Public Health Concerns for Neighbors of Large–Scale Swine Production Operations

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Abstract

This article provides a review and critical synthesis of research related to public health concerns for neighbors exposed to emissions from large–scale swine production operations. The rapid industrialization of pork production in the 1990s produced a generation of confined animal feeding operations (CAFOs) of a size previously unseen in the U.S. Recent research and results from federally sponsored scientific symposia consistently indicate that neighbors of large–scale swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. Symptoms experienced by swine CAFO neighbors are generally oriented toward irritation of the respiratory tract and are consistent with the types of symptoms among interior confinement workers that have been well documented in the occupational health literature. However, additional exposure assessment research is required to elucidate the relationship of reported symptoms among swine CAFO neighbors and CAFO emissions.

Keywords. *Swine, CAFOs, Public health, Neighbors.*

The report "Agriculture at Risk: A Report to the Nation" (Merchant et al., 1989) played a central role in elevating agricultural health issues to national prominence. The cast of agricultural health issues laid forth in the report set the stage for shaping priority research issues. However, the rapid pace of agricultural industrialization resulted in tremendous change in the agricultural sector between the time of the report in 1989 and the present. Nowhere is this more evident than in the livestock sector, particularly the swine industry. The rapid structural shift in the swine sector towards concentration and consolidation created environmental and public health problems largely unforeseen in the 1989 report, or even in the Surgeon General's Report on Agricultural Safety and Health issued three years later (Myers et al., 1992). Specifically, the swift growth of large–scale confined animal feeding operations (CAFOs) in the 1990s has resulted in the emergence of whole new agricultural health issues previously unmentioned.

In this article, I focus on emergent agricultural health concerns related to CAFOs, namely public health concerns for neighbors exposed to CAFO emissions. Concerns have been directed at a broad spectrum of CAFOs, including dairy, cattle, and poultry. However, the swine industry has received the most attention from both a public health and public policy standpoint. In addition, considerable research on occupational

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health challenges among swine confinement workers was in fact present at the time of the "Agriculture at Risk" report, and numerous subsequent conferences provide a backdrop for consideration of CAFO neighbor health issues. Consequently, this article will focus directly, though not exclusively, on reviewing research and concomitant agricultural and public health issues related to CAFO emissions and neighbor health concerns in the swine sector.

Background

The industrialization of agriculture dates back to at least the previous century and is characterized, in part, by the substitution of fossil fuels and capital intensive production technology for human labor (Thu and Durrenberger, 1998). The substitution of fossil fuel–based technology in place of farmers has resulted in the consolidation of production into fewer hands and the attendant growth of large–scale production operations. The swine industry is a classic example of this industrialization process. There is very little difference between the total U.S. inventory of hogs in the year 2000 (59.3 million) compared with the total inventory of hogs produced over 80 years earlier in 1915 (60.6 million) (USDA NASS). However, while overall production volume has changed little, the structure of the industry has shifted radically. As revealed in figure 1, the number of hog producers in the U.S. declined precipitously from the 1960s to the present. Notable in this regard is the rapid rate of decline and concurrent emergence of relatively large production operations. For example, in a mere six–year period from 1993 to 1999, there was a 250% increase in the total U.S. hog inventory concentrated in operations with 5,000 or more hogs each (USDA NASS).

The structural shift in the hog industry paralleled technological changes. Most notable among these is the transformation from pasture–based and open–lot hog production to totally confined production beginning in the 1970s. Movement to totally confined production provided a seeming advantage to the bulk of hog farmers in the Midwest by providing an antidote to harsh climatic conditions that impeded growth rates and time to market. Moreover, enclosed production units provided an opportunity for stricter control of feed rationing and reproduction. However, as is so often the case, technological changes produced unforeseen costs.

Worker Health Problems and Swine CAFOs

One of the principles underlying confined animal production is to control the climatic elements that hinder swine growth, particularly in temperate regions. To accomplish this, an enclosed environment is created to keep outdoor conditions, most notably the frigid cold, from coming indoors. This also means that elements inherent to hog production will, to varying extents, be confined to the inside. Soon after confinement production emerged in the 1970s, studies began to reveal that confining pigs also meant confining airborne elements injurious to both workers and pigs. In a 25–year period beginning in the 1970s, nearly 30 published studies consistently revealed a variety of health problems among swine confinement workers, the most notable of which are a series of respiratory problems (see reviews in Thorne et al., 1996; Cole et al., 2000).

