Mathematician models the spread—and prevention—of crime as a wave

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'It's not enough to crack down on crime without changing the attitude of the community,' says Stanford researcher Nancy Rodriguez.

(Phys.org)—Crime can happen anywhere, but it usually doesn't. Researchers have noticed that criminal activity seems to be concentrated in self-perpetuating hotspots. Crime leads to more crime. Then, from these epicenters, crime spreads outward through the community.

Mathematicians have a model they've used to study this kind of behavior. It's called a reaction-diffusion-advection system, and criminologists have found it a useful way to analyze issues like "near-repeat victimization" – the observation that single neighborhoods, and even single households, see a disproportionate share of crime.

Stanford mathematics postdoctoral scholar Nancy Rodríguez is particularly interested in what the model says about stopping these waves from spreading.

She's done this by looking at what mathematicians call the "gap problem" – how many resources need to be allocated to halt a wave in its tracks – and her solution may have implications for how we fight crime.

The paper, coauthored by Stanford mathematics Professor Lenya Ryzhik and Henri Berestycki of the Institute for Higher Studies in Social Sciences in Paris, will appear in the journal *Multiscale* Modeling and Simulation.

Called reaction-diffusion-advection systems because they incorporate a reaction that tends to propagate the wave, the diffusion that tends to kill it and the advection that transports it from one location to another, these mathematical models are used to analyze wavelike behavior in a number of fields. This approach makes appearances in research on the movement of invasive species, the propagation of genes and the spread of chemical reactions.

Other attempts to examine crime had, however, relied on a simplification.

"Previous analysis of criminal behavior models always assumed that the population was fundamentally pro-crime," said Rodríguez.

This choice is significant, because a crime wave spreading through a pro-crime population can't be entirely stopped. You end up, Rodríguez said, "always having crime everywhere."

The news is nearly as bad when the population has a neutral attitude toward crime. Although crime primarily persists in hotspots, waves of crime are just as unstoppable.

But if the population has an overall anti-crime stance – meaning that the population is more reluctant to engage in criminal activity – two outcomes are possible. High crime rates can spread, but so can waves of zero criminal activity. And, unlike in the other scenarios, high crime rates can be stopped by adding in a "gap."

In the world of the model, the gap is a stretch of space where the incentive to commit a crime is zero. This corresponds to real-life disincentives to commit crimes, such as an increased police presence, with longer gaps representing more anti-crime efforts.

Rodríguez found that a long enough gap – a large enough police crackdown, for instance – will completely contain a crime outbreak.

The research is theoretical and doesn't pretend to offer real-world suggestions about police strategy. But, she pointed out, the primary implication of the research is that police alone aren't the answer.

Because an anti-crime environment is necessary for waves to be stoppable in the first place, Rodríguez said, the model suggests that it's necessary to "change the perspective of the population."

"It's not enough to crack down on crime without changing the attitude of the community," she said. "It's not just that the more police presence you have, the better it is."

Provided by Stanford University