Environmental Exposure and Health Effects From Concentrated Animal Feeding Operations

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Abstract: Modern concentrated animal feeding operations generate sizeable amounts of manure and related emissions into water and air. These present potential harm to human health. Adverse respiratory effects have been documented among workers in these feeding operations, but there has been little research on wider environmental effects. Few conclusions are possible at this time but recent studies (including a report in this issue of EPIDEMIOLOGY by Radon and colleagues) suggest possible adverse effects. Respiratory outcomes of greatest concern include nasal allergies, airflow obstruction and asthma. Another concern among residents near concentrated animal feeding operations is adverse effects from malodors. The potential impact of these operations on quality of life and health needs to be documented.

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Historically, livestock was raised on small family farms spread throughout agricultural regions. Over the past 4 decades, the total number of livestock farms has sharply declined, while the number of confined animals being raised in concentrated feeding operations has increased. Since 1960, the number of cattle farms in the United States has fallen 59%, the number of dairy farms has fallen 94%, and the number of hog farms has fallen 95%—even though the total number of livestock has been relatively constant.[1] Today, concentrated animal feeding operations make up 5% of all livestock farms in the nation but raise 54% of all livestock.[2,3] This trend is exacerbated by the nation's "cheap food policy" in which consumer demand for inexpensive food leads to increasing production efficiencies utilizing larger livestock facilities.[4] Modern livestock industries simply follow Henry Ford's rule of producing the highest quality goods at the lowest costs possible.

Modern animal feeding operations produce large amounts of animal waste (288 million tons in the United States annually).[2,3,5] Disposing of this sizeable amount of manure is a challenge. There are potential adverse human health effects of manure and its related emissions into water and air.

Communities in regions with large-scale animal production can range from small family farms (crop- or animal-producing), to rural nonfarm residents to urban residents in neighboring towns. In some parts of the United States, there is a shift of populations from cities to the countryside where they experience the nuisances of concentrated livestock production.[6] This can lead to complaints, conflict, and ultimately a need for legislative and regulatory actions.

Until recently, most of the attention to human health risks posed by concentrated animal feeding operations was related to water quality (eg, nitrate leaching in ground water). However, air emissions from livestock facilities present a growing challenge. Concentrated animal feeding operations emit several compounds of concern, including endotoxin, particulate matter, ammonia, hydrogen sulfide, volatile organic compounds, and various greenhouse gases.[7] Studies are needed to investigate the emissions from concentrated animal feeding operations and their potential health effects, to identify vulnerable worker and neighborhood groups, and if warranted, to identify and implement options for mitigation.

Occupational Health Concerns

Work in the animal agricultural industries continues to rank among the most hazardous of all occupations.[8–12] The 2 main contributors to worker injury are machinery-related and animal-related incidents.[11,12] Air pollutants also pose a risk.[13,14] Harmful air emissions in animal farming arise from the handling of feed, movement of animals on manure, and the storage and removal of manure. The composition of air emissions (gases and particulate matter) can differ widely according to farm layouts, management type, region, and species of animals housed. This variability makes it difficult to identify specific practices and recommend changes.[7]

As with other occupational hazards, higher exposures occur to workers than to neighboring residents. Thus, research to understand the effects of exposures from animal feeding operations often progresses from studies of workers to studies of neighbors who experience lower exposures. The respiratory effects of agricultural occupational exposures have been well documented in recent years.[13,14] Agricultural exposures, particularly those from animal farming, are associated with a wide range of airway diseases including mucous membrane irritation, bronchitis, asthma, asthma-like syndrome and chronic obstructive pulmonary disease. Acute toxicity from high-dose gas exposures (eg, nitrogen oxides, hydrogen sulfide, ammonia) and interstitial diseases (hypersensitivity pneumonitis, interstitial fi-

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brosis) also are well documented. Many adverse respiratory effects of farming result from the wide spectrum of respiratory toxicants (eg, organic and inorganic dusts, gases, agrochemicals, biologic agents) as well as the exposure to high concentrations.

