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## **The Public Health Impacts of Concentrated Animal Feeding Operations on Local Communities**

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### ABSTRACT

Large-scale farm animal production facilities, also known as concentrated animal feeding operations (CAFOs), release a significant amount of contaminants into the air and water. Adverse health effects related to exposure to these contaminants among CAFO workers have been well-documented; however, less is known about their impact on the health of residents in nearby communities. Epidemiological research in this area suggests that neighboring residents are at increased risk of developing neurobehavioral symptoms and respiratory illnesses, including asthma. Additional research is needed to better understand community-scale exposures and health outcomes related to the management practices and emissions of CAFOs.

The US Government Accountability Office (GAO) estimated in 2008 that the number of farm animals raised in large-scale industrial production facilities increased 246% from 1982 to 2002.<sup>1</sup> In 2008, nearly 10 billion land animals were raised for meat, egg, and milk production in the United States.<sup>2-4</sup> Approximately half (54%) of all confined farm animals by weight are concentrated in just 5% of the country's animal agriculture operations.<sup>5</sup>

The rapid growth of these concentrated animal feeding operations (CAFOs) has contributed to significant animal welfare issues, as well as to human health concerns for workers and residents of nearby communities. The US Environmental Protection Agency (EPA) estimates that there are approximately 18 800 CAFOs in the United States.<sup>6</sup> Poor waste management practices, the widespread use of pesticides, and confinement and feeding practices customary to industrial farm animal production systems all have potential environmental and public health consequences.

Although the adverse health effects related to exposure to CAFO pollutants among workers have been well-documented, less is known about their impact on the health of residents of nearby communities. Community health issues are more recently being identified as a significant area of concern, as noted in the 2008 report by the Pew Commission on Industrial Farm Animal Production, which states that

public health concerns associated with ... [CAFOs] include heightened risks of pathogens (disease- and nondisease-causing) passed from animals to humans; the emergence of

microbes resistant to antibiotics and antimicrobials, due in large part to widespread use of antimicrobials for nontherapeutic purposes; food-borne disease; worker health concerns; and dispersed impacts on the adjacent community at large.<sup>7(p11)</sup>

## CAFO-RELATED EXPOSURES

The EPA has estimated that confined farm animals generate 3 times more excrement than is produced by humans in the United States.<sup>8</sup> Much of the environmental harm caused by CAFOs results from that volume of manure, which must be stored and disposed of when continuously confining so many animals exclusively or primarily indoors, with some operations producing as much waste as a city.<sup>9</sup> According to data from the US Department of Agriculture (USDA) and the EPA, farm animal confinement operations produce approximately 500 million tons of manure every year,<sup>8</sup> with CAFOs generating 47%<sup>10</sup> to 60%<sup>6</sup> of this excrement. The GAO has reported that the manure that a large facility can generate depends primarily on the types and numbers of animals confined on-site, but can range from more than 2800 tons to more than 1.6 million tons per year.<sup>1</sup>

Over the past 2 decades, shifts in animal agriculture industries have exacerbated existing waste management problems, with more animals being intensively confined in fewer, but larger, operations.<sup>11,12</sup> The USDA's Natural Resources Conservation Service and the EPA outline the changes as follows:

- the move toward intensive confinement;
- the steady replacement of small- and medium-sized operations with large confinement operations;
- the continued consolidation of all aspects of production;
- the increase in numbers of confined animals per operation; and
- the spatial concentration of operations in high-production areas.<sup>11,12</sup>

These developments have resulted in industrial animal agriculture facilities producing more manure than can be assimilated by available land, particularly in high-production areas,<sup>11,12</sup> which is a significant concern given that CAFOs tend to cluster in geographic locales where input costs—expenses for components such as land and labor—are lower and where their vertically integrated industry infrastructure is well-developed.<sup>13</sup>

A customary manure storage system used in pig and dairy operations is the manure “lagoon.”<sup>14,15</sup> In this system, liquefied manure is stored in an outdoor, open-air pit and ultimately sprayed onto fields.<sup>10</sup> Manure lagoons pose the risk of spillage or leakage, poisoning surface or groundwater. In one incident, more than 20 million gallons of waste spilled from a North Carolina pig production operation into a nearby river, causing a massive fish kill.<sup>16</sup> In 2005, a manure lagoon at an upstate New York dairy farm burst, polluting the nearby Black River with millions of gallons of manure and killing more than 375 000 fish.<sup>17</sup>

