

Occupational Health and the Rural Worker: Agriculture, Mining and Logging*

David S. Pratt

ABSTRACT: *More than 50 million Americans live in rural areas. These rural residents often work for small businesses or in the extraction industries (farming, mining, and logging). Because of the size of the businesses, the mandate of the Occupation Safety and Health Administration (OSHA) does not cover these workers and they are seldom afforded the same protection as urban workers. This review focuses on the special health problems facing farm workers, farmers, miners, and loggers. Farm workers are often ill and are affected by psychological illness, injuries, parasites, skin diseases, and the dangers of agrichemicals. Farm owners also face the hazards of stress and have very high rates of suicide. In addition, they are often injured on the job and suffer the highest rate of job related fatality of any work group. The complex farm environment presents a continuous threat to the lungs. This danger has worsened with the increased use of confinement buildings for poultry, hogs, and cattle. As farming has changed with increased mechanization, attendant medical problems have arisen. These "illnesses of innovation" are important. Mining and logging also are dangerous occupations with acute and chronic problems including respiratory illness, vascular problems, and malignancy. The decade of the 1990s must be one of increased attention to rural occupational health care and research.*

More than 50 million Americans live in nonmetropolitan counties. Those who do not commute to urban areas to find work are likely to be involved in the production of goods (rather than services) and are often self-employed (Cordes, 1989). Like other Americans, rural residents face health hazards on the job. Because many of the businesses in the countryside are small, they fall outside the mandate of the Occupational Safety and Health Administration (U.S. Congress, 1976). Thus, many rural workers are not afforded the same protection that their urban counterparts enjoy.

The majority of rural residents work in small businesses. Because the Bureau of Labor Statistics collects information exclusively on businesses with 11 or more employees, the injury experience of most rural workers is not recorded. Certain segments of the rural work force that face unique dangers have gotten considerable attention in the published literature during the last decade. This review will, by necessity, focus on a few of the high-risk rural occupations including farming, mining, and logging. While the workers in these occupations represent a minority of the rural work

* For further information write: David S. Pratt, MD, Director, New York Center for Agricultural Medicine and Health, The Mary Imogene Bassett Hospital, One Atwell Road, Cooperstown, NY 13326.

force, their special problems merit close attention.

The review is also limited by the quality of the information available on injuries and illnesses in the rural American work force. These limitations are significant and are recognized. Fortunately, steps are underway to correct and improve future data collection (National Research Council, 1987). By the turn of the century we should have far better estimates of work related health problems for all Americans.

Agriculture

The Economic Research Service of the U.S. Department of Agriculture (USDA) estimates that about two million Americans gain their sole or primary employment from agriculture. Another million report that some of their earnings come from farming. Migrant and seasonal workers add another 2.5 million members of the agricultural work force. Hence, a total of more than 5 million individuals are directly involved in producing the agricultural products that we eat, wear, or sell to others (U.S. Department of Agriculture, 1988). In addition to the workers, an estimated 5 million family members depend on farming as the source of their economic well being.

American agriculture is a huge international business, bringing gross sales of more than \$130 billion annually to this sector of the economy (U.S. Department of Agriculture, 1988). Feed grains constitute the largest portion of the industry with an annual market value of \$58 billion. Livestock production contributes \$35 billion, while fruit and vegetable farms combined have gross sales of about \$16 billion.

While mechanization has changed some kinds of agriculture, fruit and vegetable harvesting still requires hand picking in many cases. It is this type of farming that has the greatest need for migrant and seasonal help.

Migrant Agricultural Workers

The migrant farm workers in this country who harvest the fruit and vegetable crop often come from racial minorities. There is no comprehensive system for tracking their health problems with the exception of the Migrant Student Record Transfer System developed by the U. S. Department of Education. That system was designed to follow the health of the children of migrant farm workers. Because many children also work in the fields, this system may, unintentionally, track the health status and needs of some of this worker group (Fuentes, 1974).

General Health Status of Migrants. In an attempt to review the health problems of migrants, the National Association of Community Health

Centers (NACHC) conducted a survey of clinics receiving federal funding for migrant health care. Of the 122 centers surveyed, 60 (49%) responded. Unfortunately the data were collected in a descriptive way and do not allow age and sex adjustments, or rate estimates. Nonetheless, the findings are of interest. Upper respiratory tract infection was the most common diagnosis reported, followed by hypertension, pregnancy, and diabetes. The NACHC group also looked at the most frequently reported diagnoses by geographic location. The centers that are in the northern states are called upstream, while those in the areas that migrants call home are referred to as downstream. Upstream centers reported more gastrointestinal illness and parasitic infestations while downstream locations had more prenatal and obesity visits. Some have postulated that the frequency of gastrointestinal symptoms may reflect poor sanitation and hygiene in the northern camps (Wilk, 1986).

