

Connecting Environmental Justice and Community Health

Effects of Hog Production in North Carolina

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Environmental justice means equal access to a healthful environment for all. In North Carolina, many sources of pollution disproportionately affect low-income communities and communities of color. Clinicians who recognize effects of environmental injustices can improve patient care and community health. As an example, we present the effects of industrial-scale hog operations in North Carolina.

Clinicians who understand that environmental factors influence health—with some communities more polluted than others—are better poised to recognize symptoms and conditions associated with known sources of pollution and identify new environmental health concerns. This commentary will introduce the concept of environmental justice, present adverse health effects related to industrial-scale hog production as an example of environmental injustice in North Carolina, and discuss the clinician's role in applying knowledge of environmental injustices to patient care. Although many environmental injustices exist, the effects associated with industrial-scale hog operations are presented here because they are among the most well-studied.

Understanding Environmental Justice

Healthy communities require good environmental quality to achieve complete physical, mental, and social well-being [1]. Research shows that polluting industries are more likely to locate in low-income communities and communities of color than in high-income, white communities [2, 3]. Environmental inequality contributes to racial and economic disparities in health and quality of life. The goal, then, is environmental justice—equal access to a healthful environment, regardless of race, ethnicity, or income (see Table 1).

Modern efforts to achieve environmental justice have strong roots in North Carolina. The movement gained momentum in 1982 following a series of nonviolent protests over the location of a hazardous landfill in majority African-American Warren County. The landfill was installed to store soil contaminated by polychlorinated biphenyls (PCBs), but through continued efforts, in 2001 the community was able to secure state and federal funding to incinerate the PCB-contaminated soil onsite, completing remediation several years later [7]. Since the advent of the modern environmen-

tal justice movement, community groups and partners have worked to call attention to and address a range of environmental injustices [7].

Hog Production in North Carolina

Food animal production is a major component of the North Carolina economy and culture. North Carolina is ranked 2nd in the United States for production of hogs and turkeys and is also a major producer of layer and broiler chickens [8].

Animal production has shifted from small, diversified family farms to a system in which animals are confined in large barns, with each barn containing hundreds of hogs or thousands of poultry [2]. During 1982 through 2017, the number of hogs in North Carolina increased from approximately 2 million to 9 million, while the number of hog farms dropped from 10,000 to 2,000 [8, 9].

These industrial-scale facilities are termed animal feeding operations (AFOs) by the US Environmental Protection Agency (EPA) and the NC Department of Environmental Quality (NC DEQ) [10]. AFOs that exceed a certain size and are deemed to be a point source of pollutants are called concentrated animal feeding operations (CAFOs) [11]. In North Carolina, hog CAFOs are predominantly located in the southeastern part of the state, especially in Duplin and Sampson counties; these counties are also home to a large number of poultry operations [8] (see Figure 1).

Hog CAFOs as a Source of Pollution

Hog waste from these facilities is collected in open-air holding ponds called lagoons. For disposal, the liquefied hog waste is often sprayed as fertilizer on surrounding fields using conventional irrigation equipment. This aerosolizes the waste, creating a fine mist that can travel airborne for several miles depending on atmospheric conditions [13, 14].

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TABLE 1.
Definitions of Environmental Justice Currently in Use by Selected US Agencies and Organizations

Organization/Agency	Definition
US Environmental Protection Agency	Fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies [4].
US Institute of Medicine	A concept that addresses in a cross-cutting and integrative manner the physical and social health issues related to the distribution of environmental benefits and burdens among populations, particularly in degraded and hazardous physical environments occupied by minority or disadvantaged populations [5].
North Carolina Environmental Justice Network (NCEJN)	The right to a safe, healthy, productive, and sustainable environment for all, where “environment” is considered in its totality to include the ecological (biological), physical (natural and built), social, political, aesthetic, and economic environments. Environmental justice refers to the conditions in which such a right can be freely exercised, whereby individual and group identities, needs, and dignities are preserved, fulfilled, and respected in a way that provides for self-actualization and personal and community empowerment [6].

The complex mixture of pollutants released during waste-spraying, lagoon off-gassing, and barn ventilation includes harmful gases such as ammonia, hydrogen sulfide, and methane; volatile organic chemicals, disinfectants, and cleaning agents; organic dusts containing dander, mold, and particulate matter; and viruses and bacteria, including antimicrobial-resistant types [13, 15-17].

The mixture of pollutants can also create strong odors that can enter homes, schools, and businesses. These odors are associated with measured air pollutant concentrations and can negatively impact neighbors’ health and activities [13]. Odor and measured air pollutant concentrations are often higher during times of relative atmospheric calm, like on cloudy days or at night, when there is reduced horizontal mixing from wind or reduced vertical mixing from solar radiation [13, 18].

