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Work-Related Fatalities in the Agricultural Production and Services Sectors, 1980–1989

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A total of 6,727 workers died of work-related injuries in the agricultural production and agricultural services sectors between 1980 and 1989, as established by data from the National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities (NTOF) surveillance system. The agricultural production sector accounted for the higher fatality rate (22.9 deaths per 100,000 workers), due largely to deaths caused by machinery and motor vehicles. The leading cause of death in the agricultural services sector was being struck by falling objects, primarily trees. Fatality rates were highest in the East South Central United States and lowest in the New England states. Blacks had the highest fatality rate (26.4 deaths per 100,000 workers) while workers other than white or black had the lowest rate (18.9 per 100,000 workers). Males were at higher risk of death than females, with the 65 years of age and older male group having the highest rate (60.5 deaths per 100,000 workers). Males 16–24 years of age exhibited the largest decrease in their average annual fatality rate during the 10-year period, down to 7.2 from 20.6 deaths per 100,000 workers. Possible reasons for this decrease are suggested. © 1995 Wiley-Liss, Inc.*

Key words: occupational fatalities, NTOF, farms, agriculture services, death certificate

INTRODUCTION

Workers in the agriculture industry have received a great deal of attention in recent years because of their high risk of fatal and serious nonfatal injuries [Runyan, 1993; National Institute for Occupational Safety and Health (NIOSH), 1992a; Merchant et al., 1989]. Three sources of data have estimated the agriculture industry to have an occupational fatality rate ranging from 17 to 42 deaths per 100,000 workers [NIOSH, 1993; Bureau of Labor Statistics (BLS), 1992; National Safety Council (NSC), 1991]. The differences in the estimated fatality rates are due largely to the methods used to collect fatality data and to different definitions of the worker population at risk [NSC, 1991]. Despite the wide range in these fatality rates, all three sources show agriculture to be among the four most hazardous industrial divisions in the United States.

NIOSH is one of the federal agencies that monitors occupational fatalities in the

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United States. The surveillance system developed by NIOSH for this purpose is the National Traumatic Occupational Fatalities (NTOF) surveillance system. NTOF is a death certificate-based census of work-related deaths as reported by all 52 vital statistics reporting agencies in the United States. To be included in NTOF, a certificate must meet the following criteria: the victim was 16 years of age or older; the cause of death was external; and the certificate had the injury-at-work item marked "yes." For the agriculture industry, the NTOF does undercount agricultural work-related fatalities by not capturing juvenile deaths under the age of 16 years, or by assigning agricultural deaths to other industries because the usual industry of the victim was not stated as agriculture [Murphy et al., 1990]. The fatalities of juveniles under the age of 16 years is the major group missed by the NTOF. Further details on NTOF, including advantages and limitations may be found in Bell et al. [1990].

The most recently published fatality rate from NTOF for the agriculture industry, covering the years 1986 through 1988, was 15 deaths per 100,000 agricultural workers [Bobick and Jenkins, 1992]. A previous NIOSH report covering the years 1980 through 1985 reported the agricultural fatality rate as 21 deaths per 100,000 workers [Myers, 1990]. Since the release of these two reports, fatality data for the year 1989 have become available. A re-examination of NTOF agriculture fatality data was done, focusing on trends in agricultural work-related fatalities not covered in the two previous reports. Furthermore, these analyses were limited to the agricultural production (i.e., farms) and agricultural services sectors (e.g., landscaping, custom agricultural services, tree removal services) of the agricultural industry division as defined by the Standard Industrial Classification Manual [Office of Management and Budget (OMB), 1987].

MATERIALS AND METHODS

Fatalities in NTOF occurring in the agriculture industry division were selected, excluding those that were classified in the forestry or fishing sectors. This left only those deaths associated with the agriculture production and agriculture services sectors, and those records that did not have the agricultural sector identified. Those records that were classified as being in the agriculture industry division, but were not classified by sector, were reviewed on a case-by-case basis to determine the appropriate agricultural sector in which the death occurred. Other deaths that appeared to be associated with agriculture, but were coded to another industry because of the "usual industry" entry on the death certificate, were not included in this analysis. If these deaths were added to the total, rate calculations based on industry employment data would be overstated because the victims who part-time farm were not counted in the agricultural industry employment figures—they were counted in the industry that was their primary employment.