The NACHC survey data has been supported by local investigations. For example, Ortiz (1980) found that 35.5 percent of all the stool samples examined from 377 Puerto Rican migrant workers in Massachusetts had parasites. This was nearly double the rate reported from a similar ethnic group in Chicago (Winsberg, Sonnenschein, & Dyer, 1975). Ortiz (1980) also found that the transmission of hookworm occurred in children born and raised in the United States from these migrant families. The prevalence of parasites and the surprising finding of apparent hookworm transmission certainly suggests that simple sanitation is a notable cause of morbidity in this group.

Studies from Florida have shown a very high reported rate of migrant families with eye problems (35%), depression (23%), and anemia (21%) (Trotter, 1984). Mines and Kearney (1982) studied 1,983 migrants in California; they found that injuries were the most common work-related problem in their sample, followed by musculoskeletal complaints. This work also identified "mental health" problems as common (29%). The mental health definition used by Mines and Kearney (1982) was perhaps overly broad and may have over estimated the frequency of *bone fide* mental health difficulties. A more rigorous study, using a well tested psychiatric screening instrument, was reported by Vega, Warheit, and Palacio (1985). They found that nearly 20 percent of Mexican-American farm workers had inventory scores suggesting a high risk of psychiatric illness. Young men (18-20 years) and older women (50-59 years) had the highest scores.

Although the literature on the health problems of migrant workers is neither voluminous nor comprehensive it does provide a basic understanding. Migrant workers appear to be at increased risk of injuries, eye complaints, mental health problems, parasitic illness, respiratory ailments, and obesity. Their risks associated with pesticides are outlined below.

Pesticides: Acute Effects. The push for high yields and the marked perishability of fruits and vegetables has led to an increasing use of

pesticides on the crops picked by migrant workers. There has been a 175 percent increase in the use of these agents during the last 25 years (Moses, 1989). In 1987, the American farmer spent 4.7 billion dollars on pesticides (U.S. Department of Commerce, 1987).

One circumstance reported in the literature is the problem of early re-entry into areas treated with pesticides. Coye, et al., (1986) described the experience of 31 lettuce workers poisoned by organophosphates when they entered fields two hours after spraying with mevinphos (48 hours is the recommended re-entry time). More than 75 percent of the workers experienced at least three symptoms of poisoning (including eye irritation, headache, and visual disturbances). No fatalities occurred and no one required hospitalization. In this episode all poisoned workers were identified from emergency room records and followed. Post-exposure cholinesterase levels on the lettuce workers allowed biochemical assessment of their recovery (Coye et al., 1986). Whorton and Obrinski (1983) reported a 19-member cauliflower picking crew also poisoned by organophosphates (mevinphos and phosphamidon). The workers re-entered a field four hours after spraying and began banding the cauliflower. Symptoms in the workers began very soon after the banding started; several had blurred vision and headaches. Two men collapsed and required emergency treatment. None of those affected were hospitalized or died. These two "outbreaks" of pesticide poisoning validate the concern that migrant workers can become seriously ill from the chemicals. The poisoning circumstances are worth noting; in both instances the workers re-entered two days before the recommended minimum time limit.

In instances where these chemicals have been used properly, few health effects have been noted. A prospective study of onion pickers was done that addressed the insecticide exposure of workers by measuring chemical levels on their gloves and in their urine (Munn, Keefe, & Savage, 1985). At the same time, levels were measured in the soil, foliar, and air. All samples were tested for the presence of toxaphene, ethyl parathion, methyl parathion, and malathion. Young workers were compared to older workers. Many of the glove samples, and all of the air samples, had no detectable insecticides. Young workers had levels lower than older persons. The urine studies suggested that there was very little absorption of chemicals by the workers.

Dermatologic problems in migrant workers have at times been ascribed to chemicals used in agriculture. Certain pesticides, like many other organic compounds, have been shown to be skin sensitizers (Adams, 1983). Crops too can cause skin rashes. Winter and Kurtz (1985) did a study with migrant grape workers to try to detect the cause of rashes commonly seen in grape harvesters. More than 1,000 workers were under surveillance for almost one year. A rate of 24 rashes per 1,000 workers was recorded. A strong association was found between thinning (the process in which excess leaves and stems are removed) and rashes, especially on hot days. Harvesting (another

task involving separating pieces of the plant) was also associated with the appearance of rashes. The only chemical chronologically associated with thinning was gibberellic acid, a growth regulator. Sixty-nine percent of the thinning cases were associated with that chemical. Pesticides, on the other hand, were temporally related to two of the reported cases.

