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IMPROVING HEALTH AND SAFETY IN THE AGRICULTURAL WORKPLACE

THE HISTORY OF OCCUPATIONAL HEALTH AS AN AGRICULTURAL CONCERN

In one of the earliest references to occupational disease, the Swedish archbishop Olaus Magnus warned in 1555 in his *Historia de Gentibus Septentrionalibus* (History of the Nordic peoples) about the "damage to the vital organs of threshers from inhaling grain dusts" (1). This respiratory hazard of farmwork was again noted 150 years later by the Italian physician Bernadino Ramazzini in his seminal work on occupational health hazards, *De Morbis Artificum* (The diseases of workers) (2). While these early observations called attention to occupational hazards in agriculture, the field of occupational health has been driven, since the late 18th century, by the urban engines and industries of the industrial revolution, and this focus on heavy industry has continued to the present time.

The industrial revolution in Great Britain was a direct cause of numerous occupational and nonoccupational health hazards in British cities. Charles Dickens's *Hard Times* paints a grim picture of the filth and pollution in his fictional but realistic Coketown:

> It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood it was a town of unnatural red and black like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves for ever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye. (3)

Urban pollution and its associated public health hazards in Great Britain led to one of the earliest triumphs of epidemiology, the recog-

nition by John Snow that cholera in London was spread by sewage-contaminated water (4). In addition to improved public sanitation, the 19th century saw many improvements in workplace conditions, but these efforts continued to focus on the heavy industries—the mines and mills—of the industrial revolution.

One English medical practitioner of note at that time was Charles Turner Thackrah (1795–1833). His seminal work, *The Effects of the Principal Arts, Trades and Professions, and of Civic States and Habits of Living, on Health and Longevity, with Suggestions for the Removal of Many of the Agents Which Produce Disease and Shorten the Duration of Life* (5), is particularly noteworthy because it focused on the prevention of disease by removal of workplace exposures. It was also prescient in its attention to bad occupational postures as a source of disability. But Thackrah's treatise failed to mention the hazards of agriculture except where those agricultural products, such as cotton, reached the urban mills and factories.

One can imagine that Thackrah and his contemporaries viewed the agricultural countryside as a healthy alternative to the filth and pollution of the industrializing cities and to the hazards of long work hours and terrible working conditions in the factories. This image of pastoral beauty, cleanliness, and health, reinforced by the artists of the time (6,7), supported the belief that agriculture itself was healthier, more wholesome, and more virtuous than urban industry. In the United States, this "agrarian myth" was embraced by Thomas Jefferson when he stated that "cultivators of the earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous, and they are tied to their country and wedded to its liberty and interests by the most lasting bonds" (8).

These themes were echoed in the 19th century in the United States by Dr. Benjamin McCready, who noted in his treatise *On the Influence of Trades, Professions, and Occupations in the United States, in the Production of Disease* that "agriculture is the oldest, the healthiest, and the most natural of employments. The husbandman, in general, enjoys pure air, and varied and moderate exercise. In this country his diet is always abundant and nutritious, and his habits much more temperate than those of the manufacturing or laboring classes" (9).

The modern era of occupational health has also failed, until recently, to focus its efforts on the occupational hazards in agriculture. Dr. Alice Hamilton began her career by exploring the health hazards of lead and other heavy metals among working-class residents of Chicago (10).

While her efforts were instrumental in focusing public health efforts on occupational diseases in the United States, her work completely ignored the occupational hazards of agriculture (11).

One of the experiences that moved Dr. Hamilton from laboratory research to field studies was attending the International Congress on Occupational Accidents and Diseases in Brussels in 1915. At that meeting, Dr. Glibert of Belgium dismissed the subject of occupational health in the United States by stating, "It is well known that there is no industrial hygiene in the United States. Ça n'existe pas." During the first half of the 20th century, industrial hygiene and occupational health were indeed more advanced in Europe than they were in the United States. While since then that situation has been corrected for heavy industry, the United States has continued to lag behind Europe in many areas of agricultural health and safety.

Agriculture was further removed from modern occupational health efforts by the Occupational Safety and Health Act of 1970, which excluded the agricultural workplace from the jurisdiction of the new Occupational Safety and Health Administration (OSHA) and its research counterpart, the National Institute of Occupational Safety and Health (NIOSH). This exclusion contributed to a drastic disparity in federal funding levels for occupational safety: In 1985, federal spending for safety was $181 per miner but only 30 cents per agricultural worker, or over $350,000 per miner death but only $600 per agricultural worker death (12).

There was finally an effort to correct the discrepancy in the late 1980s. In 1987, an international conference in Iowa City focused attention on the tragically high rates of occupational injury and fatalities in agriculture and on the diminishing local and federal resources for addressing the problem (12). That conference and the resulting report were instrumental in passing federal legislation in 1989 supporting several broad initiatives in agricultural health and safety. The momentum from this effort was continued with the Surgeon General's Conference on Agricultural Safety and Health in 1991 (13). Since 1990, most of the increase in NIOSH's extramural funding has been to support its programs in agricultural health and safety, a step toward correcting the agency's neglect of this area in its first two decades. Nevertheless, the NIOSH effort and other federal programs are still much too little to address the magnitude of the problem.

THE AGRICULTURAL WORKFORCE

In addition to overlooking the hazards of agriculture in espousing the agrarian myth, Jefferson ignored much of the workforce doing the farmwork—the southern slave population (including his own slaves). When he spoke about the valuable citizens and virtuous employment of the cultivators of the earth, he was certainly ignoring the unpaid, noncitizen slaves. This neglect of a large portion of farm labor continues even today. The "farm family" may evoke the classic iconography of Grant Wood's painting *American Gothic,* but that image is not an accurate one for much of the country.