The fatalities were classified into various categories, including gender, year of death, agricultural sector, race and ethnic origin, general occupation, and cause of death. Combinations of these categories were also examined where sufficient data existed to permit such two-way or three-way tabulations.

Industry, gender, age, and racial employment data, for the purpose of calculating rates, were obtained from the BLS "Employment and Earnings" annual average employment estimates for the years 1980 through 1989 [BLS, 1981a–1990a]. These employment figures are estimates of the national employed workforce, by

TABLE I. Frequencies and Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Year and Racial or Ethnic Origin, 1980–1989*

	White		Black		Hispanic		Other	
Year	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
1980	659	23.4	57	29.5	64	27.1	11	16.9
1981	642	22.7	47	26.4	61	24.3	13	21.7
1982	584	20.2	48	24.7	53	20.9	16	24.6
1983	521	18.3	43	22.2	50	18.2	8	11.4
1984	547	19.8	47	24.0	67	23.0	10	14.7
1985	560	21.2	58	30.7	72	24.7	15	27.8
1986	512	19.5	42	27.1	65	19.7	12	24.0
1987	527	20.4	49	29.9	68	17.1	7	12.1
1988	476	18.6	35	22.9	83	20.4	14	27.5
1989	451	17.6	40	26.7	75	17.0	6	11.3
Total	5,479	20.2	466	26.4	658	20.7	112	18.9

*The race or ethnic origin was unknown for 12 fatalities.

industry and occupation, based on a random sample of households across the United States. Employment data by Bureau of the Census geographic divisions were obtained from the BLS "Geographic Profile of Employment and Unemployment" [BLS, 1981b–1990b], which contains regional employment.

Sector-specific employment figures by occupation and age for the two agricultural sectors were not available. Age-specific rates therefore had to be calculated using the combined data of the two sectors. A lack of employment data also prevented the calculation of any occupation-specific rates.

The cause of death categories were determined using the International Classification of Diseases, 9th Revision (ICD-9), E-Codes [WHO, 1977]. The cause of death categories, based on groupings of E-Codes used in this analysis, were presented previously by NIOSH [1993].

RESULTS

A total of 6,727 deaths were identified within the NTOF surveillance system for workers in the agricultural production and agricultural services sectors during 1980 through 1989. The agricultural production sector, which employed approximately 2,542,800 workers annually during this 10-year period [BLS, 1981a–1990a], accounted for 5,823 (86.6%) of these deaths. Nine hundred four deaths (13.4%) occurred in the agricultural services sector; the average annual employment for the agricultural services sector for this 10-year period was approximately 717,500 workers.

The majority of the victims were males, accounting for 6,626 (98.5%) deaths. Females accounted for only 101 (1.5%) deaths during this time period. Whites accounted for 5,479 (81.4%) of the deaths, followed by Hispanics (658 deaths), blacks (466 deaths), and all other races (112 deaths). The highest average annual fatality rate was for blacks at 26.4 deaths per 100,000 workers (Table I).

Table II provides the average annual fatality rates for the 10-year period, for both agricultural sectors combined, by Bureau of the Census geographic divisions. The highest average annual fatality rates were in the East South Central states (23.8

TABLE II. Employment, Frequencies, and Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Geographic Region of the United States, 1980–1989*

Region	Average annual employment	Average annual deaths	Average annual rate
New England	71,225	8.9	12.5
Mid Atlantic	222,175	37.0	16.7
South Atlantic	456,950	107.5	23.5
East South Central	243,338	58.0	23.8
West South Central	396,825	75.3	19.0
East North Central	484,000	103.9	21.5
West North Central	637,188	145.9	22.9
Mountain	226,125	50.0	22.1
Pacific	512,613	86.2	16.8

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

deaths per 100,000 workers) and the South Atlantic states (23.5 deaths per 100,000 workers), while the lowest fatality rate was in the New England states. The highest number of average annual fatalities was in the West North Central states (145.9 deaths per year).

