# Possible Links Between Soil Microbial Communities and Stroke Risk

"A big part of our Agricultural Research Service culture is cross-talking with outside researchers," says ARS soil and water scientist Patrick Hunt. "Partnerships are what we do."

So one day in 2011, Hunt called Medical University of South Carolina professor Daniel Lackland to discuss a paper Lackland had published about stroke risk in the state. South Carolina is part of the U.S. "Stroke Belt," where residents have a significantly higher incidence of stroke than the rest of the U.S. population. South Carolina counties with the highest rates of stroke—between 89 and 115 cases per 100,000 residents—are found within the Southern Coastal Plain, which "buckles" the Stroke Belt (see map).

Lackland had determined that South Carolina stroke victims in the state's Pee Dee region—located in the Stroke Belt "buckle"—were on average 10 years younger than stroke victims outside the Belt. His studies also indicated that individuals born in the Stroke Belt have an increased risk of stroke in their lifetime, a risk that remained even if they moved away from the Stroke Belt later. He had identified some very intriguing trends, but he did not fully understand what might be driving those trends.

"Over the past 30 years, I've been involved with research projects focused on racial and geographical disparities in stroke risk," Lackland says. "One of the major objectives of these investigations is to identify factors associated with the high stroke risk in this part of the country. Unhealthy lifestyle and the Southern diet are often proposed as reasons for the disparities. But similar high-fat and high-carbohydrate diets are seen in other parts of the country. So we must study other factors."

### Mapping the Odds

As a result of their initial talks, Lackland and Hunt began to collaborate with ARS microbiologist Tom Ducey and ARS soil scientist Jarrod Miller to support Lackland's epidemiological research with some environmental expertise. The three ARS scientists work at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina. Retired ARS soil scientist Warren Busscher, who worked at the Florence laboratory, also contributed to the project.

"Lackland's results indicated that stroke risk was not just related to diet or lifestyle choices," says Ducey. "They strongly suggested that an environmental factor was at work as well." So the team designed a study to determine whether certain soil characteristics in the region's sandy Carolina Coastal Plain soils could serve as risk markers for stroke and whether those characteristics could be pinpointed by geostatistical analysis.

"Looking at soil patterns and stroke patterns was a reasonable place to start," Lackland says. "In addition, we were able to assess the links using data that were already available, which was a very efficient use of existing resources."

To identify associations between stroke risk and soil characteristics, the researchers obtained 10 years of South Carolina inpatient and emergency room discharge data that listed stroke as a primary diagnosis and compared it to state soil data from the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic database. The soil characteristics evaluated in the research included cation exchange capacity; hydrologic soil group; sand, silt, clay, and organic matter content; saturated hydraulic conductivity; depth to water table; septic suitability; soil surface acidity; drainage class; and flooding frequency.

In their initial analysis, the team found that stroke rates were significantly correlated with depth to water table and soil drainage class. Stroke rates were higher in counties where soil depth to water table was between 20 and 59 inches, which is often the case for shallow water tables in the Coastal Plain. (Soils with water tables less than 20 inches deep are usually found in flood-prone areas near streams, rivers, or wetlands—sites that are generally unsuitable for residential use.) Links between stroke rate and soil drainage were also significant: Well-drained soils had a negative correlation (fewer strokes), while poorly drained soils were positively correlated (more strokes).

"These links," Ducey comments, "give the scientific community a good foundation for developing further studies of the geographic distribution of stroke risk."

The team then focused their investigation on soil characteristics in South Carolina counties with the 10 highest stroke rates—all within the Coastal Plain—and those with the 10 lowest stroke rates, all in the Blue Ridge/Piedmont region. Findings from this part of the study indicated that soils with a depth to water table from 20 to 59 inches continued to be strongly correlated with stroke rate, while soils with a depth to water table of more than 79 inches were negatively correlated.

Moderately well-drained to poorly drained soils were also positively correlated with stroke rate, while well-drained soils had a negative correlation. In addition, strongly acidic soils had a strong positive correlation with stroke rate.

In short, soil characteristics with strong positive correlations to stroke risk were all typical of Coastal Plain soils.

"I had a suspicion this is what we would find," Ducey said. "It was clear that the Stroke Belt map aligned with the Coastal Plains soils map and that the distribution of stroke rates didn't show any real links to the location of the hilly and rocky Piedmont soils."

"In general, soil maps show the location of very broad categories of soil characteristics," Miller adds. "So given the broad nature of the data, it was very interesting that we found any correlations at all between soil characteristics and stroke risk."