The number of hired farmworkers, including migrant and seasonal workers, in the United States is greater than the number of farmers and family workers (14). Further, the number of persons residing on farms has been declining for the past 50 years, while there has been an increase in hired labor (15). But even these data fail to illustrate the dependence of U.S. agriculture on hired workers, which varies with specific commodities and farm practices. For example, the average labor requirement for fruits and vegetables is 120 hours per acre, compared to only three hours per acre for grains, and these labor-intensive crops are farmed primarily by hired farm labor. Over 50% of hired farmworkers on farms employing more than 10 workers are located in California and Florida, two states with a predominance of high-value, labor-intensive crops. In California, there are 18 farmworkers for each farmer, and over 80% of farmwork is performed by hired labor.

Hired farmworkers are also demographically very different from family farmers (16). The population is young and predominantly male, foreign born, and Hispanic (Table 21.1). Almost half have less than eight years of education. This contrasts markedly with family farmers, who are an aging population, predominantly White male and U.S. born. The differences in income are also striking. One-half of migrant and seasonal farmworkers are below the poverty level, as defined by the U.S. Bureau of the Census, with a median family income of between $7,500 and $10,000 (16). Six of the 10 poorest Standard Metropolitan Statistical Areas in the United States are in California's Central Valley, and median family income is negatively correlated with employment in farmwork. In contrast, our study of California farm operators found that over 50% had a household income above $50,000 per

TABLE 21.1 DEMOGRAPHIC CHARACTERISTICS OF U.S. FARMWORKERS VERSUS FARM OPERATORS

Characteristic	Farm-workers	Farm Operators
Age		
Under 25 years	30%	2%
25–34 years	35%	9%
35–44 years	19%	20%
45–54 years	8%	22%
55–64 years	7%	22%
65+ years	1%	25%
Sex		
Male	71%	92%
Female	29%	8%
Ethnicity		
White (non-Hispanic)	23%	96%
Hispanic	72%	1%
African-American	2%	1%
Asian	2%	0.4%
Other	1%	1%
Education		
0–3 years	16%	na[a]
4–7 years	32%	na
8–11 years	27%	na
12+ years	25%	na
Place of birth		
U.S. born	38%	na
Foreign born	62%	na

[a]na = not available.
SOURCES: Farmworker data from U.S. Department of Labor (1991 [16]). Farm operators data from U.S. Census of Agriculture, 1992.

year and that over 25% had an annual income above $100,000 (unpublished).

Globally, agriculture is even more dominant as a source of occupational livelihood and potential health hazards, although a detailed discussion of this topic is beyond the scope of this chapter (17). The size of the agricultural workforce relates inversely to level of development (17). In many developing countries, 70% or more of the economically active population are involved in agriculture (18).

OCCUPATIONAL FATALITIES AND INJURIES IN AGRICULTURE

Jefferson may have ignored the occupational hazards of agriculture to the slaves who provided the labor for southern farms, but the facts amply demonstrate that the "agrarian myth" is just that—a myth. This myth was exploded by John Powers in a 1939 article in the *Journal of the American Medical Association,* in which he noted,

> During the past quarter century the hazards of industry, transportation, mining and construction have been recognized; the economic value of safety has become clearly apparent and measures have been adopted to insure its promotion. For agriculture, because of its primarily individualistic character, there has been no such recognition or supervision, and farming, though the oldest occupation in the world, remains the most hazardous. (19)

Powers went on to note in a 1950 article that 26.6% of the occupational fatalities in the United States were in agriculture, and this was approximately 70% more than in manufacturing or construction (20). He also reported that over a quarter of a million people annually were estimated to incur a disabling injury in agriculture, resulting in more than six million days of lost time.

Perhaps John Powers's most prophetic observation was that the rate of fatal injuries in construction and transportation was declining, while it was increasing in agriculture. Over the past 50 years, there has been a significant decline in the work-fatality rates in mining and construction, but a comparable decline has not occurred in agriculture (Figure 21.1). A similar discrepancy has occurred for occupational injuries and illness over the past 20 years, with significant declines occurring in mining and construction but not in agriculture (Figure 21.2). While there may be many contributing factors to this absence of significant improvement in agricultural fatality and injury rates, the limited occupational health and preventive medicine programs and the exclusion of many regulatory efforts are likely to be contributing factors.

How do occupational health indicators for agriculture compare to those of other major industries? One direct measure of occupational hazardousness is the rate of unintentional work fatalities. According to the National Safety Council, agriculture had the highest rate of unintentional fatalities in 1993, with 1,100 deaths, or 35 deaths per 100,000 workers (Figure 21.3, Table 21.2) (21). This is higher than the rates for mining or construction, and while the exact rates may vary depending

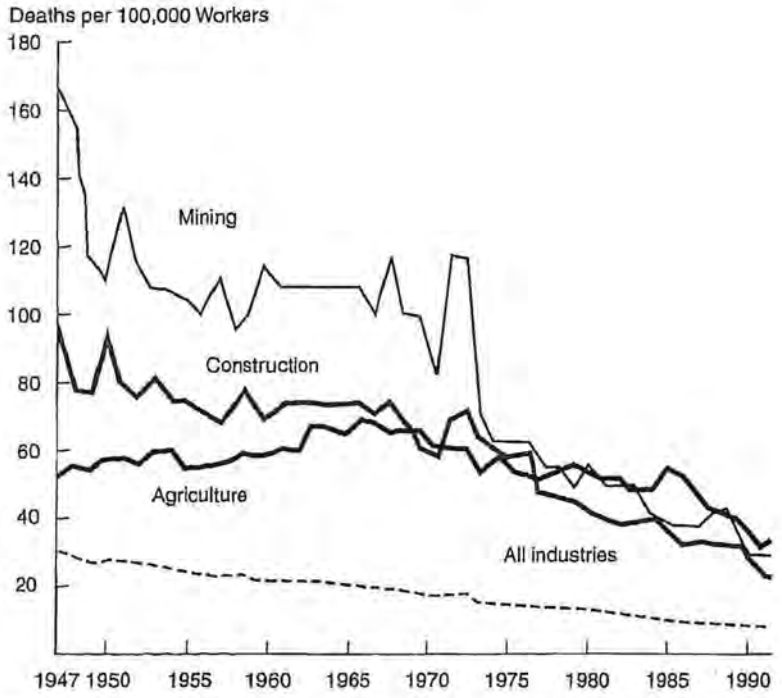

Figure 21.1. Work-related death rates in U.S. industries. Source: National Safety Council (1994 [21]).