CAFO lagoons and spraying of waste also serve as potential sources of surface and groundwater contamination, especially after rain events [19]. CAFO lagoons and barns failed during Hurricane Floyd in 1996, sending millions of gallons of fecal waste and hundreds of thousands of dead animals to mix with flood waters [2, 20]; lagoon and barn failures again occurred during Hurricane Matthew in 2016 [21].

Health effects associated with hog CAFOs

Respiratory conditions. CAFO workers may be exposed to high concentrations of these pollutants. They have direct contact with livestock, waste, and contaminated surfaces, and breathe contaminated air inside and around the barns. Occupational health effects, including chronic bronchitis and asthma, were some of the first CAFO-associated health effects identified [15].

There is also evidence of respiratory conditions among children exposed to these air pollutants. Proximity of homes and schools to hog CAFOs has been associated with increased prevalence of asthma and wheezing in children [22, 23]. Children attending schools in North Carolina where staff members noticed livestock odor inside the school twice

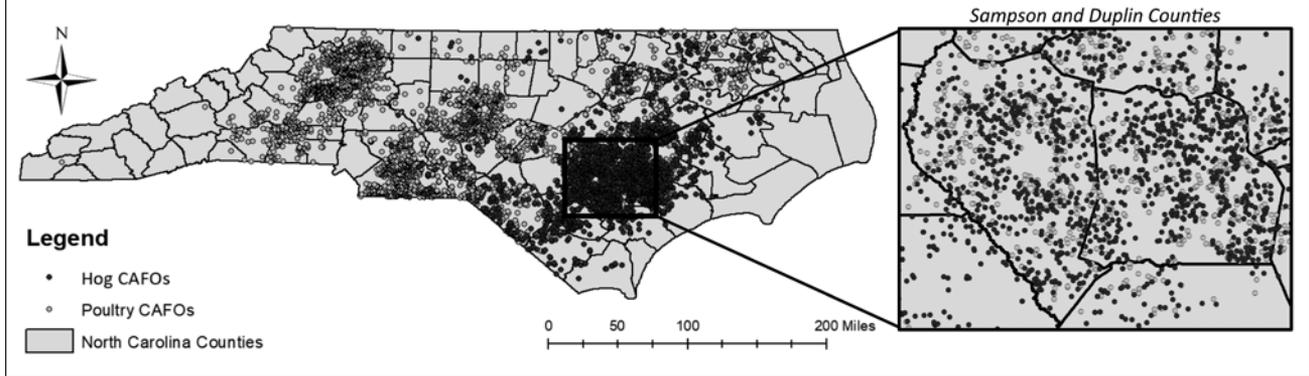
or more per month reported increased prevalence of wheezing and doctor-diagnosed asthma [14].

Irritation symptoms. Acute mucous membrane irritation of the eyes and nose has been associated with odor reports and hydrogen sulfide measurements in a repeated measures study of adult residents within 2 miles of CAFOs [24]. An experimental study in which adults were alternately exposed to diluted air from a hog CAFO and clean control air found that participants were 4 times as likely to report headaches, 6 times as likely to report eye irritation, and nearly 8 times as likely to report nausea after exposure to hog CAFO air [16].

Mental health and quality of life. Multiple studies have found associations between CAFO-related air pollutants and stress or negative mood [17]. One study followed 101 CAFO neighbors daily for approximately 2 weeks and found that measured hydrogen sulfide levels were associated with residents’ feeling stressed or annoyed and nervous or anxious [25]. In the same study, self-reported odor levels had an even stronger association with negative mood states [25]. Measured ammonia levels have also been associated with feelings of annoyance and interference with normal behavior such as outdoor activities [26]. Qualitative interviews with CAFO neighbors show that odor decreased their quality of life, including limiting their ability to go outside for recreation or social activities [27].

Infectious disease risk. The food animal production sector is a major consumer of medically important antimicrobial drugs [28]. Research studies have tracked the evolution and spread of drug-resistant, zoonotic pathogens in CAFO-dense regions to assess the contribution of food animal production to antimicrobial resistance [17]. In North Carolina specifically, studies have measured the potential for transmission of livestock-adapted bacterial strains from hogs to humans and the environment. Recent studies have shown increased prevalence of carriage of certain types of livestock-adapted drug-resistant *Staphylococcus aureus* among CAFO workers compared with workers at farms raising livestock without antibiotics [29] and among children living with hog CAFO workers compared with other children in their community

FIGURE 1.
Locations of Hog and Poultry CAFOs in North Carolina [12]



[30]. Studies conducted outside of North Carolina have identified an association between living in regions with a high density of CAFOs and swine manure application sites and a greater prevalence of methicillin-resistant *S. aureus*-related infections, including skin and soft tissue infections, compared to those living in regions with a lower density of these sites [31, 32]. Transmission of other bacteria and viruses between animals and humans in the CAFO environment has also been described [17].