Although it takes no more than a single CAFO to cause a spill or leak, the trend toward concentrating these operations within discrete geographical areas raises concerns over the ability to maintain water quality for residents within a particular watershed.<sup>5,18</sup>

Even when intact, CAFO manure lagoons may threaten groundwater and air quality through leaching and volatilization.<sup>19</sup> Manure lagoons decrease the amount of nutrients that must be applied to land, in part because much of the nitrogen content is volatilized into ammonia emissions from the pit itself.<sup>20</sup> These ammonia emissions can contribute to increased concentrations of nitrogen (nitrate) in precipitation.<sup>21</sup> If

the waste is then overapplied to land, it can further contaminate water supplies<sup>22</sup> and emit harmful gases into the atmosphere.<sup>10</sup> Because there is no requirement that CAFO manure be treated before it is applied, its disposal poses additional risks to public health.<sup>23</sup> Of particular concern are pathogens that may contaminate surface water and antibiotics, heavy metals, pesticides (such as dithiocarbamates),<sup>24</sup> and nutrients (such as nitrogen and phosphorous), all of which can leach into groundwater, run off fields where manure has been applied, and, in the case of nitrogen, volatilize into ammonia emissions.<sup>10,12</sup> According to the EPA, “the agricultural sector ... is the leading contributor to identified water quality impairments in the nation’s rivers and streams, lakes, ponds, and reservoirs.”<sup>8(p7237)</sup> It was estimated in 2003, for example, that more than \$1 million per year would be required to remove nitrates from water in California’s Chino Basin due to local dairies and the relatively rapid transformation of nitrogen in manure into nitrates, which were ultimately transported into the community’s drinking water supply.<sup>8</sup> The USDA reported that the problem of excess nutrients is most pronounced in poultry operations, which produce 52% of the excess phosphorous and 64% of the excess nitrogen created by farm animal waste.<sup>5</sup> Epidemiological studies have linked farm animal waste runoff to several waterborne outbreaks involving pathogens such as *Campylobacter*, *Salmonella*, *Listeria monocytogenes*, *Helicobacter pylori*, and *Escherichia coli* 0157:H7, as well as the protozoa *Cryptosporidium parvum*.<sup>23</sup>

Animal confinement facilities also generate a variety of air contaminants, including skin cells, feed, fungi, and other particulates, which can become airborne.<sup>25</sup> Additional contaminants include ammonia, hydrogen sulfide, and antimicrobials.

In addition, a 2006 report by the Food and Agriculture Organization of the United Nations noted that, on a global scale, the animal agriculture sector accounts for approximately 18% of all anthropogenic greenhouse gas emissions.<sup>26</sup> In the United States, methane emissions from pig and dairy cow manure increased by 34% and 49%, respectively, between 1990 and 2006. The EPA attributed this rise to the shift toward confining pigs and cows in larger operations by using liquid manure management systems,<sup>27</sup> or manure lagoons.

Many of the air pollutants in CAFOs do not currently have occupational exposure limits.<sup>25</sup> Complicating the issue, contaminants released by CAFOs are often mixtures of a variety of pollutants. Very little is known about the risks these contaminant mixtures pose to human health, and even less is known about synergistic effects of such mixtures.

Of all the gaseous by-products of farm animal manure decomposition, hydrogen sulfide is regarded as the most dangerous, creating a risk of both unconsciousness and death for those who work in or near manure pits.<sup>28</sup> The National Institute for Occupational Safety and Health (NIOSH) has deemed hydrogen sulfide to be “a leading cause of sudden death in the workplace.”<sup>29(p1)</sup> A number of reports on the NIOSH Web site document worker fatalities caused by exposure to the chemicals in manure pits.<sup>30–33</sup> Indeed, the agency issued an alert in 1990 titled “Preventing Deaths of Farm Workers in Manure Pits,”<sup>34</sup> which details the harmful effects of the chemicals commonly found in these excrement pits.