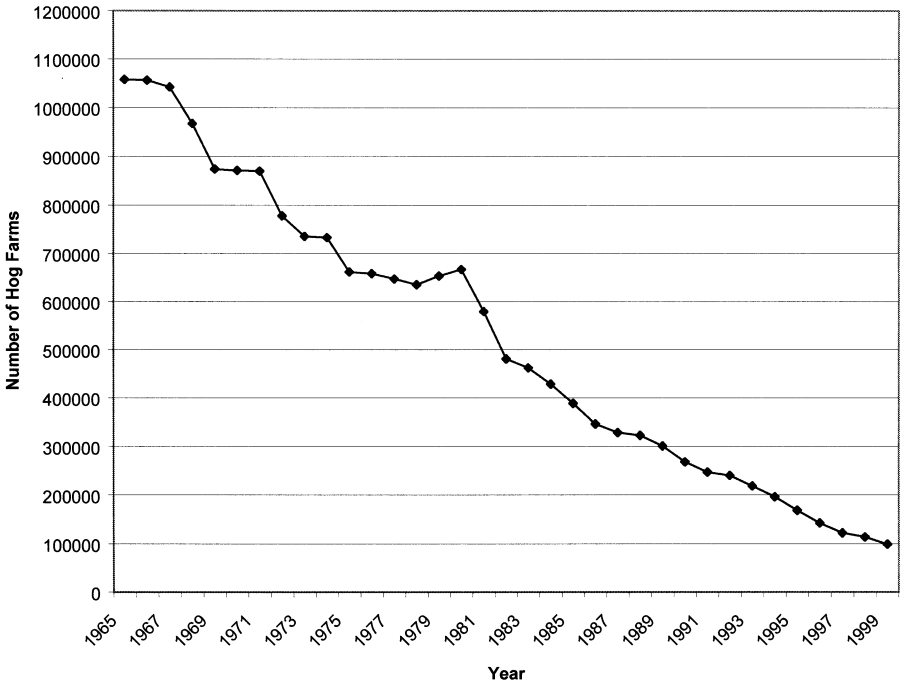

Figure 1. Total U.S. hog farmers from 1965 to 1999 (USDA NASS).

Respiratory problems include a series of overlapping conditions such as chronic bronchitis, occupational asthma, and organic dust toxic syndrome that have been documented to occur in up to 30% of swine confinement workers. Symptomatic signals of chronic problems include nagging cough with production of phlegm persisting for more than three months in a year, chest tightness and/or wheezing associated with work in a confinement, persistent fatigue in conjunction with headaches and difficulty breathing, symptoms of a cold that won't go away (stuffy nose, sore throat, and "popping" ears), and decreases in pulmonary function (Thorne et al., 1996, p. 163–164). Six or more years of exposure heightens the potential for chronic problems, while a minimal two–hour exposure inside a confinement may result in shorter–term acute symptoms such as itchy, watery eyes and chest tightness. Moreover, many of these symptoms and overarching conditions can co–occur, making them difficult to discern and assess. It is reasonably clear that persons with medical pre–conditions, such as asthma, are more susceptible to these constellations of problems. It has also been suggested that some of these conditions may result in irreversible lung damage (Thorne et al., 1996, p. 164).

More detailed research identified the concentration levels of interior ambient airborne elements, including their interactive dynamics, which put exposed worker populations at risk. For example, recommended gas (7 ppm ammonia), dust (2.5 mg/m^3 total dust; 0.23 mg/m^3 respirable dust), and endotoxin (100 EU/m^3) levels have been developed for interior swine confinement operations based on dose–response research (Donham et al., 1995; Reynolds et al., 1996). Researchers have also noted that when these elements combine (e.g., ammonia attached to small dust particles), they may have an added negative health consequence.

At the time of the "Agriculture at Risk" report, occupational health problems among swine confinement workers were clearly recognized. The occupational health research over the past ten years has resulted in further clarification of exposures and the connections to health symptomologies and defined medical conditions. However, virtually unknown in 1989 was the existence of health problems among neighbors exposed to swine CAFOs. Since the mid–1990s, research examining the health of neighbors of large–scale swine production has opened a new chapter concerning the health costs of confined swine production.