A final study that sheds light on the magnitude of the pesticide problem facing all farmers and farm workers was reported by Edmiston and Maddy (1987). They reviewed all 2,099 cases of pesticide poisonings reported through California's mandatory surveillance system for the year 1986. After the reporting forms were analyzed, only half were felt to be occupational. Of those, 746 were reported in field workers. The field worker rate calculates to be about 0.25 cases per 100 workers per year. In contrast, applicators and mixers had a rate of 2.06 cases per 100 workers per year. These numbers suggest that applicators have roughly 10 times the risk of field workers.

The authors also reviewed the occupational deaths reported during the last 11 years in California (Edmiston & Maddy, 1987). Eight deaths were associated with pesticides, including two airplane crashes that killed applicators (no evidence supported pesticides as causal in these crashes). In contrast, during a similar period, 130 California farm workers died of tractor-related injuries. This comparison between pesticide and machine fatalities strongly suggests that resources intended to reduce fatal farm injuries would be most wisely spent on machinery design, safety, and hazard awareness communication.

Pesticides: Chronic Effects. In addition to the reports of acute intoxication and the rare deaths associated with pesticides, there is an enormous amount of literature from the 1980s addressing the possible chronic effects of these economically important chemicals. While this material is reviewed in the context of migrant workers, it is just as pertinent to all rural workers exposed to these agents. The sheer volume of papers and the brevity of this review does not allow a detailed look at the chronic effects of pesticides. A few comments, nonetheless, are in order.

The chronic disease literature addresses cancer, neurologic disease and possible associations with fertility and teratogenesis. The comprehensive reviews by Moses (1989), the Council on Scientific Affairs of the American Medical Association (1988), Axelson (1987), and Sharp, Eskenazi, Harrison, Callas, and Smith (1986) will provide the reader with a great deal of information on this topic. Most experts in agricultural medicine believe that there may be some increased risk to farmers for a few selective tumors including soft tissue sarcoma, non-Hodgkins lymphoma, and perhaps chronic lymphocytic leukemia. The greatest evidence appears to support the association of non-Hodgkins lymphoma and the use of herbicides (Hoar et al., 1986). In contrast cancer mortality rates for farmers, in general, are actually lower than that of the public at large (Axelson, 1987).

Given that several families of pesticides are direct neurotoxins (organo-

chlorines, organophosphates, and carbamates), it is not surprising that chronic neurotoxic effects would be suspected. Although chronic toxicity has been reported, it is generally in industrial workers. There are no well designed studies from the 1980s that demonstrate chronic neurologic problems associated with these agents in farmers or applicators who have not suffered acute poisoning (Rosenstock, personal communication, 1990).

The medical community became aware of reproductive problems associated with pesticides when the toxicity of dibromochloropropane (DBCP) became clear in industrial workers (Milby & Whorton, 1980). Men working in the production of this fumigant had very low sperm counts and loss of fertility. However, no loss of fertility has been reported among farmers exposed to this agent. Moreover, no consistent picture of teratogenic effects due to pesticides has emerged from the agricultural literature of the 1980s.

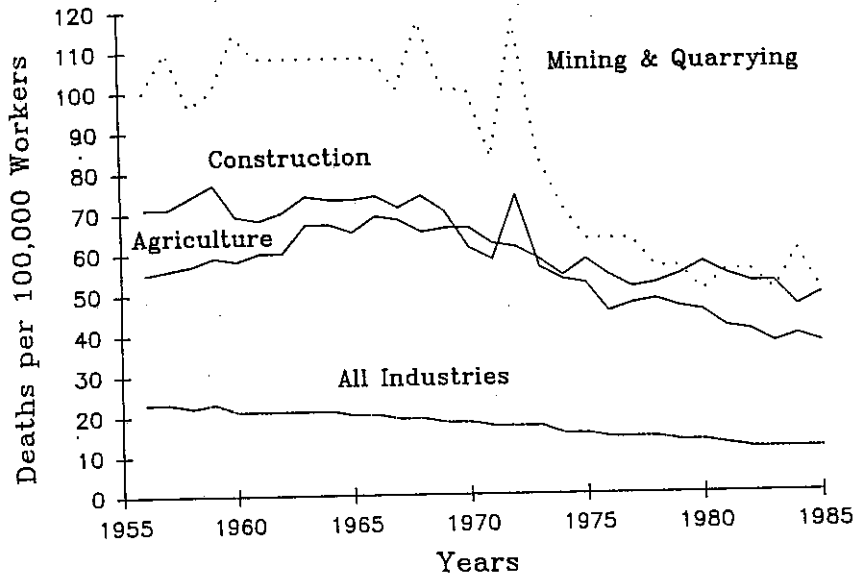
Pesticide problems are noteworthy. Serious acute poisonings with these agents appear to be infrequent and seldom fatal. Studies conducted to evaluate the absorption of properly applied pesticides have shown little risk. Nonetheless, workers who re-enter sprayed areas can become ill and have persisting evidence of toxicity. Professional pesticide applicators are more often affected than other farm workers by these chemicals. At this point, the evidence for long-term health risks from pesticides used in production agriculture, applied properly, appears marginal. Notwithstanding the scientific evidence, worker and public concern is substantial. This suggests that further research is badly needed if confidence in the safety of agrichemicals is to be convincingly established.

