RESPIRATORY RISK ASSOCIATED WITH AGRICULTURE, EMPHASIS ON ORGANIC DUSTS

Thomas J. Ferguson, M.D., Ph.D.
Internal Medicine and Epidemiology &
Preventive Medicine and Epidemiology
Univ. of CA
Davis, CA

Abstract

Agricultural processes generate occupational exposures to a variety of potential pulmonary toxicants including chemical, physical and biological agents. Study of these workers has been complicated by the often migratory nature of the exposed population and the resultant difficulty in collecting long-term epidemiologic data. Nevertheless, some of these exposures may result in respiratory effects and disease states such as chronic bronchitis, reactive airways diseases, hypersensitivity pneumonitis, and perhaps restrictive lung disease. Methods for assessing the incidence of such lung diseases among agricultural workers are reviewed. The processes and techniques used for studying the prevalence of occupational lung disease are summarized. The literature with respect to lung disease among workers in various agricultural endeavors is reviewed with special emphasis on studies from the past ten years and recommendations for future research.

Background

Ramazzini in 1713 described lung disease associated with work in farming occupations (Wright,1964). While this historic treatise would probably best be characterized as descriptive epidemiology, it documented concern that respiratory disorders such as chronic bronchitis were associated with exposure to fibrous plant materials and dusty conditions encountered in farming occupations. The past 40 years have seen tremendous upsurge in interest in the study of respiratory disease associated with agriculture and these investigation have confirmed Ramazzini's impression that certain agricultural activities may be associated with adverse health effects.

In contrast to a typical industrial worker, an agricultural worker varies activities throughout the year depending on the nature of the crop, geographical location of the agricultural endeavor, and the type of handling or processing required to bring the product to market. Over the past 50 years, there have been significant changes in distribution of the population employed within United States farming activities. While productivity of the nation's farms has steadily increased over time, the absolute number of individuals in the work force has declined significantly. This reflects the increased mechanization of processes and the resultant increased efficiency in agricultural production. This mechanization has contributed to changes in exposures and probably decreased exposure to dust in activities previously associated with heavy dust exposure. For example, the increased use of enclosed tractors significantly reduces exposure to field dust. It has been very difficult to estimate accurately the population of workers at risk for occupational injury in agricultural industries because of the large number of seasonal or migrant workers employed in these endeavors. The health status of migrant workers has been tremendously difficult to assess because of lack of longitudinal follow-up of health status. This is especially the case in California and other western states, where migrant labor is used for certain high risk activities for respiratory disease, such as harvesting, processing and storage of crops.

The purpose of this presentation is to briefly review the current state of knowledge regarding agriculture related respiratory disease with emphasis on some of the recent literature regarding respiratory disease associated with dust exposure.

Methods for Studying Respiratory Disease

A standardized questionnaire or survey is typically employed to delineate medical history and exposure information. When such standardized instruments are used in assessments, the results may be compared with those from study of other working populations. Different survey instruments have been used in such studies, but standardization has been difficult because of the diverse nature of respiratory exposures and farming activities. However, the American Thoracic Society has a standardized medical history questionnaire which defines the most important respiratory concerns (Ferris, 1978). In addition, Rylander and associates developed a questionnaire for assessment of organic dust exposure (Rylander, et. al., 1990).

In addition to questionnaires, measurement of pulmonary function is typically employed in assessing respiratory disease states. Spirometry is a simple non-invasive procedure that may be administered as a large scale screening instrument with relative ease. When employed in a standard manner, spirometry results may illustrate a pattern of respiratory impairment, which can also be compared with questionnaire results (ATS, 1987). Additional testing, such as methacholine challenge or specific inhalation challenge testing with known materials may elucidate respiratory hyperactivity to specific agents or tendency for reactive airways disease. However, specific inhalation challenge testing is very time consuming and potentially dangerous and should be reserved for cases in which diagnosis can not be confirmed by other means.

Physical examination findings may also help support diagnosis of lung disorder. However, many of the physical findings typically associated with lung disorders may not occur until late in the course of the disease process. Thus,

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:207-210 (1998)
National Cotton Council, Memphis TN

physical findings are usually of limited value in screening efforts for pulmonary disorders.