on the method of ascertainment and population estimation, this indicator confirms that agriculture is clearly among the most hazardous occupations, with a death rate approximately four times that of all industries combined. Further, many studies have demonstrated that farming is underreported as an occupation in standard injury surveillance data, with actual mortality rates being 30% to 100% greater (22,23).

Consideration of farm residents paints an even worse picture, with 2,400 deaths in 1993, or 51 deaths per 100,000 farm residents (21). This reflects the hazards to farm family members, who are not counted among the agricultural worker totals. For example, there are nearly 300 deaths per year to children and adolescents from farm injuries, a particularly tragic statistic unique to agriculture, where the home and the workplace are the same (24).

Another perspective on agricultural fatalities is obtained from studies of cause-specific mortality in agricultural populations. The California Occupational Mortality Study found that the mortality rate for falls

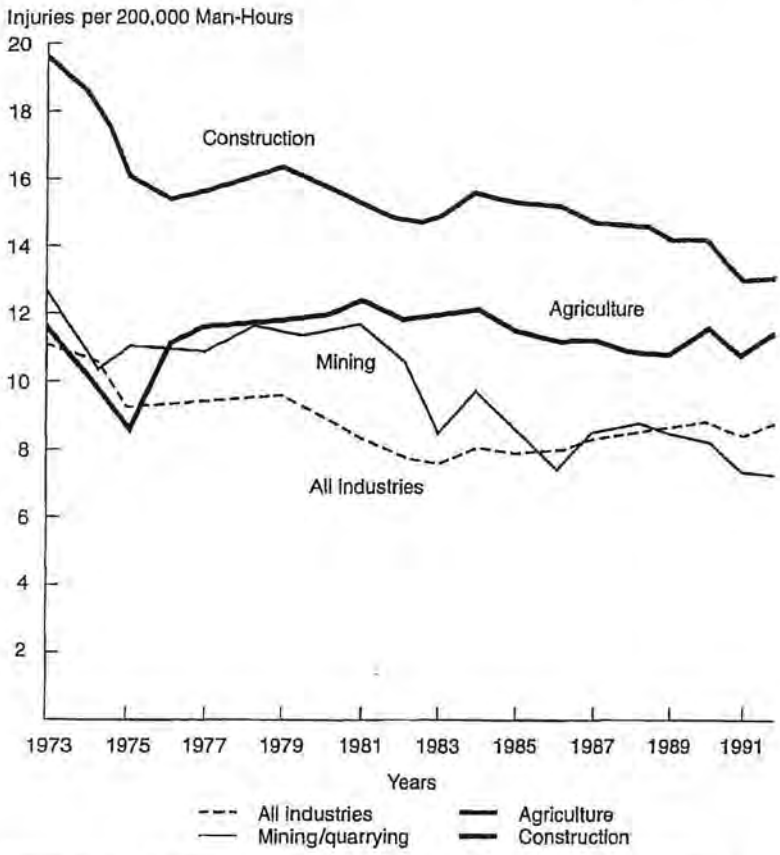

Figure 21.2. Occupational injury and illness incidence rates by industry. Source: National Safety Council (1994 [21]).

and machinery accidents among male farmworkers was 3.8 times the age- and race-adjusted rates for men in all other occupations (25). Studies of mortality in other agricultural populations similarly have shown deaths from injuries to be several times the rate in the general population (26).

Farm machinery is an obvious work hazard in agriculture and has repeatedly been shown to be the major cause of fatal work injuries. Farm vehicles account for approximately half the fatal farm injuries, and the majority of these deaths are due to tractors (21,27). Farm equipment, and specifically tractors, are also the predominant cause of fatal injuries to children in agriculture, accounting for approximately half the deaths

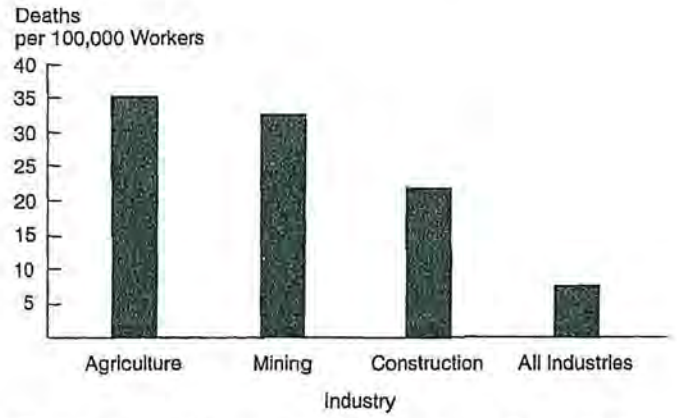

Figure 21.3. Work death rates by industry, 1993. Source: National Safety Council (1994 [21]).