An Emergent Public Health Issue: Swine CAFO Neighbors

There is no indication in the earliest occupational health literature that swine CAFOs posed any real or potential health problems to neighbors. This is understandable since the relatively modest size of early–generation swine CAFOs simply did not seem likely to pose an air–quality challenge beyond nuisance odor. Indeed, an entire cottage research industry developed among agricultural engineers to understand and control emissions from livestock facilities as an odor problem largely devoid of any heath reference (Hobbs, 1995; Miner, 1975; O'Neill and Phillips, 1992). Nonetheless, a close examination of early odor literature provides clues that a lingering health issue could be present.

For example, early agricultural engineering reports (Overcash, 1984) indicated the possibility that livestock odors could elicit deleterious physiological responses, including nausea, vomiting, headaches, coughing, and irritation of eyes, nose, and throat. In addition, health science literature showed odor exacerbating pre–existing conditions such as asthma (Chang and Williams, 1986). Within the tradition of livestock odor research, Warner et al. (1990) examined emissions from a swine facility in Michigan in order to assess the intensity and distance that odor traveled in creating a nuisance, or quality of life, problem. Moreover, embedded in this work was a health survey that recorded health symptoms among neighbors as an early indication that something beyond an unpleasant nuisance was involved. These early studies reveal that odor has a tangible physical property that elicits a physiological response. Moreover, odor is only one dimension of the panoply of swine CAFO emissions, which include over 160 identified compounds (see Ritter, 1989; and overview odor discussion in Melvin et al., 1996). Consequently, this early research may have mistakenly assumed that odor was the primary constituent of CAFO emissions exposure responsible for reported health symptoms.

In 1995, Dr. Susan Schiffman and colleagues at Duke University published the first research specifically focused on the negative health effects of exposure to emissions among neighbors of swine CAFOs. The results were based on a matched control study examining the psychological effect of odors from commercial swine operations in North Carolina (Schiffman et al., 1995). Researchers administered a standardized mood states (POMS) and total mood disturbances (TMD) scale to 44 neighbors of commercial swine operations and 44 controls not living near such operations who were matched based on age, gender, education, and race. Results showed that the neighbors subjected to odors scored significantly higher on both scales, exhibiting higher rates of tension, depression, anger, and fatigue than did the control group. Elsewhere, Schiffman describes a variety of mechanisms that explain how odor can have a deleterious human health effect, including a physiological pathway between the olfactory lobe and the immune system, which directly implicate odor as a health risk (Schiffman et al., 1998).

As a follow–up to the Schiffman study, Thu et al. (1997) published the results of a control study based on physical and psychological health data from 18 neighbors living within a two–mile radius of a 4,000–sow swine confinement production facility. They compared the results with data from 18 demographically comparable rural residents who did not live near concentrations of livestock in Iowa. The results indicated that the neighbors of the swine operation reported significantly higher rates of four clusters of symptoms previously documented to represent toxic or inflammatory effects of the respiratory tract among confinement workers. One cluster reported by swine CAFO neighbors includes symptoms such as coughing, sputum production, breath shortness, chest tightness, and wheezing. A second cluster includes symptoms of nausea, weakness, and feelings of dizziness. A third cluster consists of headaches and plugged ears, while a fourth cluster encompassed symptoms of a runny nose, scratchy throat, and burning eyes. Most notable is the fact that for the first time the configuration of respiratory symptoms among neighbors was documented to be consistent with the scientifically well–established pattern of respiratory health problems among swine confinement workers discussed previously.

In April of 1998, a scientific workshop on odors and health problems was held at Duke University and spearheaded by Dr. Susan Schiffman. The workshop, in which I participated, was sponsored by Duke University, the Environmental Protection Agency, and the National Institute on Deafness and Other Communication Disorders and brought together nearly 50 experts from a broad array of scientific fields to assess the current state of scientific knowledge concerning the health consequences of odor exposures, particularly odors generated by large livestock operations. The results, published two years later (see Schiffman et al., 2000), revealed three general paradigms whereby ambient odors can indeed produce health problems: (1) physiological irritation from emission levels causing toxicological effects in which odor is simply a marker, (2) symptoms produced by malodors but without concomitant toxicological irritation, and (3) odors as part of a mixture of co–pollutants. In paradigms one and three, the odor serves as a signal that other ambient emission elements are creating the health symptoms. The over–riding conclusion of the workshop was that odors and their interconnected airborne emission partners can cause health problems:

> "Our current state of knowledge clearly suggests that it is possible for odorous emissions from animal operations, wastewater treatment, and recycling of biosolids to have an impact on physical health. The most frequently reported symptoms attributed to odors include eye, nose, and throat irritation, headache, nausea, hoarseness, cough, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations of mood" (Schiffman et al., 2000, p. 57).

