Consequences of Respiratory Exposures in the Farm Environment

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Depending on the type of farming practice, respiratory symptoms are common among agricultural workers. Farmers are at risk for pulmonary illnesses, including chronic bronchitis, organic dust toxic syndrome, farmer's lung diseases, allergic and nonallergic asthma, nasal irritation and polyps, and chemical pneumonitis.

The agricultural environment presents numerous opportunities for exposures that may affect the respiratory system. Exposures vary by the type of agricultural occupation, but may include various dust particles, including inorganic particles such as silica, and various organic particles such as molds, bacteria, endotoxins, mycotoxins, pollens, grains, and animal feed. Other substances that may be inhaled include various gasses, from working in confined animal feeding operations (CAFOs). Numerous chemicals used or generated on farms may be inhaled, such as pesticides, exhaust fumes, fertilizers, and nitrogen oxides [1, 2]. Additionally, some zoonotic pathogens may be spread by the inhalation route.

Exposures can cause disease of either the upper or the lower respiratory tract, or both. Farmers often report more problems with smell impairment and often have more nasal polyps and hyperemia of the nasal mucosa, possibly indicating effects of allergens and irritants in their workplaces [3]. In contrast, other studies found that growing up on a farm appears to have a protective effect, with a lower prevalence of allergic rhinitis and asthma [4-6]. Surprisingly, farmers have lower rates of lung cancer, probably because of a lower prevalence of smoking.

Animal Exposures

Most farms have various species of animals present. Animals may be raised as a source of income (eg, beef cattle, swine, poultry, goats, and sheep) or may be used to guard other animals (dogs, donkeys, llamas), or they may be present simply as domestic pets.

Animals may be the source of allergens (saliva, urine, and dander) or zoonotic pathogens. Zoonotic infections that may be spread by the respiratory route include anthrax, brucellosis, Q fever, tularemia, plague, leptospirosis, hanta virus, influenza, psittacosis, and Newcastle disease virus. Disturbing the soil on farms may also increase exposure to fungi, which could result in mycotic infections such as histoplasmosis, blastomycosis, coccidioidomycosis, and cryptococcosis. Additionally, agriculture workers, especially migrants, have high proportional mortality rates from tuberculosis [7]. *Mycobacterium bovis* may occur in ruminants and can be spread to workers, but most cases are caused by *Mycobacterium tuberculosis*. Migrant workers often live in camps, in close quarters, which aids in the spread of tuberculosis to fellow workers.

Workers in CAFOs are likely to be exposed to organic dust from animal waste, feed particles, endotoxins, glucans, and various gasses, such as ammonia, methane, carbon dioxide, hydrogen sulfide, and volatile organic compounds. Exposures to these dusts and chemicals may cause mucous membrane irritation, organic dust toxic syndrome (ODTS), bronchitis, allergic asthma, and nonallergic asthmalike symptoms [1, 2, 8]. It has been estimated that 60% of CAFO workers will have 1 or more respiratory symptom if they work longer than 6 years in this environment [9]. It is estimated that 25% of all workers in swine CAFOs will experience chronic bronchitis [2]. Likewise, farmers in egg, poultry, and dairy production are more likely to wheeze, compared with farmers not raising animals [10].

Agricultural Chemicals

Pesticides are commonly used on farms to control weeds, nematodes, and insects that damage crops. Disinfectants (also classified as pesticides) are used inside CAFOs to clean floors and utensils. Overexposure can cause acute upper and occasionally lower respiratory symptoms. Fumigants such as methyl bromide, phosphine, chloropicrin, sulfuryl fluoride, and vikane are highly irritating, and overexposure may result in pulmonary edema and death. Exposure to organophosphate and carbamate pesticides may result in individuals presenting with respiratory symptoms of wheezing, bronchorrhea, and respiratory depression, along with other classic parasympathetic manifestations. Ingestion

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of the pesticide paraquat may lead to death or permanent respiratory impairment. Paraquat ingestion leads to a proliferation of connective tissue in the lungs, resulting in pulmonary fibrosis. Recent research on the effect, on farmers, of pesticide use has found an increased risk of wheezing, chronic bronchitis, asthma, and hypersensitivity pneumonitis (Table 1) [11-13].

Anhydrous ammonia is used as a fertilizer on farms. It is often a cause of skin and eye burns in farmers. Massive exposure, such as from a ruptured hose, may cause severe inflammation at all levels of the respiratory tract, resulting in acute pulmonary edema. Chronic sequelae may include chronic bronchitis, bronchial hyperreactivity, and bronchiolitis obliterans.