Injuries among Non-Migrant Farm Workers and Family Farmers

In contrast to the few papers written about migrant workers during the last decade, family farmers were the subject of numerous reports. The literature provides a convincing picture that injury is the most serious health problem facing agriculture (Cogbill & Busch, 1985; Field & Tormoehlen, 1982; Geller, Bultena, & Lasley, 1988; Goodman, Smith, Sikes, Rogers, & Mickey, 1985; Hartye & Mathis, 1989; Jansson 1987; Michigan Department of Public Health, 1989; Purschwitz & Field, 1987; Rivera, 1985; Rowe & Cliff, 1982; Stallones, 1989). Though the data sources are generally poor, it does appear that, in comparison to other occupations, farming probably does have the highest work-related injury and death rates in this country (National Safety Council, 1988).

Figure 1 provides a graphic comparison of death rates among three types of work and the mean rate for all industries. It is clear that while death rates for mining and construction have been declining, farming has remained unchanged. According to the National Safety Council (1989) more than 25 percent of all farm deaths are tractor related. A full 44 percent of the tractor-related deaths are caused by drivers being crushed under an overturned

Figure 1. Work Accident Death Rates.



Source: National Safety Council, *Accident Facts*, various editions.

vehicle. As of 1990, there is no legal requirement in America that tractors must have roll-over protective devices (ROPS) to protect occupants in the event of an overturn. Sweden, Great Britain, and West Germany all have such laws and have lower fatality rates (Skromme, 1987).

Mechanization in farming is substantial on all but the smallest farms. Tractors have increased in size and power during the past 40 years as capital has replaced labor and farms have become larger but less numerous. Tractors are designed to pull and transmit power to other equipment on the farm. This power transmission is usually accomplished with an external drive shaft called a power take-off. The power take-off transfers rotational power from an adapter on the rear of a tractor to pieces of equipment that are either stationary or towed behind. It is not uncommon for these devices to be unguarded. In such a circumstance, if a farmer's pant leg or other clothing should touch the shaft, spinning at thousands of revolutions per minute, entanglement may well ensue. These episodes often end in disabling fractures or amputations of legs or arms, injuries to the genitals, and/or thoracic trauma (Heeg, ten Duis, & Klasen, 1986). Farm children, too, are injured in power take-offs, with tragic results (Cogbill, Busch, & Stiers, 1985). More fortunate farmers who have close calls with farm equipment often sustain injuries to the fingers, hands, feet, legs, and back (Simpson, 1984).

Changes in the mechanization of farming has resulted not only in severe injuries, but also totally new kinds of trauma. One example is Hay Baler's

Fractures. These serious injuries occur when large, round (700 Kg) bales of hay, lifted high in the air by a front end loader on a tractor dislodge and strike the farmer on the back, fracturing the spine and sternum (Mayba, 1984; Friesen & Ekong 1988). These injuries may result in death by crushing or paralysis from transection of the thoracic spinal cord. In recent years, many farmers in the northeastern United States have begun baling hay in this way because they can do it without extra help. Traditional rectangular bales frequently require at least two and perhaps three people for baling. Hay Baler's Fractures may presage other "injuries of innovation."

Rivera (1985); Swanson, Sachs, Dalhgren, and Tinguely (1987); and Stallones (1989) have written about the children who are injured on American farms. Although the numbers are imprecise, most researchers agree that about 300 children die on farms in this country each year. Fatal injuries to children often involve machinery. Field and Tormoehlen (1982) estimated that 80 percent of all childhood fatalities involved machinery, with tractors accounting for a full 60 percent. Stallones (1989) reported that more than 50 percent of farm deaths to toddlers in Kentucky were machine related. This unfortunate situation is not unexpected if one considers the farm as an "industrial" work place. Although the dangers in farming are greater than mining, construction or heavy industry, one would seldom see a child on these latter kinds of job sites.

The literature of the 1980s suggests that injury is one of the most pressing health problems of the farm community. Farming, unfortunately, has the highest on-the-job injury rate of any occupation. Tractors that do not have roll-over protective structures are dangerous and kill nearly one half of all the farmers that die at work. Innovation and increased mechanization may worsen the risks for farmers. The special problems of childhood injury reported in the past decade should prompt careful reconsideration of the safety of play in the farm work place.