The average annual fatality rate for this 10-year period was 22.9 per 100,000 workers in the agricultural production sector and 12.6 deaths per 100,000 workers in the agricultural services sector. The annual fatality rates for the two sectors are shown in Figure 1. The agricultural services sector had an observable decrease in its average annual fatality rate, from a high of 18.7 deaths per 100,000 workers in 1981 to a low of 10.1 in 1989.

Table III provides fatality frequencies for occupational groups by sector and racial or ethnic origin. The occupational group which accounted for the largest proportion of deaths in the agricultural production sector was farmers, although this did vary depending on the race of the victim. For whites, the most common occupational group of the victim was farmer, while the most common occupational group for black and Hispanic victims was farm worker. The most frequent occupational group for all other races was a nonagricultural occupation. For agricultural services, victims who were white, black, or from all other races were most commonly working in a nonagricultural occupation, whereas Hispanics were most commonly in the farm worker occupational group.

Table IV provides the average annual fatality rates for both the agricultural production and agricultural services sectors by cause of death. The average annual fatality rates for these two sectors are very different. The agricultural production sector showed much higher average annual rates for machinery, motor vehicle, environmental, and suffocation deaths compared to the agricultural services sector. The single greatest rate differential was found in the risk for machinery deaths—the

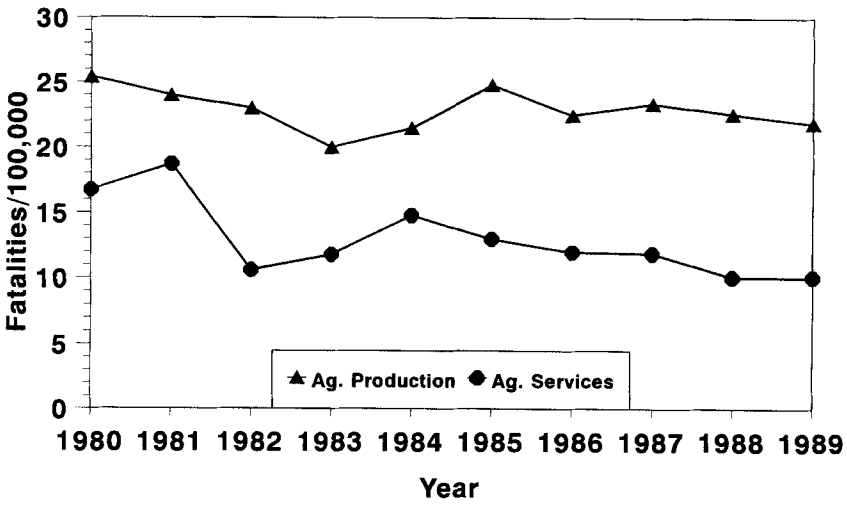

Fig. 1. Annual fatality rates for the agricultural production and agricultural services sector in the United States, 1980–1989.

TABLE III. Frequencies of Work-Related Fatalities for Occupational Groups by Race and Agricultural Sector, 1980–1989*

	Occupation[a]				
Race by sector	Farmers N (%)	Managers N (%)	Farm worker N (%)	Other occupation N (%)	Total N (%)
White					
Production	3,267 (48.7)	300 (4.5)	656 (9.8)	571 (8.5)	4,794 (71.4)
Services	52 (0.8)	56 (0.8)	143 (2.1)	434 (6.5)	685 (10.2)
Black					
Production	119 (1.8)	9 (0.1)	142 (2.1)	80 (1.2)	350 (5.2)
Services	10 (0.1)	7 (0.1)	33 (0.5)	66 (1.0)	116 (1.7)
Hispanic					
Production	62 (0.9)	21 (0.3)	385 (5.7)	105 (1.6)	573 (8.5)
Services	15 (0.2)	6 (0.1)	45 (0.7)	19 (0.3)	85 (1.3)
Other					
Production	25 (0.4)	3 (0.1)	29 (0.4)	37 (0.6)	94 (1.4)
Services	1 (>0.1)	0 (0.0)	6 (0.1)	11 (0.2)	18 (0.3)
Total	3,551 (52.9)	402 (6.0)	1,439 (21.4)	1,323 (19.7)	6,715 (100.0)

