Fatal Harmful Substances or Environmental Exposures in Agriculture, 1992 to 1996

Nelson Adekoya, DrPH
John R. Myers, MSF

Data from the Census of Fatal Occupational Injuries surveillance system from 1992 through 1996 were analyzed to allow a better understanding of exposures to harmful substances or environments that resulted in agricultural work fatalities. There were 357 fatalities as a result of these exposures in the agriculture production and agriculture services sectors, representing 10% of all work-related deaths that occurred in these industry sectors during this period. Contact with electric current represented 52.9% of these fatalities. Agricultural services reported 87 electrocutions, 50 of which occurred among tree trimmers. The events most likely to result in fatalities were contact with overhead power lines (26.3%) and drowning (17.1%). The overall fatality rate was 2.1 deaths per 100,000 workers. The development of appropriate hazard-awareness training for workers, such as that for electrical and drowning-related hazards, may help prevent future deaths in these industry sectors.

Many hazards in agriculture operations combine for the high number of deaths recorded each year in the industry. Analyses of the events responsible for occupational fatalities in the United States, according to the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI), suggest that exposure to harmful substances or environments, as defined by the BLS, accounted for 10% of the fatalities in all industries between 1992 and 1995.[1] Under the BLS coding system, these events encompass fatalities from contact with electric current; contact with temperature extremes; exposure to air-pressure changes; exposure to caustic, noxious, or allergenic substances; exposure to noise; exposure to radiation; and oxygen deficiency. Confined space events were included as appropriate. Distributions of these events vary by industry sectors, regions, and states. A special report for the state of Oregon showed that exposure to harmful substances or environments accounted for 12% of fatalities reported from 1992 to 1996 in the agriculture industry.[2] In Texas, these same exposures represented 18% of work-related agricultural fatalities from 1991 to 1995.[3]

Through the CFOI, the BLS has reported occupational fatalities on an annual basis since 1992.[4] To date, a comprehensive analysis of deaths in the agricultural production and services sectors due to the exposure to harmful substances or environments has not been conducted. To better understand these deaths, this study describes fatal injuries due to exposures to harmful substances and en-

From the Division of Safety Research, National Institute for Occupational Safety and Health, Morgantown, WVa.

Address correspondence to: Nelson Adekoya, DrPH, National Institute for Occupational Safety and Health, Division of Safety Research, 1095 Willowdale Road, P-180, Morgantown, WV 26505.

TABLE 1
Distribution of Agricultural Work Fatalities Resulting From Harmful Substances or Environments, by Year and Agricultural Sector: United States, 1992 to 1996 (n = 357)

Year	Crop	Livestock	Services	Total	Rate*	95% CI†
1992	28	20	25	73	2.2	2.1 to 2.3
1993	27	21	26	74	2.4	2.3 to 2.5
1994	32	23	23	78	2.2	2.1 to 2.3
1995	32	15	23	70	2.0	1.9 to 2.1
1996	18	16	28	62	1.7	1.6 to 1.8

* Deaths per 100,000 workers.
† CI, confidence interval.

vironments within these sectors of the agriculture industry.

Methodology

The CFOI was the fatality data source used in this study. The CFOI was developed by the BLS to monitor occupational fatalities in the United States through the use of a national census approach. Case subjects in the database met the following criteria: the decedent was employed at the time of the event (working for pay, compensation, or profit) and was engaged in a legal work activity or was present at the site of the incident as a requirement of his or her job.[1] The CFOI covered all industries, occupations, and types of injury events leading to work-related fatalities and had no age restriction on the inclusion of deaths in the system. CFOI data cover all 50 states and the District of Columbia and were compiled from records such as death certificates, state and federal workers' compensation reports, motor vehicle fatality reports, coroner or medical examiner reports, and work-related fatality reports from the Occupational Safety and Health Administration (OSHA), Mine and Safety Health Administration, Employment Standards Administration, and other sources.[1] Participating state agencies verified all fatal occupational injuries and obtained descriptive information on the circumstances surrounding each fatal event. Fatalities were counted if at least two data sources indicated a work relationship or if a single source document contained sufficient information for inclusion. At the time of this study, CFOI data were available from the years 1992 to 1996.