Stress among Farmers

The 1980s were a period of rapid economic change for agriculture. A recession in 1981 caused a fall in farm prices. Interest rates increased and weather was bad. At the same time, land values were falling and farm values were, likewise, in a slump (Winkler, 1985). The government undertook the "whole herd buyout" program to reduce the number of milking cows in production in hopes of bringing the supply of milk closer to the demand. During this period, many farmers lost hope and quit. Walker and Walker (1989) studied the self-reported stress levels of 817 Canadian farmers and 109 urban residents. Nearly half of the farmers reported trouble relaxing, loss of temper, and fatigue. Symptoms were more frequent in women, younger farmers, those with off farm work, and individuals working in mixed farming operations. Reported problems among farmers were more frequent than those of urban residents. Berkowitz and Perkins

(1985), writing about New York farm wives, found surprisingly little relationship between stress and task loads, farm complexity or intrapersonal role conflict. Much stronger relationships were found between stress and interpersonal role conflict, husband support, and marital satisfaction.

Given the nature of farming, one would guess that there would be seasonal variation in stress levels. This is what was found by Tevis (1982) in a non-random sample of 1,379 farmers subscribing to a popular farm publication. A full 60 percent of farmers reported stress during the growing season. The stressors reported, in descending order, were: machinery breakdown, price uncertainties, machinery costs, interest rates, planting, and weather. Chronic stress is also an identified difficulty. Rosenblatt and Anderson (1981) reported on the effects of intergeneration stress, generally between father and son. The men's natural give and take was often complicated by the transfer of farm property with its legal and financial implications. Rosenblatt and Anderson (1981) also commented on the struggles of husbands and wives in their attempts to define their roles on the farm.

Behavior resulting from stress and desperation increased in the 1980s. Hsieh, Khan, Cheng, and Curran (1988) reported a steady increase from 1981 to 1985 in farmers seeking treatment for alcoholism in a Nebraska mental health clinic. While not a random sample, the increase in the percent of farmers being treated for alcoholism is striking (37% of alcohol clinic clients in 1981 were farmers versus 60% in 1985). An even more disturbing report came from Daymond and Gunderson (1987). The authors reviewed the patterns of suicides in Minnesota, North Dakota, South Dakota, Montana, and Wisconsin from 1980 through 1985. They found that suicide rates that were very high for farm owners—58 events per 100,000 farmers. The rate for all white males during the same period for these states was 31 per 100,000. An important disparity was noted among all those who worked in farming and the risk of suicide. Owner-operators were much more likely to take their lives (58 per 100,000) than hired workers (3 to 5 per 100,000) or farm women (1 to 2 per 100,000). This information suggests that the perceived pressures on those in charge must be far greater than for others on the farm.

Farming emerges as a very stressful occupation with significant health consequences including somatic complaints, alcohol abuse, and suicide. Farm family members perceive stress as coming from different stressors (wives with their relationship to their husbands; farmers from the weather, equipment break downs, and price uncertainty). Male farm owners appear to be at special risk for suicide.

Respiratory Illness

Respiratory problems affecting those who work with grain and agricultural products have been identified since the late 1600s (Ramazzini, 1700). That farmers and millers might develop respiratory symptoms is not at all

surprising given the daunting array of environmental pollutants they face (Cockcroft & Dosman, 1981). Although respiratory illness was long known to occur in farmers, it wasn't until the 1980s that significant progress was made in clarifying some of the syndromes resulting from dust exposure.

In the early 1980s our group noted that farmers working with moldy silage often developed fever and systemic illness if the dust exposure was great (Pratt & May, 1984; May, Stallones, Darrow, & Pratt, 1986). In addition it was reported that farmers opening silos often got a massive exposure to dust. Following the exposure, many developed symptoms of chills, fever, cough and muscle aches. The illness resembled acute Farmer's Lung Disease except that no pulmonary function or chest radiographic abnormalities were seen. In spite of an earlier report of a similar syndrome associated with dust, there was much skepticism that such an illness existed (Emanuel, Wenzel, & Lawton, 1975).

In the spring of 1985 an international meeting was convened to try and reach consensus on this dust-related febrile illness. At the conclusion of three days of discussion in Sweden, there was agreement that such a syndrome existed, and that it would be henceforth called organic dust toxic syndrome (ODTS) (Rylander, Donham, & Petersen, 1986). In addition to an article describing in detail the illness that was associated with dust (May, et al., 1986), two other excellent articles provided epidemiologic details and incidence estimates (Malmberg, Rask-Anderson, Palmgren, Hoglund, Kolmodin-Hedman, & Stalenheim 1985; Husman, Terho, Notkola, & Nuutinen, 1990).

