

Neighbor Health and Large-scale Swine Production

Kendall M. Thu, Ph.D.
Department of Anthropology
Northern Illinois University
DeKalb, Illinois 60115-2854
Phone: 815/753-0479
Email: KThu@NIU.edu

Introduction

The 1989 report "Agriculture at Risk: A Report to the Nation" 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. No where 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 paper 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 health challenges among swine confinement workers was in fact present at the time of the "Nation at Risk Report" and numerous subsequent conferences which provide a backdrop for consideration of CAFO neighbor health issues. Consequently, this paper will focus most 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. As illustrated in Figure 1, there is very little difference between the number of hogs produced in the U.S. in the year 2000 compared with the number of hogs produced over 80 years earlier in 1915.

[Figure 1. U.S. Hog Production in 1915 and 1999 (USDA NASS)]

While overall production volume has changed little, the structure of the industry has shifted radically. As revealed in Figure 2, 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

[Figure 2. Total U.S. Hog Farmers from 1965 to 1999 (USDA NASS)]

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 which impeded growth rates and time to market. Moreover, enclosed production units provided an opportunity for stricter control over 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, particularly in temperate regions, that hinder swine growth. 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 alike. In a 25-year period beginning in the 1970s, nearly 30 published studies consistently reveal 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, Todd and Wing, 2000). These 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 nearly 30 percent of swine confinement workers. 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/m³ total dust; .23mg/m³ respirable dust), and endotoxin (100 EU/3) levels have been developed for interior swine confinement operations based on dose-response research (Donham et al., 1995; Reynolds et al., 1996).

At the time of the "Nation 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 among neighbors. This is understandable since the relatively modest size of an early generation of 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 health reference (Hobbs, 1995; Miner, 1975; O'Neill and Phillips, 1992). Nonetheless, a close examination of early odor literature does provide clues that a lingering health issue was present.

For example, early agricultural engineering reports (Overcash et al., 1984) indicated the possibility that livestock odors could elicit deleterious physiological responses, including nausea, vomiting and headaches, coughing, and irritation of eyes, nose and throat. In addition, health science literature showed odor exacerbating pre-existing conditions such as asthma (Change and Williams, 1986). Within the tradition of livestock odor research, Warner, Sidhu, and Chadzynski (1990) examined emissions from a swine facility in Michigan in order to assess the intensity and distance odor traveled in creating a nuisance, or quality of life, problem. However, embedded in this work was a health survey which recorded health symptoms among neighbors as an early indication that something beyond an unpleasant nuisance was involved. These early works 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 that 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, Susan Schiffman and colleagues from Duke University published the first research specifically focused on the negative neighbor health effects of exposure to emissions from 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). They administered a standardized mood states (POMS) and total mood disturbances (TMD) scale to 44 neighbors of commercial swine operations and 44 matched controls not living near such operations. 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. published the results of a control study (1997) 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 lived near minimal livestock in Iowa. 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. Most notable is the fact that for the first time the configuration of respiratory symptoms among neighbors were documented to be consistent with the well-established pattern of respiratory health problems among swine confinement workers evident in the occupational health literature.

In 1998 the National Center for Environmental Health, Centers for Disease Control and Prevention, responded to growing nation-wide concerns expressed through state health agencies about the environmental and public health consequences of CAFOs by sponsoring a workshop, "Public Health Issues Related to Concentrated Animal Feeding Operations." The workshop brought together over 35 experts and divided them into two groups to focus on water and air contamination from CAFOs. It is noteworthy that the group of scholars who focused on CAFO air contamination agreed that "adequate evidence currently exists to indicate airborne emissions from large-scale swine facilities constitute a public health problem" (CDC, NCEH, 1998:30).

In 1999, a landmark study funded by the North Carolina Department of Health and Human Services, Division of Public health, was released. This was the largest study to date examining the health and quality of life of residents living in proximity to large swine operations. Later published in *Environmental Health Perspectives* (Wing and Wolf, 2000), researchers examined three different rural communities to include 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. Controlling for age, gender, smoking, and work, the findings among the 155 participants were consistent with Thu, et al. (1997) and Schiffman (1995) 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 study are notable for two fundamental reasons. First, the results indicate reporting bias was not a problem. It is clear that participants in this study, as well as the comparable study by Thu, et al. (1987), could be subject to reporting bias because residents may simply want to provide negative responses to the pork industry that they may disagree with. However, if that is the case, it is extremely difficult to explain away 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. (ibid) study or the Wing and Wolf research (2000). Indeed, in the Wing and Wolf research, many of the symptoms reported were similar in all three groups. Second, the configuration of reported symptoms are consistent with well-documented symptoms among swine confinement workers. It appears highly unlikely that two cohorts of swine CAFO neighbors could accidentally stumble upon selecting a consistent set of symptoms that match symptoms among swine confinement workers.