TABLE 21.2 UNINTENTIONAL WORK-RELATED DEATHS AND DISABLING INJURIES IN THE UNITED STATES, 1993

Industry	Workers (1000s)	Deaths	Death Rates[a]	Disabling Injuries
Agriculture	3,100	1,100	35	130,000
Mining, quarrying	600	200	33	20,000
Construction	5,900	1,300	22	280,000
All industries	118,700	9,100	8	3,200,000

[a] Deaths per 100,000 workers in each group.
SOURCE: National Safety Council (1994 [21]).

of children (24,28). In our study of agricultural fatalities to children in California, deaths of children due to machinery were 80 times more likely to occur in a farm setting (29).

Data on occupational injuries and illnesses show similarly increased rates in agriculture. Agriculture consistently ranks with construction and manufacturing in having the highest incidence rates for occupational injuries and illnesses, based on Bureau of Labor Statistics data (21). Since these data exclude workplaces with fewer than 11 employees—a category that includes 95% of U.S. farms—the actual rates in agriculture may be much higher. Underreporting of injuries among migrant and seasonal farmworkers may also contribute to the underestimate of agricultural injuries. It is likely that this total is one-half or less of the actual rate (30). Nevertheless, in California alone, there are over

20,000 reported disabling injuries annually among agricultural workers. In Iowa, hospital admissions for traumatic injuries among farmers are more than three times the rate for nonfarmers (31).

CHRONIC ILLNESSES AMONG FARMERS

While traumatic injuries are the most obvious cause of death and disability among agricultural populations, a wide range of chronic illnesses are also more prevalent in agriculture, putting another nail in the coffin of the "agrarian myth." Chronic diseases also may be made worse for farmers and farmworkers because of barriers to health care in rural locations (32).

The National Health Interview Survey (NHIS) provides some perspective on chronic diseases and impairments among U.S. farmers (33). An analysis of health outcomes among 2,681 White male farmers found significantly increased age-adjusted prevalences of amputations, arthritis, cardiovascular disease, and hypertension among farmers compared to blue- or white-collar workers (Table 21.3). Although hearing loss was not more prevalent among farmers as a whole, it was significantly more prevalent in farmers over 65 years of age. Both asthma and chronic respiratory diseases were increased (70% and 30%, respectively), although not quite achieving statistical significance. Many of these findings are even more remarkable because cigarette smoking prevalence is lower among farmer populations, thus reducing the impact of one of the major preventable causes of chronic disease in society (34).

Mortality of farmers in California was significantly increased for many chronic illnesses, including cerebrovascular disease, chronic obstructive pulmonary disease, and cirrhosis (27). Studies of cause-specific mortality also have found increased suicide deaths among farmers, often attributed to the economic stresses of farming (35).

Finally, analysis of cause-specific mortality in 23 states found excess mortality among farmers from vascular lesions of the central nervous system, asthma, and several cancers, in addition to several types of fatal injuries (36).

CHRONIC ILLNESSES AND MORTALITY AMONG FARMWORKERS

Data on chronic diseases and mortality among migrant and seasonal farmworkers are more difficult to obtain because of the lack of separate

TABLE 21.3 AGE-ADJUSTED PREVALENCE FOR SELECTED CHRONIC CONDITIONS BY OCCUPATIONAL GROUP

	Age-Adjusted Prevalence (%)[a]					
Condition	*Farmers*	*95% CI*[b]	*Blue-Collar Workers*	*95% CI*	*White-Collar Workers*	*95% CI*
Amputations	3.1	1.3–4.9	1.4	1.0–1.8	0.8	0.6–0.9
Arthritis	11.7	8.8–14.6	9.7	8.7–10.7	6.8	6.0–7.6
Cardiovascular diseases	18.7	14.4–23.0	14.9	13.3–16.4	13.4	12.4–14.4
Ischemic heart disease	2.9	1.5–4.3	2.2	1.2–3.2	2.4	2.0–2.8
Hypertension	15.5	11.8–19.2	12.3	11.1–13.5	10.8	9.8–11.8
Hearing loss	11.6	8.5–14.7	13.0	11.8–14.2	10.2	9.2–11.2
Skin cancer	1.4	0.4–2.4	0.9	0.5–1.2	1.2	0.8–1.6
Chronic respiratory diseases	6.7	3.4–10.0	5.2	4.4–6.0	5.3	4.5–6.1
Asthma	5.2	2.7–7.8	2.8	2.2–3.3	3.5	2.9–4.1
Back pain	7.8	4.9–10.7	6.9	6.1–7.7	6.0	5.2–6.8
All selected conditions	76.0	66.0–86.0	68.1	64.1–71.9	56.9	55.0–59.9

[a]Indirectly age-adjusted using the employed population as the standard.
[b]Confidence interval.
SOURCE: National Health Interviews Survey, 1986–1990. Reprinted from Brackbill et al. (1994 [33]).

enumeration in most surveillance data sets, missing or inaccurate denominator data, and numerous difficulties in conducting epidemiologic investigations in this population (37,38). A comprehensive assessment of the health status of farmworker families in McFarland, California, confirmed the poor health status and inadequate health care in this population (38). Forty percent of families reported barriers to medical care, the greatest of which was cost (39). In a screening of almost all (92%) of the children 1 to 12 years of age in the town, 71% were found to have one or more medical problems requiring referral. Forty percent of the children were referred for vision problems, 37% for dental care, and 22% for anemia. This study and others emphasize the lack of preventive health services in this population (40). A Michigan study found that less than 1% of office visits for 1- to 4-year-old children of migrants were for preventive care, compared to 34% of visits by nonmigrants (41).

Clinic-based surveys of farmworkers show that proportionately more health care is provided for acute, infectious disease problems and less for chronic diseases, such as hypertension (42). Among farmworkers, health problems are exacerbated by poverty, lack of access to health

care, lack of workers' compensation coverage in many states, migratory or seasonal work patterns, and legal or regulatory impediments to health care access (37,43,44).