The Occupational Injury and Illness Classification Structures, a coding system developed by the BLS, was used to code the event leading to the fatal injury.[5] Industry was coded according to the 1987 Standard Industrial Classification System, a classification of establishments according to their structure and economic activities.[6] For this analysis, fatalities attributed to Occupational Injury and Illness Classification Structures event codes 3000 through 3900 (harmful substances or environments) for agricultural production (Livestock and Crops) and agricultural services sectors (Standard Industrial Classification codes 0100 to 0783) were selected. In the CFOI data provided to the National Institute for Occupational Safety and Health, cases were grouped by age, with workers less than 20 years of age combined into one group. To allow description of fatalities to youths aged 15 to 19 years, a request was made to the BLS to provide specific data for this age group.

Agricultural crop production includes establishments such as crop farms, orchards, greenhouses, and nurseries, but excludes forestry operations. Agricultural livestock production includes establishments such as dairy farms, ranches, feedlots, swine operations, egg-production facilities, broiler facilities, and poultry hatcheries. Agricultural services include establishments engaged in soil-preparation services, crop services, veterinary services, farm labor and management services, and landscape or horticultural services for others on a contract or fee basis.

Fatality rates were calculated using denominators derived from the Current Population Survey (CPS) microdata files and expressed as deaths per 100,000 workers. CPS is a monthly survey of US households selected from a probability sample representative of the civilian noninstitutionalized population.[7] To derive the denominator, monthly estimates of employment in agricultural production and agricultural services were averaged to provide an annual average employment estimate.[8] Appropriate 95% confidence intervals for the rates were derived from the standard errors of the CPS employment estimates.

Results

There were 357 work-related deaths from exposure to harmful substances or environments in the agriculture production and services sectors in the United States between 1992 and 1996. This figure represents 10% of the total fatalities (3605) reported in production agriculture and agriculture services during the study period. There were 73 fatalities in 1992, 74 deaths in 1993, 78 deaths in 1994, 70 deaths in 1995, and 62 deaths in 1996. Fatality rates showed some decline between 1992 and 1996 (Table 1).

Crop production accounted for 38.4% of the deaths, livestock production for 26.6%, and agriculture services for 35.0%. Males comprised the majority (97.8%) of those fatally injured. Sixty-five percent of fatally injured males were in agricultural production. Four of the eight females fatally injured were in agricultural services. Eighty-six percent of the fatally injured were white, 7% were black, and 7% were of other or unknown race. Thirty-eight percent of white victims worked in crop pro-

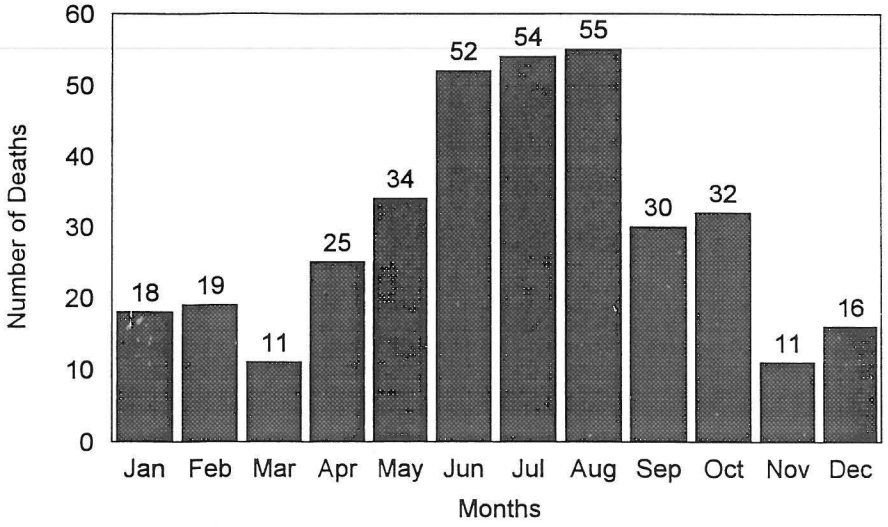

Fig. 1. Agricultural work fatalities resulting from harmful exposures or events, by month: United States, 1992 to 1996 (n = 357).

duction, 29% in livestock production, and 33% in agricultural services.

There were seasonal variations in fatalities, as presented in Fig 1. Fatalities were concentrated between April and October, with a peak in August. Fifty-five percent of the total fatalities were reported between May and August. Fatalities also varied by employment status (Table 2). The proportions of fatalities that occurred to individuals working for pay or compensation, self-employed individuals, and other family members working in family businesses were 60%, 33%, and 7% respectively. Across all sectors, the greatest proportion of deaths occurred among individuals working for pay or compensation: 55% in crop production, 51% in livestock production, and 74% in agriculture services. Of the 117 deaths in the self-employed category, 75% were in agricultural production.