In June of 1998, the same year as the Duke conference, the National Center for Environmental Health, Centers for Disease Control and Prevention, responded to growing nationwide concerns expressed through state health agencies about the environmental and public health consequences of CAFOs by sponsoring their own scientific workshop, "Public Health Issues Related to Concentrated Animal Feeding Operations," in which I also participated. The scientific workshop brought together over 35 experts and divided them into two groups to focus on water and air contamination. The CDC workshop produced a report consistent with the Duke results, indicating that exposure to odor–related emissions from large–scale livestock facilities can result in health problems for neighbors. The group of scientists focusing

on CAFO–related air contamination agreed that "adequate evidence currently exists to indicate airborne emissions from large–scale swine facilities constitute a public health problem" (CDC, 1998, p. 30).

In 1999, a landmark study funded by the North Carolina Department of Health and Human Services, Division of Public Health, was released and later published in *Environmental Health Perspectives* (Wing and Wolf, 2000). This was the largest study to date examining the health and quality of life of residents living in proximity to large swine operations. The researchers examined three different rural communities, which included residents living near a 6,000–swine CAFO, residents living near two intensive cattle operations, and a control area where residents lived at least two miles from any livestock operation that used a liquid manure system. After controlling for age, gender, smoking, and work, the findings among the 155 participants were consistent with Thu et al. (1997) and Schiffman et al. (1995), as well as with the two 1998 scientific workshops, in revealing elevated health problems among residents living in proximity to the swine CAFO. There were significantly elevated rates of headaches, runny nose, sore throat, excessive coughing, diarrhea, and burning eyes among neighbors of the swine operation.

The results of the Wing and Wolf (2000) study are notable for two reasons. First, the results indicate that reporting bias was not a problem. It is clear that participants in this study, as well as in the comparable study by Thu et al. (1997), could be subject to reporting bias because residents may simply want to provide negative responses to the pork industry. However, if that is the case, then it is extremely difficult to explain the highly selective nature of reported symptoms and the fact that participants chose not to report elevated rates of all symptoms when given the opportunity. That did not occur in either the Thu et al. (1997) study or the Wing and Wolf (2000) research. Indeed, in the Wing and Wolf research, many of the reported symptoms were similar in all three of their research groups in North Carolina. Second, the configuration of reported symptoms is consistent with well–documented symptoms among swine confinement workers. It appears highly unlikely that two groups of swine CAFO neighbors would stumble upon a consistent set of symptoms that match symptoms among swine confinement workers.

Further evidence for health problems among swine CAFO neighbors comes from the Bureau of Epidemiology within the Utah Department of Health (Keller and Ball, 2000). In 1993, one of the largest hog operations in the country began construction near the town of Milford (population 1,305) in Beaver County, southern Utah. In the following two years, the facility was populated with pigs whose sow base reached 44,000 (with a reported target of 120,000 total sows). At the request of the Southwest Utah District Health Department, Utah's Bureau of Epidemiology responded to concerns about increases in diarrheal and respiratory disease among nearby Milford residents. A retrospective study of hospital discharge records from nearby Milford was compared with two comparison populations in the region, in addition to statewide averages for Utah as a whole. The investigation examined whether hospital discharge records from Milford indicated higher rates of respiratory and diarrheal illness during the years 1992 to 1998 (when the swine CAFO was constructed and became operational) compared to other communities in the region and the state as a whole. The findings demonstrated an increase in both diarrheal and respiratory illness cases in Milford during the period from 1992 to 1998 when the swine CAFO became operational. For example, Milford experienced a quadrupling of hospital diarrheal case rates, from 88 per 10,000 in 1992, to 409 per 10,000 in 1997. During the same period, Milford reflected a tripling of hospital cases involving respiratory illness, from 159 cases per 10,000 in 1992, to 517 cases per 10,000 in 1997. Moreover, the

incidence rates were significantly higher than those found in comparison populations and in the state as a whole, leading the authors to conclude: “The results of this investigation found evidence that suggests elevated incidence of diarrheal and respiratory illness in Milford as compared to Parowan, Panuitch, and the State of Utah during the time period of 1992 through 1998” (Keller and Ball, 2000, p. 7). The investigators do not ascribe causation to the neighboring swine CAFO, but the implication is clear.