Limited mortality studies among farmworkers provide evidence of increased mortality from infectious and parasitic diseases (45). Increased tuberculosis mortality has been specifically identified among farmworkers and farmers (28), consistent with recent data indicating an increased prevalence of tuberculosis among farmworkers in some parts of the United States (46).

SPECIFIC CHRONIC ILLNESSES AND HAZARDOUS EXPOSURES IN AGRICULTURE

Respiratory Disease

A wide range of respiratory hazards exists within the agricultural workplace, often in concentrations much higher than in other industries (Table 21.4) (47–50). Most studies of respiratory hazards have focused on organic dust hazards, such as those that exist in hay barns, grain silos, and animal confinement units. These complex, antigenic exposures are associated with acute and chronic respiratory disease, including bronchitis, asthma, organic dust toxic syndrome, and hypersensitivity pneumonitis. Acute gaseous exposures to nitrogen oxides can occur in confinement situations and result in "silo-filler's disease," which may range clinically from transient respiratory symptoms to acute pulmonary edema and death. In New York State, deaths occur from this exposure every year, with an estimated annual incidence rate of 5 deaths per 100,000 silo-exposed farmers (51). Respiratory morbidity and mortality are also common from exposure to animal confinement–generated gases, such as ammonia, chlorine, and hydrogen sulfide (50).

Chemical exposures cause respiratory disease, either directly affecting the respiratory tract or causing systemic illness via respiratory absorption. Paraquat is an herbicide that causes death from respiratory failure following ingestion and may result in respiratory morbidity from occupational exposures (52). Examples of agricultural chemicals absorbed through the lungs that cause significant morbidity and mortality include the fumigants phosalone and methyl bromide (53,54).

Recent studies have focused on inorganic dust exposures in agriculture, particularly in dry climates such as California and other western states (55). Exposures to dusts in agriculture may be substantially

TABLE 21.4 RESPIRATORY HAZARDS IN AGRICULTURE

Agent	Examples	Sources	Diseases
Dusts			
Organic	Grain, cotton, hay, endotoxin, vegetable fiber, sugarcane	Barns, silos, storage facilities, harvesting operations	Asthma, hypersensitivity pneumonitis, organic dust toxic syndrome (ODTS), byssinosis, chronic bronchitis
Inorganic	Silica (quartz), silicates	Soil-disturbing operations	Pulmonary fibrosis, chronic bronchitis
Gases	NH_3, H_2S, NO_2, CH_4, CO, CO_2	Silos, animal confinement facilities	Silo-filler's disease, acute tracheobronchitis, pulmonary edema, asphyxiation
Chemicals			
Herbicides	Paraquat	Applicators, storage	Pulmonary fibrosis
Fertilizers	NH_3	Storage containers	Mucous membrane irritation, tracheobronchitis
Miscellaneous			
Solvents, fuels	Diesel fuel	Storage containers	Mucous membrane irritation
Welding fumes	NO_x, O_3, phosgene, metals	Welding operations	Bronchitis, emphysema

greater than levels for nuisance dusts in general industry. Further, toxic components in inorganic agricultural dusts, such as the fibrogenic agent crystalline silica, may be present at levels above the allowable industry standard in a majority of samples (55). We have recently demonstrated an independent association of wheezing and chronic bronchitis with agricultural dust exposure among California farmers (56), and our earlier work found reduced vital capacity of the lungs among grape workers (57), a crop with higher exposure to dust and silica (55). Earlier studies have shown fibrotic dust diseases of the lungs of agricultural workers in California and elsewhere (50,58), and recent work has also identified increased prevalence of interstitial or fibrogenic disease of the lungs among farmers, although the extent of these disorders is largely unknown.

Pesticide Illnesses

While most popular impressions of agricultural health hazards immediately focus on pesticides and other agrochemicals, these toxic agents actually account for only a small proportion of known disease and illness in the agricultural workplace in the United States and other developed countries. Conversely, pesticides account for a disproportionate share of the agricultural morbidity and mortality in developing countries (59). Nevertheless, many pesticides are potent systemic toxins and neurotoxins that result in acute illnesses and deaths each year, and the long-term effects of exposures are largely unknown. In California, where pesticide illness is reportable, there are over 1,000 acute illnesses among agricultural workers reported annually (60). The spectrum of acute effects, or "toxidromes," from pesticides ranges from eye and skin toxicity to several systemic manifestations, including respiratory, gastrointestinal, central, and peripheral neurologic impairments (61).

Many chronic illnesses have also been associated with pesticide exposure, including cancer (62), respiratory insufficiency, chronic neurologic disorders (63,64), and miscarriage and other reproductive toxicity (33). While most of these findings have not achieved a scientific consensus as to causality, others have shown consistent, biologically plausible associations in several studies. An example of this latter situation is the association of lymphoma with exposure to the phenoxy herbicides (62,65,66). For other health outcomes, such as Parkinson's disease (64) and neurobehavioral impairment (63), provocative hypothesis-generating studies exist that require further investigation before any causal linkage can be confirmed. The possibility exists that cumulative low-level exposures or acute high-dose exposures may result in delayed adverse health effects (63). Surveillance of acute illnesses will not detect these effects, which occur years after the exposure.

Musculoskeletal Trauma

Many characteristics of farmwork typify ergonomic factors associated with an increased risk for musculoskeletal trauma and degenerative disorders. Farmwork often requires heavy lifting, commonly in abnormal postures. This situation exists for the farmer loading hay into a barn as well as for the farmworker harvesting fruit into bags while balancing on a ladder. Incorrect postures and whole-body vibration are associated with driving tractors and other farm equipment, and these factors in-

crease the risk of low-back pain (67). This exposure may be further exacerbated by the very long hours of tractor driving required in agriculture. Many harvesting tasks require farmworkers to perform rapid, repetitive motions of the upper extremities, factors known to cause or exacerbate ergonomic stress and cumulative trauma injuries.