Fatalities by region ranged from 133 cases in the South to 31 fatalities in the Northeast (Table 3). The South reported the most fatalities in crop production (49 deaths) and agricultural services (55 deaths). The Midwest reported the most fatalities in livestock production (37 deaths). The highest fatality rates were seen in the South and the West, whereas the Northeast rate was comparable to that of the Midwest.

The events most likely to result in fatalities were contact with overhead power lines (26.3%) and drowning (17.1%) (Table 4). Being struck by lightning accounted for 9% of the deaths, and inhalation in enclosed/confined spaces represented 8.4% of the deaths. Agricultural services alone accounted for 66% of the 94 fatalities attributed to contact with overhead power lines. Half of the 125 fatalities in agricultural services were caused by contact with overhead power lines, whereas electrocutions, including contact with power lines, accounted for 70% of the total fatalities in this agriculture sector. Fifty tree trimmers were specifically identified as being electrocuted during work activities in the agricultural services industry. Together, contact with electric current accounted for 189 fatalities in the production agriculture and agriculture services sectors. By age groups, the proportion of deaths due to electric current were as follows: 52% for youth less than 20 years of age; 76% for the 20- to 24-year age group; 68% for the 25- to 34-year age group; 47% for the 35- to 44-year age group; 50% for the 45- to 54-year age group; 32% for the 55- to 64-year age group; and 23% for those aged 65 years and older.

In the three agricultural sectors studied, there were 61 drowning-related fatalities: 23 cases in crop production and 19 cases each in agriculture services and livestock production. Collectively, deaths due to oxygen deficiency, which included drowning, accounted for 73 fatalities. Contact with temperature extremes contributed 27 fatalities. Lastly, exposure to caustic, noxious or allergenic substances was responsible for an additional 68 fatalities, 30 of which had occurred in a confined or restricted space (Table 4).

Table 5 lists fatality rates and incidence by age groups. The crude fatality rate for the 5-year period for workers 15 years of age and older was 2.1 deaths per 100,000 workers. The highest fatality rate of 2.9 deaths per 100,000 workers was reported in the 25- to 34-year age group. This rate was significantly higher than those for all other age groups except that for workers in the 20- to 24-year age group and workers 65 years of age and older. The rate of 2.4 deaths per 100,000 workers in the 65 years and older age group was significantly higher than the rates for workers less than 20 years of age and workers 45 to 64 years of age. The lowest fatality rate was reported among youth who were 15 to 19 years of age (1.2 per 100,000).

The predominant event type associated with these deaths among workers 65 years of age and older was drowning (12 deaths). Frequencies for other causes of death for these older workers included oxygen deficiency (16 deaths); electric current (nine deaths); exposure to caustic, noxious, or allergenic substances (nine deaths); and temperature extreme (six deaths). Twenty-three deaths were reported among youth less than 20 years of age; 52% of youth fatalities were due to contact with electric current and 39% to oxygen deficiency.

TABLE 2
Distribution of Fatalities From Exposure to Harmful Substances or Environments, by Employment Status and Agricultural Sector: United States, 1992 to 1996 (n = 357)

Employment Status	Crop	Livestock	Services	Total
Pay/compensation	75	48	93	216
Self-employed	52	36	29	117
Other family members working in family business	10	11	3	24

TABLE 3
Distribution of Agricultural Work Fatalities Resulting From Harmful Substances or Environments, by Region and Agricultural Sector: United States, 1992 to 1996 (n = 357)

Region*	Crop	Livestock	Services	Total	Rate†	95% CI
South	49	29	55	133	2.3	2.1 to 2.5
West	38	18	43	99	2.3	2.1 to 2.5
Midwest	41	37	16	94	1.7	1.6 to 1.8
Northeast	9	11	11	31	1.8	1.5 to 2.1

* **South Region states:** Virginia, West Virginia, Kentucky, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Arkansas, Delaware, Maryland, District of Columbia, Oklahoma, and Tennessee. **West Region states:** Washington, Montana, Wyoming, Idaho, Oregon, Colorado, Utah, Nevada, California, Arizona, New Mexico, Hawaii, and Alaska. **Midwest Region states:** North Dakota, South Dakota, Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, and Iowa. **Northeast Region states:** Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, and New Jersey.

† Deaths per 100,000 workers.