The evidence is mounting that a public health problem appears to be present for not only swine confinement workers but for neighbors of swine CAFOs as well (Thu, 1998). These studies, as well as federal and state reports, independently and consistently show that neighbors, including farmer neighbors, of large–scale swine production are experiencing abnormally high rates of health problems compared with other populations. Moreover, the health symptoms experienced by neighbors are consistent with, and similar to, the types of health symptoms that have been well documented among interior confinement workers. However, in contrast to occupational health research among CAFO workers, comparable exposure studies investigating potential toxicants and their relationship to neighbor health problems are notably lacking.

There are clues from the occupational health literature, the odor research, and investigations in other industries that suggest the direction for future human exposure research. Among the airborne elements to examine are hydrogen sulfide, volatile organic compounds (VOCs), dusts, endotoxin, and perhaps ammonia, in addition to the irritant dimension of odors (see Reynolds et al., 1997). It should be noted that many of these ingredients have an interactive and synergistic effect, such as gas molecules attaching to dust particles.

While the likely culprit is some combination of emission constituents, exposure to hydrogen sulfide merits particularly attention. Hydrogen sulfide is a known toxic gas produced by the anaerobic digestion of protein in swine CAFOs. Chronic or acute occupational exposure to hydrogen sulfide concentrations near or above 500 ppm is known to result in Acute Respiratory Distress Syndrome (ARDS) or pulmonary edema among swine confinement workers, which can be fatal. However, less attention has been devoted to examining the consequences of longer–term exposure to low levels of hydrogen sulfide. In the oil refinery industry, exposure to low levels of hydrogen sulfide produces symptoms such as shortness of breath, headache, eye irritation, small–airway obstruction, and diarrhea (Kilburn and Warshaw, 1995). Moreover, longer–term exposure to low levels of hydrogen sulfide can result in permanent neurological dysfunction with accompanying physiological damage (Kilburn, 1993, 1997). This threat has resulted in six states establishing hydrogen sulfide or reduced sulfur standards. Hydrogen sulfide monitoring of swine CAFOs in Minnesota by the Minnesota Pollution Control Agency (MPCA) confirms the relevance of research on chronic exposure to low levels of hydrogen sulfide (Sullivan, 1999). The MPCA data reveal that swine CAFOs can emit hydrogen sulfide onto neighboring property at levels that exceed World Health Organization recommended standards (Roth, 1993). Moreover, recent work prepared in conjunction with Minnesota policy planning provides a comprehensive review of livestock emission constituents and their potential human health consequences (Earth Tech, Inc., 2001).

Discussion

The decade following the release of "Agriculture at Risk: A Report to the Nation" (Merchant et al., 1989) witnessed a dramatic change in the structure of the livestock industry, particularly the swine sector. The rapid industrialization of pork production produced a generation of confined production facilities at a scale never before experienced in the U.S. The enormous size of these operations has given rise to the necessity of moving beyond a traditional odor–based research paradigm and toward a more encompassing public health research paradigm. Nearly three decades of research on the interior environment of swine CAFOs and the well–documented exposure consequences for confinement workers provide important direction for research on external emissions to better understand the health consequences for CAFO neighbors. 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. It should be noted that odor is but one component of emissions and can both create problems by itself and act as a marker for the presence of irritant toxins. Symptoms experienced by swine CAFO neighbors are generally oriented toward irritation of the respiratory tract and are consistent with the types of symptoms that have been well documented among swine confinement workers. However, additional exposure assessment research is required to elucidate the relationship of reported symptoms among swine CAFO neighbors and emissions from CAFOs.

Research is currently underway and progress is being made toward identifying emission elements potentially responsible for health problems. However, much research continues to be technically focused, with lesser attention on the people involved, particularly from the neighbors' standpoint. Many of these issues involve rural quality of life expectations and considerations that can and should be investigated in concert with technical research. Indeed, common law nuisance and state air pollution statutes may focus more directly on the experiences, expectations, and quality of life norms of neighbors than technical measurements of various emission constituents. Hence, we need not only additional epidemiological and exposure assessment research, we also need additional anthropological and social science research to more fully understand quality of life norms and expectations among rural residents.

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