Evidence of environmental injustice

Against this backdrop of health concerns, there is evidence that hog CAFOs in North Carolina are disproportionately located in low-income communities and communities of color [2, 33]. Research published in 2000 showed that there were approximately 10 times the number of CAFOs in North Carolina census block groups with the highest proportions of poverty and non-white populations, even after adjusting for population density, compared to block groups with the lowest proportions of poverty and non-white populations [2]. An updated analysis in 2014 revealed a similar picture [33].

Communities where CAFOs are concentrated have vulnerabilities common to other rural populations that can exacerbate exposure to pollutants and increase the risk of harmful effects. A large proportion of residents in southeastern North Carolina rely on private wells for drinking water that are not regulated under the Safe Drinking Water Act [34]. Sandy soils and a high water table may facilitate the spread of contaminants into ground and surface water following waste-spraying on fields or unintentional releases from lagoons during flood events and hurricanes [20]. Affected communities are known to experience high rates of chronic conditions including asthma and heart disease that may increase the risk of adverse health outcomes from airborne exposures [35, 36]. These communities also have high proportions of uninsured residents, potentially creating challenges to accessing medical care and preventive services [36].

In 2014, community groups filed a Title VI Civil Rights

complaint with the EPA alleging that the NC DEQ's General Permit for swine CAFOs, as well as the agency's monitoring and oversight of those operations, had resulted in the violation of Title VI and EPA's implementing regulations. The complaint was settled in early 2018, following an investigation into whether the concentration of CAFOs in southeastern North Carolina violated civil rights [37]. The settlement prompts NC DEQ to create stronger protections, including: developing an environmental justice tool to examine demographic, health, and environmental characteristics of impacted communities; strengthening the current hog CAFO permitting process; conducting air and water quality monitoring with community input; and establishing a state-wide Environmental Justice and Equity Advisory Board to assist NC DEQ in implementing change [37]. The latter is an important step given potentially limited resources and expertise at regulatory and public health agencies charged with addressing CAFO-related concerns [38].

Role of Clinicians in Addressing Environmental Injustice

Clinicians have played an important role in recognizing new sources of environmental hazards and environmental injustices, one example being childhood lead exposure [39, 40]. The following approaches may help clinicians identify these situations, reduce adverse effects on their patients' health, and call attention to environmental injustices to improve health in their communities.

Increase knowledge of environmental health. A survey of medical school graduates found that more than one-third of respondents said they received inadequate instruction in environmental health [41]. Clinicians can support enhanced environmental health education for students and seek continuing education opportunities for themselves and their colleagues. In the case of health effects associated with CAFOs, increased understanding of CAFO-related air and water pollutants and livestock-adapted bacteria and viruses may be useful in diagnosing, treating, and managing conditions such as asthma, gastrointestinal illness, and infections caused by antibiotic-resistant bacteria.

Talk with patients, especially those from vulnerable populations, about environmental hazards. The physical environment—air, water, and food quality—affects physical and mental health. Talking with patients about their neighborhood, work environment, and environmental stressors can increase understanding of relevant environmental influences on health and help identify potential points for intervention. For example, for patients with asthma or chronic bronchitis, engaging in discussions about their environment, including proximity to CAFOs, may help identify triggers.

Further, by discussing environmental concerns, clinicians have the opportunity to potentially identify new hazards or disproportionately affected communities. To do this effectively, clinicians should make special efforts to engage patients of color who are more likely to be affected by environmental injustices [2, 3, 33].

Provide information about environmental injustices to advisory boards, regulatory agencies, and public health agencies. Clinicians with knowledge of local environmental injustices that may harm health can take action not only by tailoring individual patient care, but also by providing information to entities trying to address problems at the community level. These entities include advisory boards, environmental regulatory agencies, local and state public health departments, and federal environmental and public health agencies. For example, CAFO-related concerns can now be brought to North Carolina's new statewide Environmental Justice and Equity Advisory Board.

Conclusion

Low-income communities and communities of color may be disproportionately exposed to pollution compared to higher-income, white communities. In North Carolina, the health effects of hog CAFOs provide a well-documented example of an environmental injustice. Through continued education and training about the effects of the environment on health, engagement of patients in discussions about their environment, and sharing information with entities working to improve conditions, clinicians can continue to play an important role in recognizing and addressing the impacts of environmental injustices on their patients' health. **NCMJ**

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