Rask-Anderson et al. (1985) provided the Swedish estimate of seven to 10 ODTS cases per 1,000 full-time farmers per year. The illness also has been reported to occur in association with cereal grain dust and swine confinement (Donham, Scallon, Popendorf, Truehaft, & Roberts, 1986; National Institute for Occupational Safety and Health, 1986).

Farmer's Lung Disease is an illness that is associated with the inhalation of the spores of certain (often heat loving) mold-like bacteria. Although rare, the illness can cause either an acute illness with fever, chills, sweats, and lung injury or chronic problems that may appear like bronchitis (cough, sputum and weight loss). The chronic form has been associated with scarring of the lung. Also referred to as hypersensitivity pneumonitis or allergic alveolitis, this illness is not limited to the farm workplace (Lopez & Salvaggio, 1988).

During the 1980s, Terho, Husman, and Vohlonen (1987) provided a comprehensive overview of the epidemiology and environmental factors causing this illness in Finnish farmers. It was their observation that winter-time was the most common season for Farmer's Lung Disease. If the previous summer and fall had been damp, the risk increased. Poor grain drying methods also were associated with the exposure to implicated organisms. A similar population-based study was reported from Sweden by Rask-Andersen (1988). She established, through careful medical inter-

views and a strict case definition, that Farmer's Lung Disease occurred in about two to three farmers per 10,000 per year. This low rate helps explain why there have been few large clinical series published. Rask-Andersen (1988) also found that, as in the Finnish study, women were frequently affected, and nonsmokers seemed to be more susceptible to this illness. Work by Cormier and Belanger (1985); and Kusaka, et al., (1989) have reported that smoking farmers have lower levels of antibody to the molds and bacteria implicated in this illness. The bizarre possibility that smoking may protect against Farmer's Lung Disease has emerged during this decade.

Silo Filler's Disease is a respiratory illness that occurs when farmers inhale the higher oxides of nitrogen. These gases are generated in the complex process of "making" silage in silos. Plants, rich in nitrates from the soil and fertilizer, are chopped up and blown into a silo. After settling in the silo the plant material undergoes acidic fermentation and converts the nitrates into nitrites. The nitrites go on to form nitrous acid and then NO , NO_2 and N_2O_4 - the higher oxides of nitrogen, or silo gas. Inhalation allows these gases to combine with moisture in the airways and lung to form strong acids that cause a chemical burn. Two important articles were written about this illness in the 1980s. Douglas, Hepper, and Colby (1989) described the Mayo clinic experience with 17 patients over 32 years. Most of their cases occurred in association with corn silage, and every case involved an exposure during the peak danger period (10 hours to 10 days after filling the silo). Zwemer, Pratt, and May (1988) reported 20 cases from New York and confirmed the hazard associated with corn. They were able to demonstrate that this is a very low frequency illness occurring in five cases per 100,000 farm workers per year. In the cases studied, there was a fatality rate of 20 percent. These two reports suggest that this rare, yet easily avoidable illness, can be very dangerous.

The literature of the last decade has provided a reasonably comprehensive picture of the respiratory problems of farmers. A clear clinical image of a new entity called Organic Dust Toxic Syndrome has emerged. The frequency of Farmer's Lung Disease has been established as has the first estimate of the incidence of Silo Filler's Disease. The occupational lung problems associated with animal confinement have also become better understood.

Mining

Unlike farming, mining has shown improvement in the injury rates to its workers during the past two decades (Figure 1). The reduction in the early 1970s may be attributable to the passage of the Occupational Safety and Health Act of 1971 and subsequent implementation and enforcement. The decrease might also be due to a significant increase in surface mining and

a reduction in the more dangerous underground work (Findeis & Tallichet, 1986). Surface mines are not without problems. Frequent injuries in surface mine workers inspired an interesting token system of stamps used for safety performance on the job. Miners with good safety records and work teams with few injuries were rewarded with stamps that could be redeemed for goods. Stamp awards were lost for injuries and equipment damage (a proxy for unsafe work practices). This interesting behavior modification plan resulted in a significant and sustained reduction in injuries (Fox, Hopkins, & Anger, 1987).