While radiographic assessment may provide definitive evidence of acute pulmonary injury, lung scarring of sufficient magnitude to lead to visible changes on x-ray may not occur until late in the course of a disease process. For example, certain mineral agents such as asbestos or silica may lead to interstitial abnormality on standard chest x-ray. Typically, however, these chest x-ray changes may lag exposure by several years or even decades. Nonetheless, standardized methods for assessing x-ray abnormalities have been described for such conditions as coal workers pneumoconiosis, silicosis, and asbestos exposure related lung disease. Newer radiographic techniques such as thin section computerized tomography may prove more useful for objective assessment of radiographic changes.

Under certain circumstances, individual immune response may contribute to following respiratory exposures. For example, a granulomatous lung disease similar to sarcoidosis has been described among workers chronically exposed to low level beryllium dusts (Cullen, et.al., 1987). Assessment of this disorder has demonstrated that individuals so affected have abnormal specific blood lymphocyte proliferation tests. As new immunologic techniques and molecular biology brings new testing procedures into the practice of clinical medicine, it is likely that improved techniques to aid in the clinical assessment of occupational/environmental lung disease related to activation of the immune response.

Classification of Agricultural Lung Disease

There are several classification systems available for defining occupational/environmental lung disease associated with agricultural activities. It is probably most useful to review these processes on an activity associated basis.

Field preparation and harvest activities, may lead to exposure to a variety of inorganic and organic substances. Soil tilling activities may expose workers to relatively high levels of dust over a short period of time. In the past, field preparation activities likely resulted in high exposure to particulate materials. With increased mechanization of farm activities in the 20th century, however, most field preparation activities are performed from enclosed cab vehicles. The amount of dust exposure and the physical characteristics of the dust, varies widely by geographic location and associated environmental conditions, such as humidity, temperature and wind. At least one autopsy study has demonstrated that significant particulate loads may be associated among farm workers (Sherwin, et al, 1979). In addition, Gamsky *et al* demonstrated that restrictive lung function abnormalities were present in grape harvesters in the San Joaquin Valley of California (Gamsky, et al, 1992) While relatively few case reports exist regarding restrictive lung disease among agricultural workers, particulate exposure may be of particular biological significance, when one considers that respirable particulate may act as vehicles for delivery of organic compounds or other biologically active materials, deep into the respiratory system. Finally, activities such as fertilizing with ammonia compounds or applying pesticides/herbicides to fields can expose workers to respirable chemicals or potentially toxic dusts.

Grain storage activities and facilities have been one of the areas in which agricultural activities have been studied for the past 10-15 years. Several trends among grain handlers have been identified. It has been demonstrated that some grain workers have a dose related across shift fall in peak expiratory flow and dose related symptoms of cough and dyspnea (James, et. al., 1990). A recent study of grain induced lung disease demonstrated that endotoxin concentration in the bioaerosol from this environment was the most likely source of these effect (Schwartz, et. al., 1995). This result supports other research which has documented that exposure to inhaled endotoxin is strongly associated with development of acute decrements in airflow among a variety of exposed workers including cotton carding, swine confinement workers and poultry processors (Donham, et al, 1989; Rylander, et. al., 1985, Thelin, et. al.,1984).

Large scale animal housing facilities are employed for commercial production of sheep, cattle, swine and poultry. Workers caring for animals housed in such facilities may be exposed to bioaerosol, feed dust, bedding dusts, and other organic materials. Swine confinement respiratory disease syndromes have been characterized by a variety of authors. Reynolds, et al recently documented a dose response decrease in FEV-1 across shift at relatively low dust level concentrations for swine confinement workers (Reynolds, et. al., 1996). This study also suggested a role for the relatively complex mixtures of biologically active components of the swine aerosol including ammonia and endotoxin. In another study of male swine confinement workers, it was recently demonstrated that compared to a non-farming rural dwelling cohort there was an annual decline in FEV1 and FVC for such workers (Senthilselvan, et. al., 1996). The occurrence of increased airway hypersensitivity among agricultural workers is supported by a recent study which demonstrated increased bronchial reactivity by standard methacholine challenge testing for a group of non-smoking animal handling farmers compared to grain/vegetable crop farmers (Carvalheiro, et. al., 1995).