Airborne bacteria present at CAFOs can be a potential pathway for transferring antibiotic-resistant bacteria from farm animals to humans. Workers in CAFOs and members of nearby communities are at potential risk of exposure.<sup>35</sup> In a study of airborne concentrations of resistant bacterial forms at CAFOs, Gibbs et al<sup>36</sup> found that bacteria were recovered inside and downwind of the facilities at concentrations that could cause a potential human health hazard. Alarming rates of methicillin-resistant *Staphylococcus aureus* (MRSA) detection in live farm animals and retail meat in Europe has led to increased scrutiny of the agricultural use of antibiotics.<sup>37</sup> The recent discovery of MRSA in North American pigs and pig farmers suggests that the potential public health risk attributed to farm animal-associated MRSA may be a global

phenomenon.<sup>38,39</sup> While the European Union banned the use of medically important antibiotics as farm animal growth promoters in 2006,<sup>40</sup> no such comprehensive step has yet taken place in the United States.

## HEALTH OUTCOMES ASSOCIATED WITH CAFO-RELATED EXPOSURES

There has been significant research in the area of occupational health at CAFOs. More than 70 articles have documented adverse health outcomes in workers at pig CAFOs.<sup>41</sup> These studies note that at least 25% of the workers report respiratory problems, including asthma, bronchitis, acute respiratory distress syndrome, and, in some cases, organic dust toxic syndrome.<sup>25,41</sup> Exposure to endotoxin, a family of gram-negative bacteria membrane lipopolysaccharide fragments, is often implicated in adverse respiratory effects, particularly among workers in caged hen facilities.<sup>42</sup> Studies also indicate that 6 or more years of exposure at these facilities put workers at risk for chronic health problems.<sup>41</sup>

Despite strong evidence linking adverse health outcomes to occupational exposures at CAFOs, the impact on community health has not been studied as intensively. The 2008 report by the Pew Commission on Industrial Farm Animal Production noted that

[c]ommunities near ... [CAFO] facilities are subject to air emissions that, although lower in concentration, may significantly affect certain segments of the population. Those most vulnerable—children, the elderly, individuals with chronic or acute pulmonary or heart disorders—are at particular risk. The impact on the health of those living near [CAFO] facilities has increasingly been the subject of epidemiological research.<sup>7(p17)</sup>

Studies have indicated that people residing near CAFOs may be at increased risk of developing respiratory illnesses, neurobehavioral symptoms, and psychological impairments because of exposure to contaminants released at the facilities. The disproportionate siting of CAFOs proximate to nonwhite, highpoverty communities may further exacerbate the disease burden already faced by these vulnerable populations.<sup>43</sup>

In 1997, Thu and colleagues conducted a study of a community situated close to a pig CAFO. The authors noted that “neighbors of the large-scale swine operation ... reported experiencing increased rates of a number of interrelated symptoms, including headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness.”<sup>44(p20)</sup> In 2002, Thu noted that

recent research and results from federally sponsored scientific symposia consistently indicate that neighbors of swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. Moreover, such problems can be created by several different CAFO emission constituents acting alone or synergistically.<sup>45(p182)</sup>

Studies of asthma and allergies among children exposed to a farm environment have generally been inconclusive. Some studies have found lower prevalences of asthma<sup>46–48</sup> and allergies<sup>46,48,49</sup> among those with early exposures to a farm environment. For example, Kilpeläinen et al found that “[a] childhood farm environment seems to have a protective effect against allergic rhinitis and/or conjunctivitis, and more weakly against asthma and wheezing irrespective of family size,”<sup>46(p201)</sup> and Ernst and Cormier<sup>47</sup> found a significantly lower prevalence of asthma among children raised in a farm environment than among children living in a rural environment but not near a farm. Similarly, Riedler et al found that “[l]ong-term and early-life exposure to stables and farm milk induces a strong protective effect against development of asthma, hay fever, and atopic sensitisation.”<sup>48(p1129)</sup> The protective effect associated with early farm

exposure has been postulated, as childhood allergy risk is immunologically modulated early in life by exposure to infectious agents.<sup>50</sup>

In contrast to these findings, however, increased rates of asthma have been found among children and adults who reside near CAFOs.<sup>50-54</sup> Radon et al,<sup>54</sup> for example, surveyed nearly 7 000 individuals in 4 German towns with a high density of CAFOs between 2002 and 2004. The authors measured specific IgE antibodies to common and farm-specific allergens, lung function, and bronchial hyperresponsiveness to methacholine challenge and found that the number of farm animal production facilities near the residence was a predictor of self-reported wheezing and decreased forced expiratory volume in 1 second, but not a predictor of allergic rhinitis or specific sensitization. Self-reported asthma and nasal allergies increased along with self-reported odor annoyance.<sup>54</sup>

