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Bearing the Brunt: Who Breathes the Air Pollutants from Hog CAFOs in North Carolina?

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Pollution from eastern North Carolina's hog industry has been studied for more than 30 years.[1,2] Concentrated animal feeding operations (CAFOs) and their open waste storage pits emit two chemicals of particular concern to human health: ammonia (NH_3) and hydrogen sulfide (H_2S).[3,4] Some previous studies of the region's hog CAFOs focused on environmental injustice,[5,6] noting that such facilities were disproportionately located near low-income communities of color. Going beyond these proximity-based analyses, a new study published in *Environmental Health Perspectives*[7] applied a dispersion model for transport of NH_3 and H_2S over space and time to estimate human exposure.[8]

The study region, with its 822,071 residents and 1,292 hog CAFOs, included Duplin County and parts of six surrounding counties. The dispersion model accounted for the permitted number of hogs at each facility in 2019 and the predicted movement of chemical plumes based on local temperatures, wind direction, and wind speed.[7]

The researchers first estimated human exposure by multiplying the number of permitted hogs at each CAFO by annual per-animal emission factors for NH_3 and H_2S.[9,10] They combined this information with meteorological data from the National Weather Service to simulate ambient concentrations for each U.S. census block group within 50 km of that facility's center.[7]

Next, they compared exposures between subgroups defined by census area demographics of race/ethnicity, age, income, education, and English language proficiency, based on the 2012–2016 American Community Survey.[11]

They found that the largest CAFOs (21,000–53,000 animals) were predominantly located in block groups where more than 56% of residents were people of color (i.e., other than solely non-Hispanic White). Compared with averages for the study region overall, exposures to NH_3 and H_2S were 66% higher for households where members spoke English less than "very well," 32% higher for adults without a high school diploma, 16% higher for people of color, and 13% higher for low-income households.

"Our study is the first to document disparities in exposure to two specific air pollutants from hog CAFOs in eastern North Carolina," says first author Brandon Lewis, a PhD student at

Hog CAFOs emit pollutants from waste lagoons, like this one next to a barn in Pitt County, North Carolina; in air exhausted from barns; and when wastewater is sprayed on fields. Image © Gerry Broome/AP Photo.

Yale University. "This environmental justice lens brings even more awareness to the [disproportionate] impact of CAFOs on vulnerable communities."

Still, the model underestimates real-life exposures due to substantial data gaps, Lewis says. The researchers obtained hog CAFO location and permitted capacity data from the North Carolina Department of Environmental Quality. However, these permits are issued only once every 5 years. In addition, the researchers were unable to account for exposures from manure that had been spread on nearby agricultural fields and the region's numerous poultry CAFOs, which contribute significantly to NH_3 emissions.[12]

Twenty years ago—the most recent data available—an estimated 80% of NH_3 emissions in North Carolina came from livestock waste; other sources included forests, vehicle exhaust, fertilizers, and nonagricultural vegetation.[13] The state's swine production grew dramatically during the period from 1982 to 2006, when massive operations by multinational corporations (predominantly Smithfield Foods) increased the state's hog population from 2 million to 10 million, even as the number of small, family-owned hog farms declined.[14] Today, 95% of hog CAFOs in North Carolina are concentrated in the eastern coastal plain.[14,15]

Both NH_3 and H_2S form during the anaerobic breakdown of nitrogen-containing chemicals in hog manure, contributing to malodor, which creates psychological and physiological stress.[16,17] NH_3 reacts with atmospheric chemicals to form fine particulate matter ($PM_{2.5}$) and through this process has been estimated to cause 69% of annual deaths attributable to reduced air quality from agricultural production.[18] Human exposure to H_2S has been associated with respiratory, cardiovascular, and central nervous system symptoms.[19–21]

"Dispersion and atmospheric chemistry are important predictors of air pollutant levels," says Jason Hill, a professor of bioproducts and biosystems engineering at the University of Minnesota who was not involved in the project. "This study advances the field by accounting for all nearby hog CAFOs to deliver human exposure estimates at high spatial resolution."

Jill Johnston, an associate professor of population and public health sciences at the University of Southern California, agrees with Hill's assessment. "This is the first study in the United States to apply detailed dispersion models of CAFO air pollutants at a multi-county scale," says Johnston, who also was not involved in the project. "Since many air pollution researchers rely on monitors located in urban areas, it is especially exciting to see high-quality studies being conducted in rural areas."

Johnston notes that the analysis reflects just a snapshot of real-world conditions. She says installing monitors in the community would be useful to validate the model estimates.

Hill suggests that any future efforts could focus on improving waste management at the subset of facilities with especially high emissions. "Addressing the environmental justice component of CAFO pollution requires analyses at both large and small scales because national policies and local permitting procedures play important roles," says Hill.

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