Is there evidence of increased musculoskeletal trauma and degenerative disease in agriculture? Poor ergonomic design is associated with increased traumatic injury, which is well established in agriculture, as noted previously. The NHIS found a significantly increased age-adjusted prevalence of arthritis among male farmers compared to other currently employed males (36). An analysis of U.S. workers' compensation injury data for agriculture showed that over one-third of claims were for strains/sprains, and one-half of these were for back injuries (68). Farmwork in the fruit and nut tree industry was specifically identified as having increased sprain and strain injuries, and the highest percentage of these were from back injuries caused by lifting. Other analyses of farmwork have identified manual lifting in the field by farmers as the greatest risk for low-back pain.

An Italian study of tractor drivers found significant reduction in spine mobility compared to a control population, a likely result of the ergonomic stresses of tractor driving (69). Other degenerative joint diseases are also more common in agriculture. For example, two studies of hip joint degeneration have found it to be significantly more common among farmers than among control groups (70,71). In one study, hip osteoarthritis was almost 10 times more common in those who had farmed for more than 10 years and was not associated with any single type of farming (70). There are little or no data on degenerative joint disease among hired farmworkers, although the nature of the work would suggest that these late-onset outcomes would be increased in frequency.

Noise-Induced Hearing Loss

Ample literature has demonstrated that excessive noise exposure is associated with high-frequency sensorineural hearing loss. Noise and vibration are integral parts of many agricultural operations. In one study, 75% of tractors without cabs had noise levels in excess of 90 decibels, the occupational standard and a level associated with increased hearing loss (72).

The NHIS found significantly increased hearing loss among farmers over age 65 (36). In a study of New York dairy farmers, 65% had high-

frequency hearing loss, which was significantly greater than the rate among control subjects (73). Other studies have confirmed the association of noise exposure in farming with increased hearing loss (74). Of even greater concern is a Wisconsin study finding an increased prevalence of hearing loss among teenage children who did farmwork compared to those who did not (75).

Cancer

Agricultural workers are exposed to a wide variety of potential carcinogens, including chemicals and physical and biologic agents (76). Potentially carcinogenic chemicals include not just herbicides and pesticides but also solvents, oils, welding fumes, wood preservatives, and other chemicals used on the farm. Ultraviolet radiation from sunlight is a physical factor directly associated with skin cancer, and biologic agents of particular concern in agriculture are viruses associated with farm animals.

Analysis of U.S. mortality data and numerous other data sources indicates that male farmers have excess mortality from cancers of the lymphatic and hematopoietic systems, lip, eye, brain, and prostate (39,65). Other cancers are increased among farmers, including cancers of the pancreas, kidney, and bone, but with less consistency. Farmers have decreased mortality from cancers of the lung and bladder, in large part because of their lower prevalence of cigarette smoking.

Most etiologic studies have focused on chemical agents, particularly pesticides. The data are consistent for an association of phenoxyacetic acid herbicides—in particular, 2,4-dichlorophenoxyacetic acid (2,4-D)—with a two- to eightfold increase of non-Hodgkin's lymphoma in studies conducted in Sweden, Kansas, Nebraska, Canada, and elsewhere (66).

Skin cancer is increased among farmers, and exposure to sunlight, a known risk factor, during work is the likely etiologic factor (77). For other cancers, a consistent increase is observed among farmers, but specific etiologic agents have not been identified; for example, many studies have documented an increase in prostate cancer among farmers (78–80).

Stress

An often overlooked health problem in farming is stress. The numerous sources of stress on the contemporary farm include financial uncertainty and losses, intense time pressures, drought and other natural disasters, intergenerational conflicts, and health and safety concerns (81). Mani-

festations of this stress may include causation or exacerbation of relationship problems, substance abuse, increased home violence, suicide, and several chronic diseases. While farm stress has been the subject of much speculation and many popular novels, few studies have looked at stress in farming populations. Surveys of urban versus rural populations have generally shown no differences in levels of overall stress or psychologic distress, but several specific factors in farm populations suggest that stress may be an important risk factor for disease. Suicides are increased among male farmers in the Midwest (82,83), although not in California (25). There are little data on stress among migrant and seasonal farmworkers, but poverty, job uncertainty, poor housing conditions, and family separations may all contribute to stress-related health outcomes (84).

Other Chronic Diseases

Many other chronic health conditions may be increased in agricultural populations, although specific etiologic factors often have not been identified. Dermatitis is increased in agriculture and may significantly contribute to workplace morbidity, although it is rarely a cause of death (85). Numerous agricultural exposures may result in adverse reproductive outcomes, including miscarriage, infertility, and birth defects (33). A few specific risk factors have been identified, such as the permanent infertility associated with DBCP (a nematocide) manufacturing (86), but most studies have observed ecologic associations and require further investigation (87) or require confirmation in different settings and investigation of specific mechanisms (88). Other chronic diseases that are increased in agricultural populations and that deserve further investigation and preventive efforts include cardiovascular and infectious diseases (26,36,39).

RECOMMENDATIONS FOR DISEASE PREVENTION AND HEALTH PROMOTION

While occupational health and preventive medicine have only recently focused much attention on the agricultural workplace, these recent efforts and increased resources suggest that progress can be made in reducing illness and injury among farmers and farmworkers. The first step, recognition of the problem, was greatly advanced with the Surgeon

General's Conference on Agricultural Safety and Health in 1991 (12). There is also evidence that farmers are concerned with occupational health and safety. A survey of approximately 1,500 farmers in the Midwest and East found a high level of concern about farm health and safety, with the major areas of concern being stress, trauma, and respiratory problems (89). In a recent survey of California farmers, we also found a high level of concern about health and safety, with injuries, pesticides/farm chemicals, and respiratory problems ranking highest (90). However, unlike their midwestern and eastern counterparts, over two-thirds of the California farmers stated that farming was less hazardous than other occupations, and only 9% correctly recognized that it was a more hazardous occupation than others.