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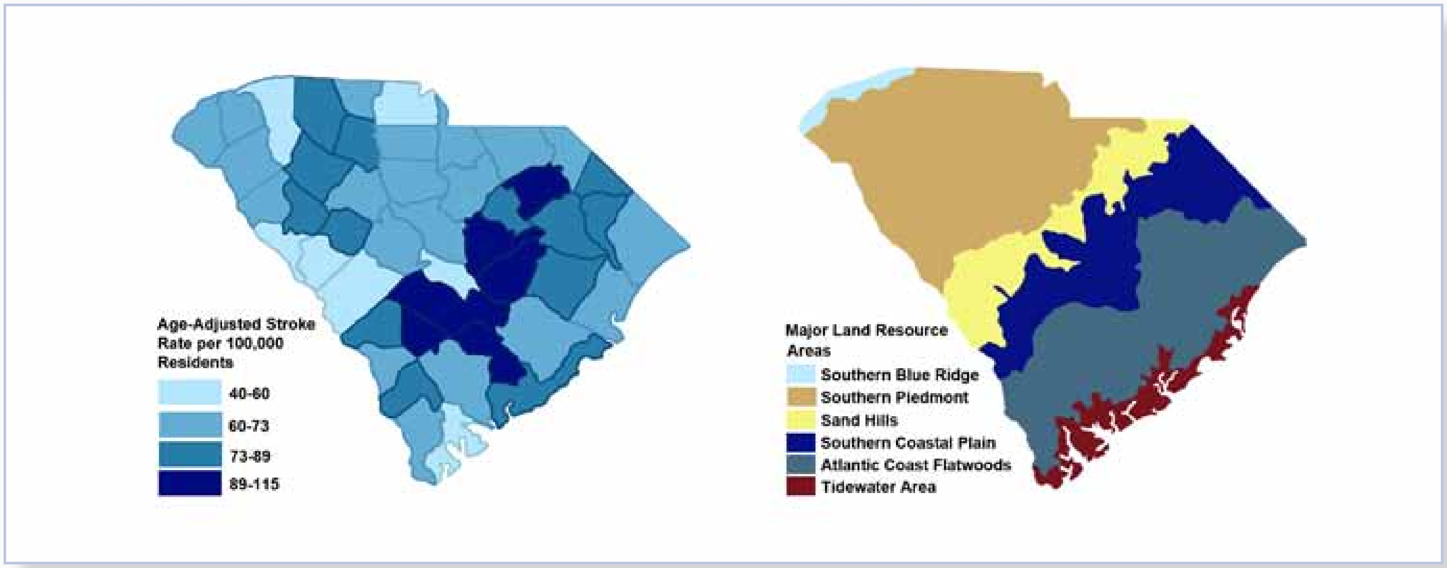


Scientists from ARS and the Medical University of South Carolina compared South Carolina stroke data to soil characteristics. They found links between the counties that have the highest stroke risk (left) and the areas that have soil characteristics typical of the Southern Coastal Plain (right).

**Risky Terrain**

There are two classic factors that affect the makeup of soil microbial communities: soil moisture and soil acidity. A different diversity of organisms can be found in moist, acidic soils than in drier, more alkaline soils. Based on this, the researchers hypothesize that Coastal Plain residents might be at higher risk for stroke because of the prevalence—or perhaps lack—of specific microbes in the region's moist, acidic soils. The scientists all strongly concur that this hypothesis will need much more testing and validation before it can be confirmed.

Discussions about how these soil microbes could specifically affect human health, including stroke risk, are just beginning. But researchers in a range of disciplines are now exploring how health and disease can be affected by the huge numbers of bacteria, viruses, and other microbes that live in the human body. This impressive assortment of microbes, which is called a "microbiome," varies from person to person, depending on what each person is exposed to—and when the exposure occurs—throughout a lifetime.

Based on their findings, the South Carolina scientists hypothesize that an early-life exposure to the specific microbial mix in Coastal Plain soils might affect microbiome development in a way that leaves some individuals more vulnerable to cardiovascular events like stroke. Although this effect would vary from person to person, depending on other environmental and genetic factors, it might help explain the puzzling regional patterns of stroke risk.

"I'm not totally surprised by these results, but I was surprised by the magnitude of correlation between soil characteristics and stroke risk," says Lackland. "This is a preliminary study, and it needs additional follow-up and confirmation. But if other studies have similar results, it could provide new information about risk factors for stroke and allow us to develop new interventions that could help reduce stroke rates in this region."

Because of data constraints, the study was restricted to South Carolina. But the Southern Coastal Plain extends from Virginia through the Carolinas, Georgia, and the Florida panhandle, as well as into Alabama, Mississippi, Louisiana, and Kentucky. All these regions are recognized as part of the Stroke Belt.

NRCS currently doesn't collect data on the distribution of soil microbial populations, so there are no clues about which microbes might be the environmental link between Coastal Plains soils and stroke risk. Ducey contends that information about soil microbe communities could be acquired using new biotech instruments in laboratories such as the ARS lab in Florence. In this way, data generated by ARS to benefit agriculture would benefit epidemiology as well.

"A microbial map of South Carolina could be developed from approximately 300 to 400 soil samples. This could allow microbial populations to be looked at in future studies," Ducey says.

"This study helps broaden the thinking about the different factors that might be involved in this serious health problem," says Hunt. "It shows how sharing theories and technologies across scientific disciplines can result in valuable outcomes."

"We've known about the geographical and racial disparities in stroke risk for five decades," Lackland agrees. "We've identified many of the factors, including high blood pressure and diabetes, that increase stroke risk, but we still don't have a comprehensive answer for why some parts of the population suffer excessive stroke rates. This work could be an important step in that direction."

The team published its findings in 2012 in the *Journal of Environmental Science and Health*.—By **Ann Perry,** ARS.

*This research is part of Climate Change, Soils, and Emissions (#212) and Water Availability and Watershed Management (#211), two ARS national programs described at www.nps.ars.usda.gov.*

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