Further evidence for swine CAFO neighbor health problems 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 sows (with a reported target of 120,000 total sows). At the request of the Southwest Utah District Health Department, Utah's Bureau of Epidemiology within the Utah Health Department, responded to concerns about increases in diarrheal and respiratory disease among nearby Milford residents. A retrospective approach utilizing hospital discharge records from nearby Milford was used and 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. Findings demonstrate 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 100,000 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 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 in Milford as compared to Parowan, Panuitch, and the State of Utah during the time period of 1992 through 1998" (Keller and Ball, 2000:7). The investigators do not ascribe causation to the neighboring swine CAFO, but the implication is clear.

The evidence is mounting that swine CAFO workers are not the only ones experiencing health problems, a public health problem appears to be present (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 being experienced by neighbors are consistent with, and similar to, the types of health symptoms 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 which suggest 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. 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 (parts per million) 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 and 1997). This threat has resulted in six states establishing hydrogen sulfide or reduced sulfur standards. Hydrogen sulfide monitoring data from swine CAFOs in Minnesota by the Minnesota Pollution Control Agency (MPCA) confirm the relevance of research on chronic exposure to low levels of hydrogen sulfide (Sullivan, 1999). MPCA data reveal that swine CAFOs can emit hydrogen sulfide onto neighboring property at levels that exceed World Health Organization recommended standards (Roth, 1993).

Discussion

Research to date indicates that neighbors of swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. This fact has been recognized in legal cases, such as an Appellate Court decision in Missouri, that have upheld local government authority to establish public health based ordinances to influence the siting of CAFOs in order to protect the health of its citizenry based on established science. Such local health board activity has already occurred in North Carolina and Missouri, with comparable efforts underway in a number of other states. In addition, nuisance lawsuits leveled by farmer and non-farmer neighbors against CAFOs will most certainly make increasing use of public health problems from both an air emissions and water quality premise.

In 1998, the President of the United States released the Clean Water Action Plan (CWAP) which provided a blueprint for restoring and protecting water quality across the Nation. The CWAP called for the development of a USDA/EPA Unified Strategy to minimize the water quality and public health impacts of animal feeding operations. This effort has resulted in a comprehensive set of rules to be enforced via the National Pollution Discharge Elimination System (NPDES) permits for CAFOs which are currently in the Federal Register for public comment. However, this effort has focused primarily on water quality, with little attention to air quality. Comparable research and policy attention to exterior air quality problems, human exposures, and health conditions resulting from CAFOs is necessary.

References

Centers for Disease Control and Prevention. 1998. The Confinement Animal Feeding Operation Workshop. Washington, D.C.: National Center for Environmental Health.

Chang, S., and M.H. Williams. 1986. Effect of Odors in Asthma. *American Journal of Medicine* 80:18-22.

Cole, D., L. Todd, and S. Wing. 2000. Concentrated Swine Feeding Operations and Public Health: A Review of Occupational and Community Health Effects. *Environmental Health Perspectives* 108(8):685-699.

Donham K.J., S.F. Reynolds, P. Whitten, J. Merchant, L. Burmeister, and W. Popendorf. 1995.

Respiratory Dysfunction in Swine Production Facility Workers: Dose-Response Relationships of Environmental Exposures and Pulmonary Function. *American Journal of Industrial Medicine* 27:405-418.

Hobbs, P. 1995. Measurement of Swine Odor Using Electronic Nose Technology. In *International Round Table on Swine Odor Control*, pp.36-39. Ames, Iowa: Iowa State University.

Keller, K.H. and R.W. Ball. 2000. A Retrospective Study of Diarrheal and Respiratory Illness Incidence Rates in Milford, Utah 1992-1998. Salt Lake City, Utah: Bureau of Epidemiology, Utah Department of Health.

Kilburn, K. 1997. Exposure to Reduced Sulfur Gases Impairs Neurobehavioral Function. *Southern Medical Journal* 90(10):997-1006.

Kilburn, K. 1993. Case Report: Profound Neurobehavioral Deficits in an Oil Field Worker Overcome by Hydrogen Sulfide. *The American Journal of the Medical Sciences* 306(5):301-305.