Questions have been raised about pesticide drift, dust exposure, plant antigens, and other agricultural agents that might affect neighboring populations. The capacity for adverse community effects from agricultural exposures was demonstrated in the Barcelona epidemic of asthma from exposure to soybean dust.[15] However, few studies have investigated the environmental effects of agricultural exposures in general, and those from concentrated animal feeding operations in particular, on local communities.

Environmental Health Effects

Recent work has begun to focus on the potential environmental health effects of concentrated animal feeding operations. A first step is the measurement of contaminant concentrations in the vicinity of such operations. This sampling needs to address temporal variability, plume dispersion, and individual exposures, taking into account indoor–outdoor gradients, physical activity, and other determinants. The pollutants of primary concern are ammonia, hydrogen sulfide, particulate matter and its contaminants (microorganisms, endotoxin), volatile organic compounds, and odors. Several studies have shown high concentrations of microbial organisms[16] and of endotoxin[13,17] in these feeding operations. For example, concentrations of endotoxin from hundreds to several thousand EU/m^3 may occur in some swine confinement operations,[18] while environmental endotoxin concentrations have been reported in single digits in residences near these operations.[19] More definitive exposure studies, epidemiologic studies, and modeling are needed to predict downwind concentrations and resulting health effects from concentrated animal feeding operations.[20]

What is currently known about adverse effects to the local communities? There are few studies on the potential health effects of environmental exposures from concentrated animal feeding operations, but this is changing.[21,22] Major outcomes of concern are those observed among workers, including respiratory and systemic effects,[23] reduced lung function and increased decline in lung function,[24–26] and asthma.[27,28] There are ample data showing an association of agriculture or concentrated animal feeding operations with asthma,[13,29] and endotoxin exposure alone may cause or exacerbate asthma.[30] However, little is known about environmental exposures from concentrated animal feeding operations and asthma. This question is particularly interesting because of studies showing a reduction of atopic sensitization with agricultural exposure to endotoxin.[31]

Odors are a product of concentrated animal feeding operations. While odors are not highly correlated with respiratory toxicants, self-assessed level of odor annoyance is a strong predictor of negative quality-of-life scores.[32,33] An immunosuppressive effect of odor on mucosal immunity has been hypothesized.[34] Studies of the health effects of odors are particularly challenging because objective outcome measures are required to reduce reporting bias.

The article in this issue by Radon and colleagues[35] adds important new data to our understanding of environmental health effects of CAFOs. They have shown an association of residence near CAFOs and self-reported wheeze and airflow obstruction (decreased forced expiratory volume in one second), but no association with asthma or allergic rhinitis. However, many questions remain before their observations can be accepted as causal. Specifically, replication is needed in different populations with better exposure characterization and careful selection of controls. Differences between European and larger U.S. CAFOs should also be studied. The complex relationship of agricultural exposures, atopy and asthma needs further elucidation, and may result in models suggesting different effects depending on the age and duration of an individual's exposure.

Adverse health effects of exposures from concentrated animal feeding operations have not been addressed by traditional ambient air quality studies or regulations. The same tools of air pollution research are needed to provide a scientific basis for regulatory decision-making. Careful studies need to evaluate individual exposures to neighboring residents, preferably coupled with real-time measurements of objective outcomes. The complex mixture of emissions from concentrated animal feeding operations needs to be studied to understand the etiologic agents. This should preferably be related to animal and exposure chamber studies to understand underlying mechanisms. Health effect studies are required to evaluate suspect adverse respiratory effects, with particular attention to dissecting the positive and negative effects of endotoxin exposure.[36] As with other air pollution health effects, meteorological conditions must be taken into account. Studies should also consider the impact of odor on health. Epidemiologic studies need to pay particular attention to acute as well as lifetime exposure histories. Finally, regulatory efforts will require assessment of the specific farming conditions and practices that produce harmful exposures.

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