Recently filled grain silos may generate high levels of nitrogen oxides. Upon entering the silo, a reddish brown gas may be visible over the grain. Inhalation of this gas may lead to a condition known as silo filler's disease. Sudden death, acute or delayed pulmonary edema, or latent bronchioloitis obliterans may occur [1, 2].

Farmers often perform equipment repairs indoors, especially during the winter season, in preparation for the spring planting. Operating gasoline or diesel fuel engines indoors can result in carbon monoxide poisoning. Welding on galvanized steel may produce zinc oxide fumes that, when inhaled, may result in metal fume fever. Exposure to diesel exhaust and solvents used in painting, cleaning, and other activities also increases the risk of wheezing in farmers. Proper ventilation in the facility is important to prevent these from occurring.

TABLE 1.
Pesticides Associated with Respiratory Symptoms or Diseases

Symptom/Disease	Pesticides
Wheezing	Chlorpyrifos, malathion, parathion, dichlorvos, phorate, alachlor, atrazine, EPTC, petroleum oil, trifluralin, permethrin
Allergic asthma	Coumaphos, heptachlor, parathion, carbon tetrachloride/carbon disulfide (80/20 mix), ethylene dibromide
Nonallergic asthma	DDT, Malathion, Phorate
Chronic bronchitis	Dichlorvos; DDT; cyanazine; paraquat; methyl bromide; heptachlor; carbaryl; carbofuran; chlordane; lindane; toxaphene; coumaphos; diazinon; malathion; parathion; 2,4,5 T; 2,4,5 TP; petroleum oil
Hypersensitivity pneumonitis	Lindane, aldicarb, DDT
Lung cancer	Arsenicals, metolachlor, pendimethalin, diazinon, chlorpyrifos

Dust Exposure

Dusts on farms can be broadly classified as organic or inorganic in nature. Exposure to organic dust, such as pollen, bacteria, fungi, animal secretions/excretions, mycotoxins, and endotoxins, may cause respiratory symptoms and diseases such as allergic asthma, ODTS, chronic bronchitis, and hypersensitivity pneumonitis. In fact, agricultural production has been recorded as the leading industry for deaths due to hypersensitivity pneumonitis [14].

Exposure to inorganic dust often occurs when farmers are plowing their fields or transplanting their crops. Sandy soils in North Carolina have high levels of respirable silica. While the rate of silicosis in farmers in North Carolina is not known, 2.4% of silicosis cases were associated with the agriculture, forestry, and fishing industry in a recent Centers for Disease Control and Prevention survey [14].

Farmer's lung (FL) disease, also called extrinsic allergic alveolitis or hypersensitivity pneumonitis (HP), is caused by the inhalation of various microbial organisms, such as thermophilic actinomycetes and *Micropolyspora faeni* that often grow in hay bales or grain. Once a farmer becomes sensitized and develops circulating antibodies to these allergens, subsequent exposures may result in antigen-antibody complexes that may occur in the lungs. Illness severity ranges from acutely reversible to a chronic debilitating disease resulting from a progressive pulmonary fibrosis [1, 2]. Noncaseating granulomas and multinucleated Langerhan's giant cells may be seen on lung biopsies. The prevalence in the United States is believed to be less than 5% [2]. FL is reported to be most typical among those who manage barn-enclosed cattle. There is a lower prevalence of FL in smokers.

ODTS, also called toxic alveolitis, mycotoxicosis, or silo unloader's disease, is a nonallergic toxic-mediated inflammatory reaction of the airways, with systemic flulike symptoms that occur within a few hours of dust inhalation. It often occurs after the removal of moldy silage from grain bin silos. The illness is usually self-limiting and nonprogressive. It is caused by exposure to high levels of organic dust and endotoxins. It is much more common than FL, with a prevalence, in one study, of 36% among farmers who attended an agricultural trade show [8].

Medical Evaluation

When an agricultural worker presents with respiratory symptoms, the health care provider must elicit a thorough occupational history during the evaluation. It is useful to determine whether the symptoms are acute or chronic in nature. If the worker has a fever, then a zoonotic infection should be considered. Most inhalation exposures to chemicals in high concentration will cause acute respiratory symptoms. Rarely will long-term respiratory damage develop after a single exposure to a low concentration of a chemical. However, chronic low-level exposure to dust and gasses in CAFOs may lead to the development of chronic pulmonary illnesses, such as chronic bronchitis, asthma, and HP [1, 2]. The health care worker should be able to recognize the difference between ODTS and HP, as HP can progress to interstitial fibrosis (Table 2). There is also concern that long-term exposure to pesticides may increase the risk of chronic lung

disease [11-13].