Organic dust toxic syndrome (ODTS) is syndrome of flu like symptoms including high fever, myalgia and respiratory symptoms which occurs after exposure to respirable organic dusts. For most intents and purposes ODTS is likely synonymous with grain fever, silo unloaders' disease, and inhalation fever. A subset of such individuals may develop a chronic condition following repeated exposure to organic dusts which is influenced by a cell mediated immune response mechanism and may progress to classic hypersensitivity pneumonitis syndrome (HPS). However, the

clinical differentiation of these two conditions is difficult to establish as illustrated by a recent case report of ODTS in 1993 (Weber, et. al., 1979). This report described illness in an individual who developed dyspnea, fever, headache, myalgia, and pulmonary infiltrates after working with compost. The patient had progressive pulmonary dysfunction with mild restrictive changes which improved without significant sequelae after 3 days. Similar syndromes have been reported for agricultural workers handling silage or other material heavily laden with biological materials such as humidifiers, moldy grains, bagasse, and mushroom compost. It appears likely that as suggested by Weber and colleagues there is considerable overlap between HPS and ODTS and that these conditions may represent a spectrum of a single biological process rather than distinct clinical entities. That is, the acute response may result in an intense inflammatory reactions which if allowed to continue over time may lead to a cell mediated response and classic hypersensitivity pneumonitis.

Cotton Dust Associated Lung Disease

Chronic respiratory symptoms associated with processing of cotton or other natural fibers was described as early as 1700. In 19th century Ireland the expansion of flax spinning led to reports of respiratory symptoms among mill workers. Concern over occupational exposures and potential for occupational lung disease related to cotton dust led to development of an OSHA regulation which rather broadly defines "cotton dust". Inhalation of cotton dust has been associated with development of a relatively specific temporal pattern of chest tightness and shortness of breath which is most prominent after the first shift of work and has been described as a "Monday morning" pattern. The term byssinosis is used to describe a variety of respiratory symptoms among such workers. The pattern of acute pulmonary function changes associated with such acute exposures are characteristically reversible and associated with a 5-10% reduction in FEV-1. While concern over potential long-term health effects from cotton dust exposure led to development of OSHA regulation, there is some controversy regarding the degree to which chronic lung dysfunction can be attributed to such exposures. Several recent epidemiologic studies have correlated prevalence of byssinosis symptoms with airborne endotoxin concentration. Similarly, when human exposure trials were conducted to mimic natural dust conditions in carding operations, respiratory symptoms were clearly more closely correlated with endotoxin level than with total cotton dust concentration (Rylander, et. al., 1985).

Rice Farmer Health Survey

California is the top rice producing state in the United States. Eight Northern California counties account for greater than 90 percent of the rice acreage cultivated in the state and produce nearly 1.7 million tons of rice annually. Traditionally rice field stubble is burned post harvest because of need to return the material to the soil and prevent growth of undesirable plant pathogens. Since rice straw contains approximately 12 percent silica by weight there is concern that burning of stubble could result in release of biogenic silica fibers as an aerosol during burning. In addition, field preparation activities typically result in exposure to crystalline silica dust and may in some circumstances lead to pulmonary deposition and injury.

A study published in 1996 described occupational assessment of pulmonary function among rice farmers in Northern California (McCurdy, et. al., 1996). The format of the study involved administration of standardized questionnaire, spirometry, and chest x-ray analysis by NIOSH Certified B readers. A total of 475 participants were enlisted. Questionnaire results indicated that chronic cough was reported by 7.1% of respondents. Prevalence of chronic bronchitis was 6.3% and persistent wheeze 8.8%. Interestingly, hayfever was reported by approximately 25% of subjects involved in the study. Smoking was an important determinate for many respiratory health outcomes and current smokers had a 4-7 fold increase prevalence for chronic cough, chronic bronchitis and persistent wheeze. In addition, chronic cough was associated with reported hours per year, burning rice stubble. Chronic cough was associated in a dose response fashion with reported hours per year, burning rice stubble. While the prevalence of radiographs with profusion scores greater than or equal to 1/0 by ILO criteria, there was no association with respiratory symptoms or spirometry results.