Discussion

This research adds to an area that has been studied to a limited extent. The study indicates that an average of six workers died each month due to exposure to harmful substances and environments; males represented a higher proportion among those fatally injured; contact with overhead power lines in the agricultural services sector is a major issue; and that death resulting from contact with electric current represented more than half of the fatalities.

Substantial proportions of deaths due to electric current were observed across the agricultural sectors and all age groups. Contact with electric current such as overhead power lines has been a well-documented public health problem causing occupational fatalities in the United States.[9–15] Electrical hazards are associated with overhead power lines, unmarked buried electrical cables, faulty machinery wiring, substandard wiring, inappropriately grounded electrical circuits, damaged electrical outlets, and damaged electrical cords on equipment that may be found around agricultural operations.[9] Other electrocution events found in the CFOI data include working with inappropriately grounded equipment, stepping on high-voltage power lines, touching electric wires, backing trucks into high-voltage lines, and tractors running into power lines.

With the disproportionate representation of deaths from electric current in this study, farm managers, owners, and agricultural services workers alike should, as a precautionary measure, be made aware of potential electrical hazards, particularly overhead power lines, and of approaches to reduce the risk of electrocutions. Appropriate hazard-awareness training needed to recognize potential electrical hazards is crucial for agricultural workers generally and particularly for youth who may be asked to work in fields with or without supervision. Other prevention strategies have also been published.[10–15]

Among all agricultural workers, tree trimmers in the agriculture services showed the most fatalities for a single type of event: contact with overhead power lines. It has been suggested that many tree trimmers and their employers working in the agriculture services sector may not be knowledgeable of OSHA standards regarding safe clearance distances for work near power lines and may be unaware of the risks of inadequate or improper safety procedures.[12] A strong commitment to safety by management and workers is essential to prevent future electrocutions.[15] The feasibility of local electric utilities' de-energizing overhead power lines during tree trimming is worthy of exploration.

Drowning events constituted another major finding in this research, especially for the workers less than 20 years of age and workers 65 years of age and older. Previous studies have identified drowning as a source of fatal farm deaths occurring to youth.[16,17] In California, the extensive network of irrigation canals may present farm-related drowning hazards.[18] Caution should be exercised when work is performed around a body of water. Ponds, lagoons, or other bodies of water on farms could be fenced (environmental control) or posted as being hazardous. The fact that agricultural services, a sector not traditionally associated with drowning, represented 31% (19) of the total drowning cases illustrates that drowning is not limited to production agriculture. The work activities of the 19 agricultural services workers who drowned include operating a lawnmower, operating an earth-moving machine, and using power tools (four deaths); trimming, pruning, clearing brush and trees (three deaths); maintenance, cleaning, and material handling (four deaths), and unspecified activities (eight deaths).

This study also identified confined space as a troublesome area. Con-

TABLE 4
Fatal Events Resulting From Exposure to Harmful Substances or Environments, by Agricultural Sectors: United States, 1992 to 1996 (n = 357)

Event*	Crop	Livestock	Services	Total
Contact with electric current (OIICS codes 3100 to 3190)	**65**	**37**	**87**	**189**
Contact with electric current of machine, tool, appliance, or light fixture	12	8	6	26
Contact with overhead power lines	27	5	62	94
Struck by lightning	15	6	11	32
Contact with wiring, transformers, etc	5	5	4	14
Other contact with electric current; underground buried power lines; contact with electric current, unspecified	6	13	4	23
Contact with temperature extremes (OIICS codes 3200 to 3240)	**17**	**4**	**6**	**27**
Such as exposure to environmental heat; exposure to environmental cold, hot objects or substances)				
Exposure to caustic, noxious, or allergenic substances (OIICS codes 3400 to 3490)	**28**	**31**	**9**	**68**
Inhalation in enclosed, restricted, or confined space	12	15	3	30
Inhalation in open or nonconfined space; bee, wasp, hornet sting	10	13	3	26
Inhalation of substance, unspecified, etc	6	3	3	12
Oxygen deficiency, not elsewhere classified (OIICS codes 3800 to 3890)	**27**	**23**	**23**	**73**
Drowning, submersion	23	19	19	61
Other oxygen deficiency, not elsewhere classified; depletion of oxygen; choking; etc	4	4	4	12
Total	**137**	**95**	**125**	**357**

* OIICS, Occupational Injury and Illness Classification Structure.