Merchant et al<sup>50</sup> studied a cohort of 1000 rural Iowa families to evaluate the relationship among asthma and farm and other environmental exposures. Four types of asthma outcomes were assessed, including doctor-diagnosed asthma and doctor-diagnosed asthma/medication for wheeze, current wheeze, and cough with exercise. The authors found a high rate of asthma; the prevalence of doctor-diagnosed asthma was 12%, and at least 1 of the 4 outcomes was found in more than one-third of the study population. A particularly high prevalence of asthma outcomes was identified among children living on farms that raise pigs (44.1%,  $P = 0.01$ ) and raise pigs and add antibiotics to feed (55.8%,  $P = 0.013$ ).<sup>50</sup>

Mirabelli and colleagues<sup>55</sup> assessed respiratory symptoms related to air pollution from CAFOs in 58,169 children attending schools in North Carolina, the second leading state for both turkey and pig production.<sup>56</sup> Exposure was estimated by utilizing publicly available data about pig production operations and their proximity to public schools. The authors found that the prevalence of wheezing during the previous year was slightly higher among students who may have been exposed to airborne contaminants from CAFOs. In addition, regarding students who reported allergies, the prevalence of wheezing within the previous year was 5% higher for those attending schools located within 3 miles of a CAFO than those students at schools located beyond 3 miles and was 24% higher for those students at schools where farm animal odor was reported to be noticeable indoors twice per month.<sup>52</sup> In another study of the same cohort by the same authors, odor from farm animals was noticeable both outside ( $n = 47$ , 21%) and inside ( $n = 19$ , 8%) the schools.<sup>55</sup>

Sigurdarson and Kline conducted a cross-sectional study of children from kindergarten through fifth grade in 2 rural Iowa schools. One school was located approximately 1/2 mile from a CAFO, while the control school was not sited near any CAFOs or other large-scale agricultural operations. The authors found that children who attended the school near the CAFO had a significantly increased prevalence of physician-diagnosed asthma (adjusted odds ratio, 5.71;  $P = 0.004$ ). There was no difference in terms of severity of asthma between the 2 study populations.<sup>53</sup>

Other health outcomes in addition to respiratory illnesses have been associated with CAFO-related exposures, including odor-related illnesses. Odorant compounds produced at CAFOs can affect health in a number of ways. At high concentrations, these chemicals can produce significant irritation of the nose, throat, and eyes and induce symptoms such as vomiting, headaches, and nausea. In addition, mixtures with non-odorant chemicals can produce inflammation as well as obstruct airflow.<sup>57</sup>

Avery et al<sup>58</sup> assessed the physiological impacts related to malodor from pig CAFOs and found that there was an immunosuppressive effect of malodor on mucosal immunity.

Wing and Wolf evaluated the health status of residents living near CAFOs in North Carolina. The researchers examined 3 rural communities: 1 in the vicinity of a pig CAFO, 1 in the vicinity of 2 intensive cattle operations, and 1 in a rural agricultural area without farm animal production operations with liquid waste management systems. The authors found elevated rates of mucous membrane irritation and respiratory and gastrointestinal problems, as well as higher reporting of headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes among residents living near the pig CAFO than among those whose residence was not near a CAFO.<sup>59</sup>

Pregnant women and children are susceptible populations who may be at particular risk for exposures related to CAFO operations. In a 2008 study by Sneeringer<sup>60</sup> that assessed the impact of industrial farm animal operations on infant health, the author found that doubling of production could lead to a 7.4% increase in infant mortality, deaths driven by elevated levels of respiratory diseases.

Excess nitrates in water have also been implicated in a number of health outcomes in these susceptible populations. For instance, the Centers for Disease Control and Prevention noted that excess nitrates in groundwater due to contamination from a pig CAFO may have been linked to miscarriages reported in 1993 and 1994.<sup>25</sup> Other studies have found an association between high nitrate levels in water used in infant formula and development of methemoglobinemia, or blue-baby syndrome.<sup>61</sup>

The presence of a CAFO in or near a community can negatively impact the social structure of local residents. Wing and Wolf also assessed measures of “quality of life,” as indicated by the number of times residents reported that they were prevented by odor emanating from CAFOs from opening their windows or going outside even in favorable weather. Findings were similar in the control and the community in the vicinity of the cattle CAFO, but quality of life was greatly diminished among residents near the pig CAFO.<sup>59</sup>