In the workup of respiratory complaints, standard clinical evaluation is performed, including pulmonary function testing, chest X-rays, and, possibly, allergy skin testing and serum radioallergosorbent testing for suspected HP. Peak-flow meters may be helpful to determine whether the symptoms are work related. If a zoonotic infection is suspected, then sputum and blood cultures should be obtained. If the cause cannot be determined, a lung biopsy may be necessary.

Medical monitoring of individuals with FL should include periodic pulmonary function testing and chest X-rays [2]. Measurement of blood gases and exercise tolerance may be useful to assess the degree of impairment. If symptoms have progressed, then modification of work behaviors, environmental control measures, and use of an appropriate respirator should be advised. Rarely, the farmer may need to change jobs. Medical monitoring should be considered for individuals who are to begin work in CAFOs in which exposure to agricultural dusts and gasses are expected. Periodic examinations, including pulmonary function testing, may allow for the detection of developing airflow obstruction while it is still reversible.

Prevention of Respiratory Diseases

Preventing dust and gas buildup in the farm environment is the best way to avoid most respiratory illnesses. Adequate ventilation, especially in silos and CAFOs, protects human health, and it may also improve the health of the animals in these facilities. A tractor cab with air filtration reduces inhalation of field dust. Silos must be entered with extreme caution, to prevent asphyxiation hazards. Use of personal protective equipment, such as properly fitted respirators, may be useful, in addition to engineering methods to control dust and gas buildup.

Agricultural workers using chemicals should follow label directions on the use of personal protective equipment, and farm operators should obtain material safety data sheets on all chemicals used on farms, in case a person is exposed. Chemicals should be stored properly, and farmers should have a fire hazard plan.

Agricultural workers involved in raising poultry and swine should be encouraged to receive annual influenza vaccinations [15]. Farmers should be on the lookout for any increase in illnesses, abortions, stillbirths, or deaths in their animals. If these occur, they should seek veterinary assistance. NCMJ

TABLE 2.
Features of Farmer's Lung, Compared to Those of Organic Dust Toxic Syndrome (ODTS)

Feature	Farmer's Lung	ODTS
Epidemiology		
Incidence	2-30/10,000	1-33/100
Clustering	Uncommon	May occur
Season	Most common winter, early spring	Most common in summer, fall
Exposure	Repeated exposure to causative agent	Heavy exposure to organic dust, may occur after first exposure
Causative agents	Antigens from thermophlic actinomycetes, fungi, proteins, others	Endotoxins, others
Symptoms	Chills, dyspnea, myalgias, fever, headache, malaise, arthralgias, cough, chest tightness, fever (symptoms develop 2-6 hours after exposure); symptoms more severe than with ODTS	Chills, dyspnea, myalgias, arthralgias, cough, chest tightness, headache, malaise (symptoms develop 2-6 hours after exposure)
Clinical exam	Fever, end-inspiratory bibasilar rales	Normal or scattered rales
Chest x-ray	Usually finely nodular infiltrate more evident in lower lobes and mediastinum, interstitial strands	Normal or minimal interstitial infiltration
White blood count	Neutrophilia, also may see mild to moderate eosinophilia or relative increase in mononuclear cells	Neutrophilia with left shift
Pulmonary function test	Moderate to severe restriction, decreased DLCO	Normal or obstruction
Blood gas	Hypoxemia	Usually normal
Serum precipitins	Usually positive	Usually negative
Bronchoalveolar fluid	Elevated neutrophils and lymphocytes	Elevated neutrophils
Lung biopsy	More chronic inflammation of alveoli with mononuclear cells, possibly granulomas and foreign body giant cells, neutrophils, eosinophils	Acute inflammation of terminal bronchioles, alveolar and interstitial areas. Exudate consist of neutrophils and macrophages, may see fungal spores present
Course	Acute syndrome may resolve if no further exposures. Chronic syndrome may be progressive, leading to pulmonary fibrosis.	Usually resolves spontaneously without long-term sequelae

Note. Table adapted from Von Essen and Donham [1] and Donham and Thelin [2]. DLCO (Carbon monoxide diffusion capacity of the lung)

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