

Should I stay or should I go? Researchers look for ways to predict response to hurricane evacuation orders

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UD's Disaster Research Center is working to give emergency planners the information they need to develop better evacuation strategies. In this photo, taken Aug. 30, 2005, in New Orleans, people and vehicles are jammed up on the highways and ramps, trying to stay out of Hurricane Katrina's floodwaters.

Credit: University of Delaware

Millions of people will likely be in harm's way as a new hurricane season

unfolds in the United States. The National Oceanic and Atmospheric Administration predicts up to eight hurricanes in the 2016 season, and as many as four major storms with winds of 111 miles per hour or more.

What people do - or don't do - to get out of harm's way is of keen interest to disaster and emergency response officials.

Plans and contingencies work best when they are based on reliable predictions. Having a good idea of what people are likely to do, when they're likely to do it and how they are likely to go about it helps authorities choose the best [evacuation](#) strategy. It gives them useful information about what kind of traffic surge to expect and how best to steer it.

Researchers at the University of Delaware's Disaster Research Center have been studying evacuation data and predictors for years and have published two new papers that may help to improve prediction models used by emergency planners, leading to more efficient evacuations and possibly saving lives.

DRC includes scientists from multiple disciplines and collaborates with many others around the world. In these papers, they worked with researchers from Cornell University.

"It is an interdisciplinary project," said Rachel Davidson, professor of civil and environmental engineering and co-primary investigator with DRC Director Tricia Wachtendorf on two major National Science Foundation grants that have supported the study. "And we're working closely with practitioners to make a link from research to practice."

Sociologists, psychologists, engineers and meteorologists all have been part of the work, as have the Federal Emergency Management Agency, North Carolina State Emergency Management and the American Red

Cross, Davidson said.

The goal is to sharpen planners' insight on how many people may leave from a given area, when they are most likely to make their move and where they are likely to go.

It's not easy to guess what a human being will do. The brain processes many factors as it moves toward a decision - past experience, perception of risk and how it interprets present conditions, to name just a few. Those factors are hard to pin down in the best, most stable of times, let alone when the winds start to howl and the rain starts to pound.

Hurricanes, too, can be quite unpredictable, as evidenced by the ever-changing "cone of uncertainty" included in forecasts as storm systems approach.

But expansive review of data gathered in prior evacuations reveals patterns that can be analyzed and incorporated in regional models, based on mathematical predictions and controls, to strengthen the reliability of predictions in future storms.

That's what the two new papers show. Both draw on data from the eastern part of hurricane-throttled North Carolina, where the Outer Banks and other coastal areas have seen more than their share of evacuation orders.

One of the papers, published by *Environmental Hazards*, looks at demographic data to see which factors influence the decisions of various groups and their likelihood of evacuating when mandatory orders are issued versus voluntary orders.

"Social and environmental cues influence behavior," said Sarah DeYoung, postdoctoral researcher at DRC who was the lead author of

that paper and has just accepted a tenure-track position at the University of Georgia.

"But we understand, too, the temporal nature of that," Davidson said. "It's not like people make a decision on Day 1 and follow through with that. They see what happens and change their minds, too."

The study, based on survey data collected in 2011 through phone interviews with North Carolina residents in Wilmington, Raleigh, Jacksonville and the Outer Banks, looked at respondents' "threshold for evacuation" - whether they had a high threshold and were less likely to evacuate or a low threshold and more likely to evacuate.

Those lines moved a bit, depending on whether the storm discussed was a higher or lower category of strength and whether the evacuation order was mandatory or voluntary.

But in general, DeYoung said, white respondents had a higher threshold than non-white respondents, a finding that was particularly interesting given that other studies in the United States suggest that non-whites evacuated later.

"This was really notable for us," said Wachtendorf, associate professor of sociology and the lead social scientist on the research. "Is it that minority segments of the community are willing to leave but don't always have sufficient resources to do so? Is it because, as other research suggests, they have less trust in officials and, particularly after what happened after Hurricane Katrina, they believe they can't rely on officials if they stay? It really points to an area where more research is needed."

Respondents who had ignored previous evacuation warnings were also more likely to ignore an order in the future.

And DeYoung said most people saw wind as more dangerous than water, but in reality it is the storm surge and flooding that causes more deaths. Most [hurricane](#)-related deaths occur in areas where people decided not to evacuate. Wachtendorf said this could lead people to dismiss the threat of lower category storms, with relatively lower wind speeds, despite the threat flooding can pose.

One recommendation is to increase public awareness of the risk associated with drowning and flooding versus the probability of death caused by wind damage.

Research in progress points to other important factors in the decision-making process, including concern about traffic jams, caring for pets and livestock, and fear of crime in public shelters.

"It's a moving target," Davidson said. "There are challenges in science and challenges in engineering. But understanding people's behavior is one of the most challenging parts."

"That's one reason why the interdisciplinary approach is so valuable," said Wachtendorf.

The second paper, published on Science Direct in the journal *Transportation Research Part A: Policy and Practice* and authored by Kecheng Xu, a graduate student in Cornell University's Department of Civil and Environmental Engineering, and Cornell professor Linda Nozick, describes new models that estimate the number of evacuees in specific evacuation zones and predicted accurately what individual households would do about 70 percent of the time. Accuracy improves as data are aggregated regionally.

The work by the civil engineers on the project used data collected by the social scientists to inform many of the assumptions for their models.

Having reliable models puts the power of the knowledge into useful form for planners and helps them shape effective, efficient evacuation plans that could save lives in the future.

More information: Kecheng Xu et al, Hurricane evacuation demand models with a focus on use for prediction in future events, *Transportation Research Part A: Policy and Practice* (2016). [DOI: 10.1016/j.tra.2016.02.012](https://doi.org/10.1016/j.tra.2016.02.012)

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