TABLE 5
Agricultural Work Fatalities Resulting From Exposure to Harmful Substances or Environments, by age groups: United States, 1992 to 1996

Age Groups	Deaths	Percentage	Worker Estimate	Rate per 100,000 Workers	95% CI
<15 Years	5	1.4	NA*		
15 to 19 Years	18	5.0	1,506,565	1.2	1.1 to 1.3
20 to 24 Years	37	10.4	1,572,293	2.4	2.0 to 2.8
25 to 34 Years	111	31.1	3,781,777	2.9	2.6 to 3.2
35 to 44 Years	73	20.4	3,742,184	2.0	1.8 to 2.2
45 to 54 Years	42	11.8	2,617,445	1.6	1.4 to 1.8
55 to 64 Years	31	8.7	2,032,826	1.5	1.3 to 1.7
65+ Years	40	11.2	1,657,786	2.4	2.1 to 2.7
Total	357	100.0	16,910,876	2.1	2.0 to 2.2

* NA, not available. Employment data are not collected for this age group.

fined spaces are an acknowledged problem[19] in the agriculture production industry because of the presence of structures or equipment that can concentrate certain gases that displace breathable air, causing an oxygen-deficient atmosphere, or that allow the accumulation of toxic hazards. It should be noted that there are other confined-space deaths, such as engulfment in flowing grain bins, that are not covered by these event codes. Employers and workers must recognize the dangers of confined spaces and conduct work analyses of tasks that require entry into confined spaces. For example, in this study, among the 30 confined-space fatalities, 13 occurred as a result of exposure to toxic gases in silos and manure pits. Manure pits had previously been identified as a public health hazard, yet farm workers may be unaware of the dangers, which have been known for years.[20]

The rate of agricultural work-related fatalities to workers 65 years of age and older from harmful substances or environments is a concern, given that this age group tends to work fewer than 40 hours a week. Estimates from the CPS show that these older farmworkers worked an average of 29 hours per week. The rate of 2.4 deaths per 100,000 from these older workers is as high or higher than the rates reported for all age groups except that for 25- to 34-year-olds (2.9 deaths per 100,000). This rate indicates that older workers were at a higher risk of fatal injuries than were many of their coworkers. Drowning represented the leading event causing a death in this group, compared with all other age groups, for which electric current was the leading cause of deaths. Older workers had previously been identified as having more work-related fatal injuries.[21–23] Well-planned epidemiologic studies are needed to evaluate the factors that contribute to high fatality rates among older workers, including physical limitations and effects of medication.[23] Clearly, there is a need to focus additional safety research on these older agricultural workers to identify specific risk factors so that effective intervention strategies can be formulated.

Environmental events, such as drowning, electrocutions, lightning, confined space, heat, and cold temperature, contribute to the majority

of exposure-related deaths in the three agricultural sectors we examined. Work-related fatalities associated with harmful substances or environments have been attributed to the lack of knowledge of chemicals in use, poor upkeep of equipment, lack of appropriate training and retraining, inadequate preparation for the job, poor supervision, lack of safety policy, and human factors.[12,15,19,20,24] Research is needed to elucidate the contributions of each of these factors by industry sector, region, and nationally.

Finally, most hazards identified in this study have OSHA-related standards. These regulations are designed to protect workers; however, many cover only general industry and not agricultural operations. For those standards that do apply, for agriculture, a rider to OSHA annual funding prohibits the use of federal funds to issue or enforce regulations applicable to farming operations with ten or fewer workers. There are a sizable number of farms with fewer than 11 workers in the United States. This prohibition remains even if OSHA receives a complaint that a worker has died at work.[25] Despite these limitations to the use of OSHA standards, health and safety specialists should make employers and farm operators aware of the benefits of using these regulations as work practice guidelines for preventing occupational fatalities in their operations. This will require working closely with these operators to show them the benefits of using safe work practices on their farms.

Limitations

There are several limitations in this study. First, the age groups used in the CFOI research file make it difficult to study specific age categories that may have research and safety implications. For example, we are unable to determine the number of deaths and the fatality rate for workers 75 years of age and older. The risk of fatal injury may be different for workers aged 65 to 74 years and workers older than 75 years. In addition, although the CFOI does provide useful information on occupational deaths occurring in the United States, this information is limited and does not allow researchers to identify risk factors beyond those related to basic demographic characteristics, such as the experience of the worker in performing the task involved in the fatality, socioeconomic characteristics of the worker, training experience of the worker, or other possible risk factors that may have contributed to the fatality. Research is needed to determine the contributions of these risk factors to agricultural work fatalities.

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