*The race or ethnic origin was unknown for 12 fatalities. [a]Farmers: 1980 Bureau of the Census codes 473 and 474; managers: 1980 Bureau of the Census codes 475 and 476; farm workers: 1980 Bureau of the Census codes 479, 483, 484, 486, 487, 488, and 489; other: All other 1980 Bureau of the Census codes.

agricultural production sector had average annual machinery-related fatality rates in excess of six times greater than those found in the agricultural services sector. For the agricultural services sector, the most frequent cause of death was due to falling objects. There was a more than two-fold greater risk of being struck by falling objects for agricultural services workers compared to agricultural production workers. Ap-

TABLE IV. Separate Frequencies and Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Cause of Death, 1980–1989

	Agricultural production		Agricultural services	
Cause of death	Deaths	Rate	Deaths	Rate
Machinery	2,427	9.5	111	1.5
Motor vehicles	1,013	4.0	118	1.6
Electrocution	354	1.4	125	1.7
Environmental	318	1.2	41	0.6
Falling objects	316	1.2	206	2.9
Falls	258	1.0	101	1.4
Homicide	177	0.7	26	0.4
Suicide	136	0.5	21	0.3
Suffocation	131	0.5	3	<0.1
Air transport	121	0.5	42	0.6
Caught in/flying	102	0.4	32	0.4
Drowning	83	0.3	25	0.3
Fires	74	0.3	3	<0.1
Poisoning	65	0.3	6	0.1
Explosions	53	0.2	8	0.1
Water transport	39	0.2	15	0.2
Other/unknown	156	0.6	21	0.3

proximately 86% (179 of 206 deaths) of these deaths related to falling objects were due to workers being struck by trees, limbs, or logs.

The average annual fatality rate per 100,000 workers for males was 25.5, while females had an average annual fatality rate of 1.5. The frequencies and average annual fatality rates for age group by gender are shown in Table V. Male agricultural workers showed an increasing average annual fatality rate with increasing age. Female agricultural workers did not show as clear a pattern, although the highest female average annual fatality rate occurred in the age group of 65 years and older. For males, workers aged 65 years and older accounted not only for the highest average annual fatality rate, but also for the highest number of deaths during this 10-year period.

Table VI provides annual fatality rates by age group for male agricultural workers. Age-specific female rates were not examined because of the very small number of deaths occurring to females annually in these two agricultural sectors. The male age group that had the greatest decline in annual fatality rates for the 10 years was the 16–24-year-old group, decreasing 65% from a high of 20.6 deaths per 100,000 in 1980 to a low of 7.2 in 1989. The annual fatality rate also decreased in the 65 years and older age group. The annual fatality rate for the 25–34-year-old group decreased during the years 1980 through 1983, then stabilized for the remainder of the 10-year period. Trends in the other three age groups are not apparent. The total male annual fatality rate decreased over the 10-year period. The female annual fatality rate was too variable to interpret any trend during the same time period.

Table VII presents average annual fatality rates by gender and cause of death, and male fatality rates by cause of death and age group. Because of small numbers, females were not examined by age group. The leading cause of death for all workers

TABLE V. Frequencies and Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Age Group and Gender, 1980–1989

Age group	Total		Male		Female	
	Deaths	Rate	Deaths	Rate	Deaths	Rate
16–24	915	12.9	897	15.3	18	1.5
25–34	1,190	15.9	1,163	19.6	27	1.8
35–44	902	15.9	878	20.6	24	1.7
45–54	981	20.3	971	26.8	10	0.8
55–64	1,217	26.0	1,205	31.6	12	1.4
65+	1,506	52.4	1,496	60.5	10	2.8
Total	6,711	20.6	6,610	25.5	101	1.5

TABLE VI. Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Gender and Year of Death, and by Age Group and Year of Death for Males, 1980–1989