Research Needs

Research efforts over the past 40 years have contributed significantly to the basic understanding of respiratory disease processes for agricultural workers. This research effort has demonstrated that the endotoxin fraction of dust may be more significant than dust alone in contributing to acute respiratory effects. There is need to characterize the role of endotoxin in disorders such as organic dust toxic syndrome and whether long term exposure to endotoxin contributes significantly to chronic lung conditions. Such research will be important in making recommendations for occupational exposure standards. Finally, the physical similarity between asbestos fibers and amorphous biogenic silica is intriguing and the potential for adverse health effects among populations exposed to such material should be further investigated.

References

American Thoracic Society. 1987. Standardization of spirometry: 1987 update Am Rev Resp Dis 136: 1285-1298

Carvalheiro, MF, Peterson Y, Rubenowitz E, and Rylander R. 1995. Bronchial reactivity and work related symptoms in farmers. Amer J Indust Med 27: 65-74.

Chan-Yeung M, Enarson D, and Kennedy S. 1992 The impact of grain dust on respiratory health. Am Rev Resp Dis 145: 476-487.

Cullen MR, Kominsky JR, Rossman MD, et al 1987. Chronic beryllium disease in a precious metal refinery: clinical epidemiologic and immunologic evidence for continuing risk from exposure to low level beryllium fume. Ann Rev Respir Dis 135: 201-208.

Donham K, Haglind P. et al. 1989. Environmental and health studies of farm workers in Swedish swine confinement buildings Br J Ind Med 46: 31-37.

Ferris, B.G. 1978. American Thoracic Society Epidemiologic Standardization Project. Am Rev Resp Dis 118: 1-120.

Gamsky TE, McCurdy SA, Samuels SJ, and Schenker MB. 1992. Reduced FVC among California grape workers. Am Rev Resp Dis 145: 257-262.

James AL, Zimmerman MJ, Ee H, etal. 1990 Exposure to grain dust and changes in lung function. Br J Indust Med 47: 466-472.

McCurdy SA, Ferguson TJ, Goldsmith DF et al. 1996. Respiratory Health of California Rice Farmers. Am J Resp Crit Care Med 153: 1553-1559.

Morgan, WKC. 1978. Industrial bronchitis. Br J Ind Med 35: 285-297.

Reynolds SJ, Donham KJ, Whitten P, et al 1996. Longitudinal evaluation of dose response relationships for environmental exposures and pulmonary function in swine production workers. Amer J Indust Med 29: 33-40.

Revsbech, P Andersen G. 1989. Diurnal variation in peak expiratory flow rate among grain elevator workers. Br J Ind Med 46: 566-569.

Rylander R, P Haglind and Lundholm M. 1985. Endotoxin in cotton dust and respiratory function decrement among cotton workers in an experimental cardroom Am Rev Resp Dis 131: 209-213.

Rylander R, Peterson Y, Donham KJ. 1990. Questionnaire evaluating organic dust exposure. Am J Ind Med 17: 121-126.

Schwartz DA, Thorne PS, Yagla SJ, Burmeister LF et al. 1995. The role of endotoxin in grain dust induced lung disease. Am J Respir Crit Care Med 152: 603-608.

Senthilselvan A, Dosman JA, Kirychuk SP, et al 1996. Accelerated lung function decline in swine confinement workers. Chest 111: 1733-1741.

Sherwin, RP, Barman, and Abraham, JL. 1979. Silicate Pneumoconioses of Farm Workers. Lab Invest 40: 576-582.

Thelin A, Tegler O, Rylander R. 1984. Lung reactions during poultry handling related to dust and bacterial endotoxin levels. Eur J Respir Dis 65: 266-271.

Weber S, Kullman G, Petsondk E., et al 1993. Organic Dust Exposures from compost handling: Case presentation and respiratory exposure assessment. Amer J Indust Med 24: 365-374.

Wright, WC (transl): Diseases of Farmers, In Ramazzinin B: De Morbis Artificum (1713). New York, Hafner Publishing Company, 1964, pp 338-351.