The respiratory tract of miners has been the subject of much concern from the medical community and the lay public. In the 1980s there was continued interest in miners' lung diseases. In a 17-year follow-up study of 167 miners, Jorgensen, Kolmodin-Hedman, and Stjernberg (1988) reported that Swedish iron miners who did not smoke had no demonstrable increase in bronchitis. Kreiss, Greenberg, Kogut, Lezott, Irvin, and Cherniak (1989) studied 383 men in Leadville, CO. Two hundred thirty-six had some hard rock dust exposure with an average of 9.3 years at risk. A full series of questionnaires and pulmonary function tests were done. The miners had an increase in dyspnea, but had no increase in cough, phlegm, or wheezing compared to nonminers. In the laboratory, non-smoking miners had restrictive lung changes while smoking miners tended to have obstructive changes. Prolonged dust exposure caused alterations in the tests of many of the miners. Although the pulmonary function tests were altered statistically, the physiologic implications for these miners was unclear.

Lung cancer has been associated with underground mining for hundreds of years (Lundin, Wagoner, & Archer, 1971). Most experts feel this is quite likely due to the inhalation of radon (Ludin et al., 1971). Smoking certainly increases the risk of lung cancer in miners. Although some have described the association as synergistic (Whittemore & MacMillan, 1983), others, following miners for longer periods of time, have concluded that the association is additive (Edling, 1982). If the relationship is synergistic, then homeowners who are nonsmokers probably face little risk. If, on the other hand, the risk is additive, then as energy conservation increases, the risk may likewise increase (Archer, 1988), especially for smokers.

The powerful tools used by miners are a source of considerable vibration. Some workers so exposed develop a peculiar spasm of the blood vessels in the hands that causes the finger(s) to turn white and become numb. This disorder bears the medical eponym, Raynaud's phenomenon. It is also called "white finger" by the miners. Hedlund (1989) studied 27 Swedish miners exposed to vibration and 27 miner-controls without such exposure. The exposed group had 11 members with Raynaud's phenomenon (41%). None in the control group developed white fingers and numbness. This is a highly significant difference. Hedlund (1989) then studied the feet and found 22 percent of exposed workers with typical Raynaud's symptoms in the feet. None of the controls had such symptoms. The lack of

association with smoking and Raynaud's of either hand or foot was notable. One may infer that long-term exposure to vibration alone may increase the risk of white finger and painful hands. Unfortunately, the group of subjects was not randomly selected and may not be representative of all Swedish miners.

In summary, mining, in contrast to farming, has shown improvement in workers' injuries during the past several decades. The lung problems of miners received attention and showed that smoking miners remain at increased risk for bronchitis and probably lung cancer. Dust exposures caused differing lung problems in smoking and nonsmoking miners. The overall lung health of miners who did not smoke emerged as better than some might suspect. Vibrational problems of blood vessels associated with mining machinery was reported and appears to be dose related.

Logging

The timber industry, like mining, presents vibrational hazards to its workers (Brubaker, Mackenzie, Eng, & Bates 1983). A very large longitudinal study of white finger was published from Kumamoto, Japan. Futatsuka and Ueno (1985) studied 1,456 workers in the Japanese National Forests. Using questionnaires and corresponding medical charts, they studied workers who began using chain saws in 1956. They found that the workers from the 1950s and 1960s had the highest rates of Raynaud's. The latency period (the interval from the beginning of exposure to the development of symptoms) was estimated to be 6.4 years. Once workers develop this problem, it appears that nearly 75 percent still have difficulty two years after exposure ends. As many as 29 percent of affected workers in this study had symptoms persisting 10 years after the exposure ended. The relative decrease in the incidence of vibrational symptoms during the study period may be the result of improved chain saw designs, or better work practices.

Although exposure to vibration is an important concern, trauma remains the major hazard facing loggers. Little epidemiological information was reported in the 1980s. The single exception was an article by Holman, Olszewski, and Maier (1987). Holman and his colleagues reviewed the cases of 51 loggers transferred to the Level I trauma center at their hospital from 1980 through 1985. The average age of the injured worker was 34. Two thirds of the injuries involved men struck by falling or rolling logs. Only eight (16%) had chain saw injuries serious enough to get to a trauma center. Two patients died (4%), yet, the average length of stay was an impressive 27 days. Twenty-five (58%) of the injured men had permanent disabilities, a shocking figure for such young men. The injuries that were serious enough to be transported to a trauma center in this study were severe and had profound consequences for the workers. While providing a valuable "snapshot" of serious injuries, this paper only allows a glimpse of the tip of the

injury iceberg. There must be many less severe injuries for which we have yet to carefully account.

Although little was written about loggers in the past 10 years, this dangerous work has a high rate of both injury and disability. Chronic vascular problems related to chain saw vibration were reported. Fortunately, the trend appears to be improving, perhaps as a result of improved saw designs.

Future Research Needs for Rural Workers

The preceding sections have outlined the topics that were addressed in the occupational health literature of the 1980s on farmers, miners, and loggers. Significant information gaps need to be filled.