Year	Male							Female	
	Age group (years)								
	16–24	25–34	35–44	45–54	55–64	65+	Total	total	Total
1980	20.6	24.1	19.9	33.1	32.5	75.3	29.4	1.2	23.9
1981	16.4	28.6	19.0	27.5	33.4	64.4	28.4	1.7	23.1
1982	16.9	17.7	21.6	26.0	37.5	52.8	25.3	1.5	20.6
1983	16.1	16.4	21.4	26.3	24.1	50.4	22.7	1.0	18.4
1984	17.6	19.8	18.7	26.7	26.0	63.0	24.9	1.1	20.2
1985	14.5	18.7	26.2	25.2	37.0	74.1	27.5	1.6	22.2
1986	14.4	18.9	21.4	21.8	31.0	58.9	24.6	2.3	20.0
1987	13.3	16.1	24.1	27.8	34.0	58.8	25.3	1.7	20.4
1988	13.4	19.2	17.7	26.3	33.8	53.8	24.2	0.7	19.2
1989	7.2	18.4	16.9	26.3	29.3	57.1	22.2	2.5	17.9

in the agricultural production and agricultural services sectors during 1980 through 1989 was machinery, followed by motor vehicles, falling objects, electrocutions, falls, and environmental causes. Each of the other causes of death accounted for less than 1 death per 100,000 workers.

The male average annual fatality rates by cause of death followed the same order as the total agricultural production and agricultural services worker population, with the male average annual fatality rates being slightly higher than the total population. Female average annual rates by cause of death were all less than 1 death per 100,000 workers. The order of the leading causes of death for female workers was different from that of male workers, with the leading cause of death for females being motor vehicles, followed by machinery, environmental causes, homicide, falling objects, and electrocutions. All remaining causes of death for females had average annual fatality rates below 0.1 deaths per 100,000 workers.

The male age-specific average annual rates by cause of death showed that most risks for male workers increased with increasing age. Machinery, motor vehicles, falling objects, falls, environmental causes, homicides, suicides, fires, and other or unknown causes of death indicated a general increase in risk with increasing age. Only two causes of death exhibited decreasing risk with increasing age—electrocu-

TABLE VII. Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Gender and Cause of Death, and by Age Group and Cause of Death for Males, 1980–1989

	Male								
	Age group (years)							Female	
Cause of death	16–24	25–34	35–44	45–54	55–64	65+	Total	total	Total
Machinery	4.3	5.6	6.3	9.8	13.8	31.9	9.7	0.2	7.8
Motor vehicles	3.3	3.7	3.3	4.4	4.9	8.1	4.2	0.4	3.5
Falling objects	0.9	1.5	1.9	2.8	2.4	4.1	2.0	0.1	1.6
Electrocution	2.5	2.5	1.6	1.6	0.8	0.8	1.8	0.1	1.5
Falls	0.5	1.1	1.1	1.5	1.7	4.0	1.4	<0.1	1.1
Environmental	0.6	0.7	1.0	1.2	2.0	4.0	1.3	0.2	1.1
Homicide	0.4	0.7	0.8	0.8	0.8	1.0	0.7	0.2	0.6
Air transport	0.2	0.8	1.1	1.0	0.5	0.1	0.6	<0.1	0.5
Suicide	0.4	0.4	0.6	0.7	1.0	0.9	0.5	<0.1	0.5
Caught/fly	0.4	0.4	0.5	0.5	0.4	1.3	0.5	0.0	0.4
Suffocation	0.4	0.5	0.5	0.4	0.7	0.6	0.4	<0.1	0.4
Drowning	0.5	0.4	0.4	.02	0.4	0.5	0.3	0.0	0.3
Fires	0.1	0.2	0.2	0.2	.04	1.1	0.3	<0.1	0.2
Poisoning	0.3	0.3	0.3	0.4	0.1	0.3	0.3	<0.1	0.2
Explosions	0.1	0.3	0.3	0.3	0.3	0.2	0.2	<0.1	0.2
Water transport	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.0	0.2
Other/unknown	0.2	0.5	0.5	0.7	1.3	1.5	0.7	<0.1	0.5

tions and water transport deaths. Risk of suffocation, drowning, poisonings, and explosions varied little by age group. The caught in or struck by flying objects cause of death category also appeared to have relatively equal risk by age group, except for the 65 years and older age group, which had a higher average annual rate. Finally, the remaining cause of death category, air transport deaths, showed an inverted U-shaped pattern of risk, with workers 35–44 years of age and 45–54 years of age showing the highest risk.