Wing et al evaluated the strength of odors from farmed pigs in the homes of 101 participants from 16 neighborhoods in eastern North Carolina sited near pig CAFOs. Study participants reported odor outside on more than half the study days in 9 of the neighborhoods, and nearly one-third of all study participants reported having their daily activities affected (either changing or ceasing the activities) due to the odor.<sup>57</sup>

Schiffman and colleagues studied mood disturbance related to exposure to malodorous compounds in 44 individuals residing near North Carolina CAFOs and 44 control participants who did not live near these facilities. The authors found that those living near CAFOs had higher rates of depression, anger, tension, and fatigue than those of the control population.<sup>62</sup> Indeed, the Pew Commission report noted that “[r]educed civic participation rates, higher levels of stress, and other less tangible impacts have all been associated with high concentrations of industrial farm production.”<sup>7(p59)</sup>

Studies have also shown that property values can decline substantially when residences are near a CAFO.<sup>63-65</sup> According to an article in the journal of the Appraisal Institute, an international association of professional real estate appraisers, case studies demonstrate that “diminished marketability, loss of use and enjoyment, and loss of exclusivity can result in a diminishment ranging from 50% to nearly 90% of otherwise unimpaired value.”<sup>63(p306)</sup> Researchers in Pennsylvania have found that neighboring house prices decrease once the total live weight of confined animals exceeds 200,000 pounds.<sup>66</sup> In rural Iowa, which leads the United States in both egg<sup>67</sup> and pig<sup>68</sup> production, a 2003 survey found that the development of pig CAFOs was equally or less desirable than construction of prisons, solid waste landfills, slaughter plants, and sewage treatment plants.<sup>69</sup>

## CONCLUSION

There are inherent limitations to studies assessing health outcomes in residents of communities situated near large-scale farm animal production facilities, including the inability to control for confounders, such as non-CAFO-related exposures, the complicated nature of the disease etiology, and the role of socioeconomic status in susceptibility. In addition, most studies rely on limited exposure assessment—for example, basing exposure estimates on the distance between a residence or school and a CAFO—which does not capture specific individual-level exposures, such as specific doses or how contaminants were dispersed. It is also likely that individuals may be exposed to multiple contaminants, which compounds the ability to perform accurate assessments due to the paucity of information about health outcomes related to exposure to mixtures.

The available data on the attendant risks, however, are concerning enough to warrant precautionary action. Recommendations by the Pew Commission on Industrial Farm Animal Production included the following:

- A phase out and subsequent ban on the nontherapeutic use of antibiotics, defined as any use of antimicrobials in animal agriculture in the absence of clinical disease or documented disease exposure.
- A phase out, within 10 years, of intensive confinement systems that restrict natural movement and behavior, including veal crates for calves, gestation crates for pregnant pigs, and battery cages for egg-laying hens.
- Developing and implementing “a new system to deal with farm waste (that will replace the inflexible and broken system that exists today) to protect Americans from the adverse environmental and human health hazards of improperly handled IFAP [industrial farm animal production] waste.”<sup>7</sup>(p77) Specifically, a combination of enclosed tanks for manure storage and municipal-style waste treatment has been suggested to limit microbial efflux.<sup>70</sup>
- Improved enforcement of existing federal, state, and local regulations to improve siting and protect the health of those who live near these operations.
- Local control and public input for the siting of new facilities, as well as access to redress for neighbors when these operations fail to comply with standards.<sup>7</sup> The issuance of permits could be contingent upon the bonding of manure storage reservoirs to ensure spill clean-up and proper consideration of watershed-level animal density and airshed emission dispersion.<sup>41</sup>

The American Public Health Association has gone further, issuing a policy statement that urges federal, state, and local governments and public health agencies to impose a moratorium on the construction of new CAFOs.<sup>23</sup>

Studies have indicated that residents of communities situated near CAFOs may be at increased risk of developing certain adverse health outcomes, including respiratory illnesses. Community members may also be more susceptible than CAFO workers due to the healthy worker effect—that is, the working population tends to be healthier than does the general population, as the latter may be more likely to be afflicted with chronic health conditions. More research is needed to better understand exposures and health outcomes related to large-scale CAFO operations.



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