Migrant worker's health problems must be more fully studied. Careful documentation of clinical illness and health perceptions and beliefs ought to be addressed in the 1990s. The Migrant Clinicians Network, already in place, would benefit greatly from a strong data base from the many clinic sites across the country. The development of such a data base would help with planning and quality assurance. Migrants come in contact with some of the most perishable agricultural products. These are often the most heavily treated with pesticides. Studies are needed to follow migrant workers over time to assess their risk from pesticides. Surveillance efforts should address chronic neurologic problems, cancer, and birth defects. The available literature from the 1980s does not provide strong evidence that pesticides are causing long-term illness in migrants and other farm workers; further studies with better exposure information are needed. Such studies should quantify risks and help to thoughtfully guide the proper use of pesticides in an industry now dependent on them.

Injury is recognized as a major health problem for all the rural worker groups addressed in this review. It is only in the past five years that health professionals have accepted injuries as a public health problem, not as accidents or random events (National Research Council, 1985). The National Research Council's (1985) monograph, *Injury in America*, points out that much more needs to be understood about who gets hurt on the job and the epidemiology of those injuries. The very high injury rate in farming, mining, and logging certainly make these industries prime candidates for increased research. Surprisingly, even some of the most rudimentary epidemiologic elements are not readily available for representative samples of farm injuries. Studies to address the economic impact of injuries are vitally important and would certainly help advance the policy discussions surrounding injury in the agricultural work place. The information already in hand regarding tractors and power take-off trauma suggests that engineering research on design improvements should be increased. Research is also needed on how best to reach the farm community with health educa-

tion programs. Detailed injury studies for logging also would be of interest. Commercial logging, unlike most farming, is under the jurisdiction of Occupational Safety and Health Administration. This suggests that if injury problems are identified, regulatory action could be brought to bear. The chronic vascular problems associated with mining and logging deserve further research into the risks and circumstances which lead to Raynaud's phenomenon.

Health problems that are hardest to deal with are those of innovation or modernization. The Hay Baler's Fracture described previously is one such problem. Chronic bronchitis in swine and poultry confinement workers is a consequence of high concentrations of dust and gases resulting from housing animals indoors in high density. This is another example of technology innovation in agriculture resulting in human health hazards. Researchers must be alert to the introduction of new technology in agriculture and mining, and need to try to anticipate potential associated occupational health problems. This important challenge means that occupational health workers must remain current with the changing nature of the occupations they serve. Will workers be more subject to zoonoses (diseases transmitted from animals to man) from literally living in the same environment with cows, hogs, chickens, and turkeys? If insects are introduced for pest control, could that have an impact on workers combining grain or chopping corn? Will a new antibiotic introduced to reduce illness in cattle modify the bacterial flora in the barn and lead to resistant organisms in the food chain? The "innovation illnesses" need surveillance.

The respiratory illnesses in farmers and agricultural workers deserve further clarification. We understand the clinical picture of Organic Dust Toxic Syndrome (ODTS), but what actually causes this illness? Is it a specific bacterial product? If so, could we treat silage or cotton with an antibiotic and prevent the illness? Do masks prevent most agricultural respiratory illness? If so, which mask is the most comfortable and most effective for farmers to wear? Is the observation that smokers are seemingly protected from Farmer's Lung Disease reproducible? As silo designs change, will Silo Filler's Disease disappear? Can educational programs be designed to keep farmers from developing respiratory illness?

Rural workers are not unlike urban workers in that they must deal with job pressures and stress. Our understanding of job stress and its health consequences is rudimentary. We need more studies addressing the risks associated with stress. We also need better methods of reliable stress reduction for farmers and their families. The possible increased risk of suicide among farm operators must be confirmed and interventions planned if the risk is significantly increased. Migrants had very high scores on tests designed to identify mental health risk (Vega, Warheit, & Palacio, 1985). Psychiatric surveys and clinic visit data analysis would help us better understand the stress-related illnesses of farm workers and its physiological consequences and extent.

No discussion of the future research needs of rural occupational health would be complete without addressing an assessment of access to care. Can rural workers get competent, compassionate care? My own experience in rural New York suggests that few rural residents have faith in their physician's knowledge of occupational health problems, but survey data is needed to support these anecdotes.

Serving the occupational health needs of rural residents is rewarding, interesting work that is remarkably well received by the workers and their families. In addition, research into the health problems of rural workers is a wide open field filled with many challenging questions. Answering these questions affords rural practitioners the rare opportunity to improve the lives of many people at the same time. The focus in rural occupational health is the prevention of illness and keeping the worker working—without endangering his or her health.

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Michael K. Miller, PhD
Editor
The Journal of Rural Health
The Center for Health Policy Research
Box J-177
J. Hillis Miller Health Center
University of Florida
Gainesville, FL 32610-0177
(904) 392-2571