Annual male fatality rates for the leading causes of death by year of death are given in Table VIII. Only two causes of death appear to have decreased during the years 1980 through 1989—machinery deaths and electrocutions. The remaining causes of death exhibited no clear decreases in annual rates. Annual rates for motor vehicle deaths actually exhibited a small increase during this time period.

The decreases in the annual rates for electrocutions and machinery deaths among males were examined to see what role these reductions may have had in the decreased annual fatality rates of males 16–24 years of age and 65 years and older. The 16–24-year-old group showed decreases in annual rates for both electrocutions, down from 4.3 deaths per 100,000 in 1980 to 1.0 in 1989, and machinery, down from 6.2 deaths per 100,000 in 1980 to 1.2 in 1989. The 65 years and older age group showed a decreased annual rate for machinery deaths, down from 39.2 deaths per 100,000 in 1980 to 28.6 in 1989.

DISCUSSION

Many of the findings from this analysis of occupational fatalities in the agricultural production and agricultural services sectors are consistent with patterns of

TABLE VIII. Male Fatality Rates per 100,000 Workers for the Agricultural Production and Agricultural Services Sectors by Year and Cause of Death, 1980–1989

	Year									
Cause of death	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Machinery	11.5	11.9	10.5	8.9	8.4	11.0	9.2	9.2	8.5	7.7
Motor vehicles	4.1	4.2	4.0	3.7	4.2	5.0	4.0	4.5	4.3	4.5
Falling objects	2.4	1.9	1.6	2.0	2.1	2.2	2.0	2.2	1.6	1.7
Electrocution	2.7	2.1	1.8	1.8	2.1	1.7	1.8	1.7	1.5	1.0
Falls	1.5	1.5	1.3	1.0	1.5	1.5	1.2	1.5	1.2	1.6
Environmental	1.5	1.5	1.4	1.5	1.2	1.0	1.2	1.3	1.5	1.1
All other causes	5.7	5.3	4.7	3.8	5.4	5.1	5.2	4.9	5.6	4.6

occupational fatalities in the total U.S. civilian working population [NIOSH, 1989, 1993]. These patterns include a decrease in the annual occupational fatality rate during the 1980s, a markedly higher average annual occupational fatality rate for males compared to female workers, a higher average annual fatality rate for blacks, and increased risk for occupational fatalities with increasing age, especially for male workers.

A major difference between the agricultural production and agricultural services sectors compared with the total U.S. civilian working population is the high risk of death for the two agriculture sectors. The average annual fatality rate for the U.S. civilian working population reported by NIOSH [1993] for the years 1980 through 1989 was 7.0 deaths per 100,000 workers. The average annual fatality rates in the agricultural production and agricultural services sectors presented here were 22.9 and 12.6 deaths per 100,000 workers, respectively.

Part of the greater risk in agriculture can be attributed to machinery in the agricultural production sector, and the high risk of death due to falling objects in the agricultural services sector. The average annual machinery-related fatality rate for the U.S. civilian working population during 1980 through 1989, as reported by NIOSH [1993], was 0.95 deaths per 100,000 workers. The agricultural production sector showed a 10-fold higher average annual rate for machinery deaths during this 10-year period (Table IV). For deaths due to falling objects, the agricultural services sector had an approximately six-fold higher average annual fatality rate compared to the civilian working population, as reported by NIOSH (2.9 and 0.5 deaths per 100,000 workers, respectively). Two-fold or higher differences in average annual fatality rates for the agricultural production and agricultural services sectors compared to the civilian working population were also seen for deaths due to electrocutions, caught in/flying objects, environmental causes, and drowning.