Kilburn, K. and R.H. Warshaw. 1995. Hydrogen Sulfide and Reduce-Sulfur Gases Adversely Affect Neurophysiological Functions. *Toxicology and Industrial Health* 11(2):185-197.

Melvin, S., D. Bundy, K. Casey, R. Miner, S. Schiffman, J. Sweeten. 1996. Air Quality. In *Understanding the Impacts of Large-Scale Swine Production*. K. Thu, Editor. Iowa City, Iowa: The University of Iowa.

Merchant, J.A., B.C. Kross, K.J. Donham, and D.S. Pratt. 1989. *Agriculture at Risk: A Report to the Nation*. The University of Iowa, Iowa City, Iowa: National Coalition for Agricultural Safety and Health.

Miner, J.R. 1975. Management of odors associated with livestock production. In *Managing livestock wastes*, pp. 378-380. St. Joseph, Missouri: American Society of Agricultural Engineers.

Myers, M.L., R.F. Herrick, S.A. Olenchock, J.R. Myers, J.E. Parker, D.L. Hard, and K. Wilson. 1992. *Papers and Proceedings of the Surgeon General's Conference on Agricultural Health and Safety*. Cincinnati, Ohio: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

O'Neill, D.H. and V.R. Phillips. 1992. A review of the control of odor nuisance from livestock buildings: Part 3, Properties of the odorous substances which have been identified in livestock wastes or in the air around them. *Journal of Agricultural Engineering Research* 34:23-50.

Overcash, M.R. 1984. *Livestock Wastes Management: Volumes I&II*. Boca Raton, Florida: CRC Press Inc.

Reynolds, S.J., K.J. Donham, J. Stookesberry, P.S. Thorne, P. Subramanian, K. Thu, and P. Whitten. 1997. Air Quality Assessments in the Vicinity of Swine Production Facilities. *Journal*

of Agromedicine 4(1/2):37-46.

Reynolds, S.J., K.J. Donham, P. Whitten, J.A. Merchant, L. Burmeister, and W. Popendorf. 1996. Longitudinal evaluation of dose-response relationships for environmental exposures and pulmonary function in swine production workers. *American Journal of Industrial Medicine* 29:33-40.

Ritter, W. F. 1989. Odor control of livestock wastes: State-of-the art in North America. *Journal of Agricultural Engineering Research* 42:51-62.

Roth, S. 1993. Hydrogen Sulfide. *Handbook of Hazardous Materials*. Academic Press.

Schiffman, S., E.S. Miller, M.S. Suggs, and B.G. Graham. 1998. Mood Changes Experienced by Persons Living Near Commercial Swine Operations. In *Pigs, Profits, and Rural Communities*. K. Thu and E.P. Durrenberger, eds. Albany, New York, State University of New York Press.

Schiffman, S., E.S. Miller, M.S. Suggs, and B.G. Graham BG. 1995. The Effect of Environmental Odors Emanating from Commercial Swine Operations on the Mood of Nearby Residents. *Brain Research Bulletin* 37(4):369-375.

Sullivan, J. 1999. Feedlot Air Quality Summary: Data Collection, Enforcement and Program Development. Minneapolis, Minnesota: Minnesota Pollution Control Agency.

Thorne, P.S, K.J. Donham, J. Dosman, P. Jagielo, J.A. Merchant, and S. von Essen. 1996. Occupational Health. In *Understanding the Impacts of Large-Scale Swine Production*, K. Thu, ed. Iowa City, Iowa: University of Iowa.

Thu, K. 1998. Odor Problems from Large-Scale Agriculture: Nuisance or Public Health Problem? *Health and Environment Digest* 12(8):57-59.

Thu, K.M. and E.P. Durrenberger. 1998. *Pigs, Profits, and Rural Communities*. Albany, New York: State University of New York Press.

Thu, K., K. Donham, R. Ziegenhorn, S. Reynolds, P. Thorne, P. Subramanian, P. Whitten, and J. Stookesberry. 1997. A Control Study of the Physical and Mental Health of Residents Living Near a Large-Scale Swine Operation. *Journal of Agricultural Safety and Health* 3(1): 13-26.

United States Department of Agriculture. Multiple Years. National Agricultural Statistical Service. Washington, D.C.

Warner, P.O., K.S. Sidhu, and L. Chadzynski. 1990. Measurement and Impact of Agricultural Odors from a Large Scale Swine Production Farm. *Veterinary and Human Toxicology* 32(4):319-323.

Wing, S. and S. Wolf. 2000. Intensive Livestock Operations, Health, and Quality of Life Among Eastern North Carolina Residents. *Environmental Health Perspectives* 108(3):233-238.