The classic approach to occupational disease prevention involves a combination of the triad of engineering, education, and enforcement. I believe that each of these has a role to play in preventing illness and injury in agriculture, and I will highlight a few examples. It is important to note that approaches to this problem are complex and multidisciplinary, and solutions must be sensitive to the unique needs and requirements of farm families. Approaches to some of these problems may require the input of epidemiologists, occupational health specialists, pediatricians, behavioral scientists, sociologists and anthropologists, agricultural engineers, media experts, public health officials, educators, regulators, and farm family members and farmworkers themselves.

Engineering

One of the most dramatic engineering solutions to an agricultural health problem is the rollover protective structure (ROPS) for tractors. Tractors are the most common cause of fatal farm injuries, and tractor overturns are the single most important cause of tractor-associated fatalities, accounting for over 50% of fatalities (27,91). The rate of tractor-associated fatalities has not changed in the United States for the past 15 years. In Sweden, the annual fatality rate from tractors overturning was reduced from 12 per 100,000 farmers in 1961 to 1 per 100,000 farmers, or virtual elimination, in 1981 (92). This dramatic reduction was achieved by a 1959 law mandating ROPS on all new tractors, followed by a 1978 law prohibiting the use of tractors without ROPS. In Iowa, of 90 tractor overturns analyzed, there were no fatalities involving tractors with ROPS (93). The persistence of traumatic fatalities in the United States from tractor rollovers, when an engineering solution exists and has been

demonstrated to be effective, has been termed an "occupational obscenity" (13).

Many other agricultural hazards exist for which engineering solutions can and should be the first approach to exposure or injury prevention. For example, power takeoffs (PTOs) account for approximately 7% of tractor-related fatalities. Designing a simple, effective, and inexpensive guard for PTOs should be a high priority for reducing the morbidity and mortality associated with this piece of farm equipment.

Engineering solutions should also be developed to detect hazardous situations or to reduce the levels of exposure to toxins. For example, inexpensive monitors could be developed to detect excessive levels of endotoxin or toxic gases in enclosed farm environments. Farm equipment could be designed to be quieter, and monitors could signal excessive noise levels. Chemical exposures could be reduced by further development of enclosed systems for pesticide mixing and use and improved personal protection against agrochemicals in various climates. In general, the design and development of farm equipment should include consideration of potentially hazardous exposures in addition to improved production efficiency.

Education

Education is a fundamental element of any strategy to address agricultural health and safety issues. To be most effective, this effort should be directed to several audiences. These include the following:

- Farmers and farm family members, to increase their awareness of hazardous farm conditions and their knowledge of hazard reduction, proper equipment usage, and the proper emergency response to acute injuries and illnesses. Parents should also understand the importance of adequate supervision on the farm and the need for children to have age-appropriate tasks.
- Farm children, to increase their knowledge of farm safety and their ability to recognize hazardous situations.
- Rural residents, to promote general awareness of these issues and knowledge of first aid procedures.
- Primary care physicians and health care providers, who are often the only medical contacts for farmers and farmworkers.
- Hired farmworker populations, to educate this population by in-

creasing awareness of agricultural health hazards. An education must be culturally and linguistically appropriate.

- Agricultural extension agents.

Many potential avenues exist for these educational efforts, including schools in rural areas; volunteer organizations such as 4-H, FFA, and Farm Safety for Just Kids; and the popular media.

Educational efforts to promote farm safety have existed for decades, but there has been little improvement in agricultural injury or fatality rates. This does not mean that education should be abandoned but rather that it should be done more selectively and effectively. Educational efforts should be formally evaluated to determine their effects on knowledge, behavior, and, ultimately, health outcomes. It is no longer adequate to simply print up a poster or a brochure and expect that its existence or distribution will address the problem. Modern media and the behavioral sciences have developed powerful tools for affecting behaviors in the marketplace, and these can be applied to health and safety in agriculture and other work locations. These tools have been applied effectively, for example, to reducing cigarette smoking and other cardiopulmonary risk factors for disease. The marked decline of cigarette smoking in California, home to an aggressive antismoking campaign, provides dramatic evidence of the effectiveness of these methods. A review of the medical literature identifies hundreds of articles on strategies for reducing cardiopulmonary risk factors, including effective approaches with minorities and other special populations (94). In dramatic contrast, a search of the literature for behavioral interventions in agriculture turns up only a handful of articles.

Enforcement

Regulation has a role to play as one approach to improving farm health and safety, but its role must be both realistic and appropriate. The large number of small farms spread across the country means that most regulations would have little or no chance for enforcement. Small family farms also have few resources for additional regulatory burdens, such as record keeping, industrial hygiene assessments, or complex engineering changes. For large corporate farms, where resources do exist for the implementation of appropriate health and safety regulations, a more traditional industrial approach to health and safety may be possible. Some

regulatory approaches are both logical and have proven effective. For example, banning of the most hazardous pesticides in California is a direct contributing factor in the reduction of agriculturally related pesticide illnesses (60). Mandated educational programs for pest-control operators in California also may have contributed to a reduction in acute pesticide illnesses in the state. Mandated safety changes in agricultural equipment should also be required as they are in the automotive industry.