The high risk of machinery-related death to agricultural production workers is well documented in the literature, with reports dating back to the 1930s [BLS, 1992; Bobick and Jenkins, 1992; Etherton et al., 1991; NSC, 1991; Myers, 1989; Hoskins et al., 1988; Murphy, 1985, 1990; Jewel, 1931]. In many of these reports, farm tractors were identified as the leading machine involved in the fatalities, with the most frequent fatal event being a tractor rollover. Although NTOF death certificate records were not examined to determine the proportion of machinery deaths due to tractors in this paper, previous NIOSH reports that did examine NTOF injury description information found tractors were the single most common machine causing death in the agriculture industry [Bobick and Jenkins, 1992; Etherton et al., 1991; Myers, 1989].

The high risk to workers in the agricultural services industry for being struck by falling objects was also reported previously [Bobick and Jenkins, 1992]. These falling object-related deaths were associated primarily with trees, limbs, or logs while felling or cutting up felled trees. This is a type of work associated with tree removal or landscaping businesses, and the deaths were due to hazards similar to those identified in the logging industry [Fosbroke and Myers, 1992].

The annual rate of occupational fatalities related to machinery did decrease during the 1980s in these two agriculture sectors (Table VIII). The causes for this decrease are not known, but may relate to the increased use of rollover protective structures (ROPS) on farm tractors. According to tractor information from farming operations in 1990, the use of ROPS on farm tractors between 1980 and 1989 increased from approximately 26% to 35% [NIOSH, 1992b]. These data also indicated that more than 75% of all farm tractors purchased since 1985 were equipped with ROPS. The replacement of older, less safe machinery with newer equipment that incorporates better guarding and shielding of machinery hazards may also have contributed to this decrease. Still, the annual fatality rate for machinery remains unacceptably high, with the lowest annual rate being 7.7 deaths per 100,000 in 1989—an annual rate higher than the total annual fatality rate of the entire civilian workforce.

The identification of blacks as the racial group with the highest risk of work-related deaths in the agriculture industry (including forestry and fishing) has been reported previously [Myers, 1989]. The annual fatality rates for blacks over the 10-year period did not indicate any clear downward trend in their risk of work-related fatalities for these two agricultural sectors whereas the annual fatality rates for whites and Hispanics did indicate some decrease (Table I). This suggests that more emphasis needs to be placed on prevention programs for the black agricultural workforce.

The fatality patterns by region were in some aspects not surprising (Table II). The high average annual number of fatalities in the West North Central, East North Central, and the South Atlantic states closely parallels the concentration of farm production in the United States. The only region which might be considered to have a lower than anticipated average annual fatality count and rate was the Pacific region, which had the third lowest average annual fatality rate at 16.8 deaths per 100,000 workers, but the second highest average annual agricultural employment. This relatively low average annual rate may reflect the stricter occupational safety and health standards for the agricultural industry in California, Oregon, and Washington, which have State-Occupational Safety and Health Administration (OSHA) plans. As a State-OSHA plan, these Pacific states are not subject to the budgetary restrictions of not enforcing occupational safety and health standards on farming operations with less than 11 full-time employees as Federal-OSHA states are.

The most promising trends for these two agricultural sectors during this 10-year period were the decreasing annual fatality rates associated with male workers in the 16–24-year-old and the 65 years and older age groups (Table VI). The 65 years and older age group still remained at highest risk in each of the 10 years, despite the reduction in their annual fatality rate, and accounted for the largest number of deaths of any age group. Purschwitz and Field [1986] reported similar results in a study of Indiana farm deaths occurring between 1968 and 1985, and farm deaths from other states covering various time periods. Wilkinson and Field [1990], in a follow-up study to Purschwitz and Field, found workers 65 years of age and older accounting for approximately 24% of all unintentional farm deaths.

The data reported here indicate that prevention efforts for elderly male farm and agricultural service workers must focus on preventing machinery-related deaths, and to a lesser extent motor vehicle deaths. These two causes account for 66% of all deaths in this age group. The need to reduce machinery deaths among older workers has been pointed out by others [Purschwitz and Field, 1986; Murphy, 1985, 1990].

