoir hosts to the spread of a disease is known as transmission heterogeneity.

Vazquez-Prokopec and his co-authors propose a framework that moves beyond investigations of single sources of heterogeneity and accounts for the complex couplings between conditions that have potential synergistic impacts on disease transmission. This framework aims to uncover whether there is a hidden, unified process underlying the significant levels of heterogeneity for any infectious disease.

"The time is right to embrace the full complexity of transmission dynamics," Vazquez-Prokopec says. "We now have enough baseline data, and the necessary computer power, to develop more complex models of disease transmission to help contain outbreaks."

Vazquez-Prokopec specializes in spatial analysis of disease transmission patterns and has several research projects for dengue fever ongoing in Latin America. His work in the city of Iquitos, Peru, for instance, is focusing on how asymptomatic carriers contribute to the spread of an epidemic. Dengue is spread by the same mosquito species, *Aedes aegypti*, that spreads the Zika and chikungunya viruses, so the data his lab is gathering has the potential for broader applications.

"The wealth of data that we've collected for dengue, combining the components of humans, pathogens, mosquitos and the environment, is

giving us a detailed picture of the complexity of disease transmission across an urban landscape in the developing world," Vazquez-Prokopec says. "This information is important because Latin America is more than 80 percent urban and the *Aedes aegypti* mosquito is in every town."

More information: Gonzalo M. Vazquez-Prokopec et al, Coupled Heterogeneities and Their Impact on Parasite Transmission and Control, *Trends in Parasitology* (2016). DOI: 10.1016/j.pt.2016.01.001

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