Enforcement efforts should also focus on labor regulations for hired farmworkers as has recently been done in California with the joint CAL/OSHA and U.S. Department of Labor Targeted Industries Partnership Program (TIPP) (95). This novel program developed the first comprehensive electronic database of farm labor contractors and crew leaders who operate in California. This merged file made it possible for all agencies to cross-verify registration and license records, utilize the files for outreach to local employers, and develop strategies for education and enforcement. Subsequent work included adding compliance history information concerning specific labor contractors. Compliance records are utilized to schedule inspections, particularly involving contractors with a history of repeated citations.

Research

It is critical that research be done to identify the specific health hazards in agriculture, the factors that cause or contribute to those hazards, individuals at increased risk of disease or injury, and the effectiveness of proposed or attempted interventions. The Surgeon General's Conference noted several priorities for research to reduce agricultural injury and illness (13). These include the following:

- Better characterization of risk factors and specific physical, chemical, and biologic health hazards
- Research to address the effects on chronic diseases of combined exposures and repeated acute exposures
- Epidemiologic investigation of the safety and health problems of special populations (e.g., migrant workers, children, and women) and of regional patterns of injury and disease
- Research on intervention strategy alternatives (e.g., education, regulation, and engineering controls), protective technology, the efficacy of standards, and the role of personal actions

The Conference also identified the need for more surveillance of agricultural injuries and illnesses and for interventions in the areas of hazard elimination, passive controls, and behavioral changes. These intervention efforts must include appropriate evaluation of their effectiveness in reducing agricultural injuries and illnesses.

Recent work at the University of California, Davis, has identified risk factors for increased agricultural disease. In a study of agricultural dust exposure, a cause of adverse respiratory symptoms, specific factors associated with increased (and decreased) dust exposure were identified (96). An investigation using statewide pesticide illness surveillance and use data identified high risk factors for pesticide illness among agricultural workers in California (97). These studies are important for the prevention of respiratory disease and pesticide illnesses because they identify high-risk groups for whom educational efforts and engineering interventions will have the greatest benefit.

Other research by Davis investigators has focused on improving the standard cholinesterase assay used to measure pesticide exposure (98). With regard to California clinical testing of cholinesterase, they have found that systematic errors in the testing of blood enzymes, especially the cholinesterase of the red blood cells, introduced errors of at least 40% in the values. The application of these findings involves development and dissemination of new, more accurate methods of cholinesterase testing for medical surveillance of agricultural workers and for use in clinical research. This work is an example of agricultural health research, moving from fundamental mechanisms to application, outreach, and intervention.

THE FUTURE

Agriculture is an occupation whose hazards have historically been ignored in the United States. Other occupations thought to be "inherently" hazardous, such as mining, have seen dramatic reductions in injuries and illnesses at the same time as more productive technologies have been instituted. Unlike mining, agriculture has not suffered the sort of mass disasters that catalyze action and resources to address a problem; nevertheless, there is now increased recognition of the hazardous nature of agriculture, and the situation is changing.

Approaches to injury and illness prevention in agriculture must use modern techniques of disease prevention and health promotion. They

also must take into account the changing nature of the agricultural workplace and of health care delivery, particularly in the rural setting. Agriculture is a very diverse industry, and solutions must be appropriate to the local political, geographic, and cultural factors and to the farm practices of the region. Farming is the oldest occupation and was one of the first in which it was recognized that work could be hazardous as well as rewarding; it deserves our best efforts and the necessary resources to make it as safe, and its workers as healthy, as possible.

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Promoting Human Wellness: New Frontiers for Research, Practice, and Policy (Hardcover)

by Margaret Schneider Jamner (Editor), Daniel Stokols (Editor)

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Editorial Reviews

Product Description

This book is a state-of-the-art educational resource on the latest research and public-policy developments in the fields of wellness promotion and disease prevention. Based on award-winning lectures by University of California faculty on nine campuses as part of the Wellness Lectures Program jointly funded by The California Wellness Foundation, Health Net, and the University of California, the volume aims to widen the scope of health care research and policy to promote wellness rather than focus on illness and disease, and to incorporate proactive, interdisciplinary approaches to health care. The volume also contains chapters by distinguished scholars inthe fields of wellness promotion and disease prevention. Many of these articles fall outside the scope of what we conventionally call health promotion, bringing new perspectives to research and policy possibilities.

Promoting Human Wellness is organized around core themes such as the importance of disease prevention programs that address multiple health risks, the link between poverty and minority status and disease susceptibility, and the challenge of evaluating health benefits and cost-effectiveness. The articles discuss such timely issues as genetic determinism as a paradigm in wellness promotion, adolescent health promotion and teen pregnancy prevention strategies, racial differences in cancer epidemiology, the California smokers' helpline, strategies for reducing youth violence, HIV/AIDS prevention, domestic violence education and prevention srategies, and the future of women's health research.

Presented within the framework of social ecology, several of the chapters in this volume address new ideas and approaches in the wellness field that are only now beginning to be understood such as the social construction of variables including race, class, and gender. *Promoting Human Wellness* will be essential reading for health practitioners, policymakers, and others seeking to expand the ways we define and achieve health.

Keywords: Public health, community health, medicine, nursing, social welfare, health education, health psychology, social ecology, public policy, aging, health promotion.

From the Inside Flap

"This very important work calls for research and policy-making that is proactive, multi-level, multi-method, and interdisciplinary--not disease-driven. It synthesizes perspectives on wellness that have the potential to produce a paradigm shift in research and policy planning, implementation, and evaluation." -- Lené Levy-Storms, University of California, Los Angeles, Department of Medicine/Geriatrics

"[This book] helps broaden the field of inquiry and legitimates the social and political perspectives in health care research and planning." -- Ellen R. Shaffer, University of California, San Francisco, Program in Medical Ethics

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Product Details

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