The reduction in annual fatality rates for 16–24-year-old males during this 10-year period is clear. Young workers have shown a reduced annual rate of occupational fatalities due to electrocutions and machinery, down from a combined annual rate of 10.5 deaths per 100,000 workers in 1980 for these two causes of death to an annual rate of 2.2 in 1989. The reduction in the annual rates of electrocution and machinery deaths accounts for approximately 62% of the 13.4 deaths per 100,000 decrease in this age group.

It is possible that some underreporting did occur for occupational fatalities in the 16–24-year-old group, especially in the 16–17-year-old group, but it is not likely that such underreporting increased as the decade progressed. Also, there is some evidence that farm-related deaths for juveniles are too often denoted as work-related when they should not be [Murphy et al., 1990, 1993], which could inflate the NTOF annual fatality rates for young workers. While there may be some inaccuracy in the annual fatality rates reported here for this age group because of both underreporting and overreporting, these inaccuracies are most likely not related to the year in which a fatality occurred (i.e., the misclassifications are random in nature with respect to year). Thus, the decrease in the annual fatality rate for the 16–24-year-old group reported here is likely a real trend and not an artifact of the NTOF surveillance system.

It is not possible to determine the underlying reasons for the large decrease in the annual fatality rate to younger workers from these death certificate data. Factors such as the use of more modern and safer equipment may play a role, although it is not clear why machinery improvements would have affected the youngest age group more than workers 25–64 years of age. Farm safety awareness programs initiated in the 1970s and 1980s by such groups as the U.S. Department of Agriculture and FFA may have had an influence on work and safety practices of younger workers, but this influence has not been measured.

Economic factors may also have played a role in reducing the fatality rates of workers 16–24 years of age. Changes in farming practices, such as the use of more machinery and less manual labor, which reduced the exposure of young workers to hazards, may have played a role. Additionally, the high losses in family farming operations during the 1980s may have transferred younger workers into other industries, or into the agricultural services sector, which reduced their risk of fatal injury. The transfer of workers from the agricultural production sector to the agricultural services sector did appear to occur during the 1980s, with the agricultural services employment generally increasing by the same number of workers as the agricultural production sector decreased.

The necessary data to test these or other hypotheses about the annual fatality trends presented here for the agricultural production and services sectors are not available from the NTOF or other existing surveillance-oriented data sources. While the NTOF, and surveillance systems in general, raise questions about health effects, they are not designed to provide the explanations and answers to those questions.

Such explanations and answers will only be found through focused research using controlled epidemiologic studies.

CONCLUSIONS

These data indicate that more research and prevention programs are needed to deal with the risks faced by older agricultural workers. Emphasis must be placed in the areas of machinery hazards, motor vehicle hazards, and hazards associated with falling objects. Additional research should examine the underlying reasons for the dramatic decrease in the annual work-related fatality rate seen for workers 16–24 years of age to determine why this decrease occurred (e.g., U.S. Department of Agriculture [USDA] safety programs, use of safer farm machinery), and what lessons they may hold for prevention efforts targeted at reducing the agricultural fatality rate of workers in other age groups.

Special attention also needs to be given to black agricultural workers, who showed consistently higher risk for work-related fatalities in these two agricultural sectors than any other racial or ethnic group. Detailed epidemiologic studies to determine risk factors for black agricultural workers are needed.

Research on the reduction in the annual fatality rate for the agricultural services sector is also justified. The results of such studies may hold new insights on ways to reduce the higher fatality rate seen for agricultural production workers.

Progress has been made in areas of injury prevention in the agricultural production and services sectors in the 1980s, but more needs to be done. While these data do not provide answers on how to make these agricultural sectors safer for workers, they do point to where the most important risks exist. Future efforts should not only include epidemiologic studies, but also research to determine the most effective means of bringing prevention programs to all segments of the agricultural workforce. What progress is made in the decade of the 1990s will depend on how well safety and public health professionals address the risks presented here.

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