Identifying Work-related Fatalities in the Agricultural Production Sector Using Two National Occupational Fatality Surveillance Systems, 1990-1995

D. L. Hard, J. R. Myers, K. A. Snyder, V. J. Casini, L. L. Morton, R. Cianfrocco, J. Fields

Abstract

Workers in the agriculture industry have consistently been identified as being at high risk for death and injury. Production agriculture, the segment of the agriculture industry that represents farming, has been shown to have higher rates of fatalities than the agriculture industry as a whole. The purpose of the manuscript was to provide a descriptive analysis of agricultural production fatalities for the years 1990 through 1995. Two national occupational fatality data sources were used to calculate agricultural production fatality rates: the National Traumatic Occupational Fatalities (NTOF) and the Census of Fatal Occupational Injuries (CFOI). Employment estimates for calculating fatality rates came from the Current Population Survey (CPS). The majority of agricultural production worker decedents were white male farmers. The leading sources of injury were farm tractors, followed by trucks and harvesting equipment. Older agricultural workers (65+ years of age) were at high risk for death, with the most likely fatal event being the overturning of a tractor in a non-highway environment. Black workers in the agricultural production industry, and the occupation of black farmers in particular, were identified as having high fatal injury rates by race. Young Hispanic workers also exhibited a high fatality rate. Farm tractors were a leading source of injury resulting in death for males and females; however, there were gender differences in other types of fatalities. Females, while accounting for a small percentage of the total fatalities in agriculture production, had a higher proportion of deaths due to animals than did males, and also had a higher proportion of deaths due to being caught in running equipment than males. The two national occupational fatality surveillance systems, while showing differences in overall numbers, generally identified similar patterns of death for agricultural production workers. Finally, no clear downward trend for agricultural production fatalities was found, which is contrary to trends seen in the general worker population over the same time period.

Keywords. Agricultural production, Occupational fatalities, Surveillance systems, Statistics, Farms, Death certificate.

The authors are David L. Hard, PhD, *ASAE Member*, Team Leader, Intervention and Risk Factor Evaluation Team, Analysis and Field Evaluations Branch; John R. Myers, MSF, Health Statistician, Special Studies Team, Surveillance and Field Evaluations Branch; Karl A. Snyder, PhD, *ASAE Member Engineer*, Team Leader, Safety Engineering Team, Protective Technology Branch; Virgil J. Casini, BS, Team Leader, Fatality Assessment and Control Evaluations, Surveillance and Field Evaluations Branch; Linda L. Morton, MS, Writer/Editor, Information Management and Dissemination Activity, Office of the Director; Rosemary Cianfrocco, Epidemiology Assistant, Injury Surveillance and Analysis Team, Surveillance and Field Investigations Branch; and Judith K. Fields, Office Automation Assistant, Information Management and Dissemination Activity, Office of the Director, with the National Institute for Occupational Safety and Health, Division of Safety Research, Morgantown, West Virginia. Corresponding author: Dr. David L. Hard, National Institute for Occupational Safety and Health, Division of Safety Research, 1095 Willowdale Rd. MS/P-1133, Morgantown, WV 26505; voice: (304) 285-6068, fax: (304) 285-6047, e-mail: dlh6@cdc.gov.

Workers in the agriculture industry have consistently been identified as being at high risk for death and injury (Maley, 1986; Bobick and Jenkins, 1992; NIOSH, 1993; Runyan, 1993; Ruser, 1998). Production agriculture, a segment of the agriculture industry which commonly represents farming, has been shown to have higher rates of fatalities than the agriculture industry as a whole (Myers and Hard, 1995; U.S. DOL/BLS, 1996). Three data sources, the *National Traumatic Occupational Fatalities* (NTOF) surveillance system maintained by the National Institute for Occupational Safety and Health (NIOSH), *Accident Facts* maintained by the National Safety Council (NSC) and the *Survey of Occupational Injuries and Illnesses* maintained by the Bureau of Labor Statistics (BLS) have historically been used to report occupational fatalities in agriculture. The *Survey of Occupational Injuries and Illnesses* has recently (1992) been replaced as a fatality-gathering source with the *Census of Fatal Occupational Injuries* (CFOI) by the BLS. These data sources have identified occupational fatality rates for the agriculture industry to range from 18 to 26 deaths/100,000 workers (NIOSH, 1993; NSC, 1997; U.S. DOL/BLS,1996). The range between the various institutional rates has decreased in recent years, due to the improvements in data gathering implemented by the Bureau of Labor Statistics' (BLS) Census of Fatal Occupational Injuries (CFOI). The National Safety Council (NSC) adopted CFOI for their reported work-related fatality rates for the Standard Industrial Classifications (NSC, 1997).

The purpose of the manuscript is to provide a descriptive analysis of the first half of the decade of the 1990s for agricultural production fatalities. One of the limitations of doing the study was the fact that when the project was initially undertaken, NTOF data was available only through 1993 and the CFOI data system had just been instituted in 1992. Thus, neither system was able to provide what was desired, so it was decided to use both systems. Since two different data bases were used which collected similar data, differences are identified in how they are operationalized and collected as well as areas which were dissimilar.

Agricultural occupational fatality rates from the National Traumatic Occupational Fatality (NTOF) surveillance system are typically lower because this system tends to undercount agricultural work-related fatalities. The NTOF does not capture juvenile deaths under 16 years of age and, as a matter of protocol, when the usual industry of the deceased was not agriculture, assigns these deaths to the usual industry even if the narrative description suggests the event was associated with agricultural production (Murphy et al., 1990). CFOI identifies occupational fatalities from diverse data sources, including death certificates, workers' compensation records, news media, and investigative reports. CFOI typically captures a larger number of occupational fatalities due to the use of multiple records and because CFOI does not exclude any occupational fatalities based on age. However, due to the grouping of data by certain age groups, it is difficult to make analyses from other than the listed age groupings (i.e., <25, 25-34, 35-44, etc.).

Methods

Two national occupational fatality data sources, the NTOF surveillance system and the CFOI surveillance system, were used to calculate agricultural production fatality rates per 100,000 workers.

The NTOF is a death-certificate-based national surveillance system which represents a statistical census of all death certificates that meet the following criteria: the age of the victim is 16 years or older; the cause of death is external, as defined by the International Classification of Diseases, 9th Edition (ICD-9) E-codes; and the

injury at work item is marked "yes" on the death certificate. Because the NTOF is based solely on death certificates, it undercounts the true number of occupational fatalities occurring in the U.S. Additional details on the NTOF surveillance system can be found in the NIOSH publication *Summary of Traumatic Occupational Fatalities in the United States, 1980-1989: A Decade of Surveillance* (1993).

The CFOI is a multiple records-based national surveillance system maintained by the BLS. The CFOI also represents a statistical census; however, because multiple record sources are used to identify cases, the CFOI has a higher capture rate of occupational deaths than the NTOF. There are no age restrictions on the CFOI for including an occupational fatality. Work relationship is substantiated by two or more independent source documents or a source document and a follow-up questionnaire. Fatalities for which there is a single document are included in the data base if there is sufficient evidence of work relationship. Information on the sources of the injury and the type of injury event associated with the fatality are defined using the BLS Occupational Injury and Illness Coding Structure (OIICS) (U.S. DOL/BLS, 1992a). The CFOI was first implemented in all states in 1992. Additional information on the CFOI has been published by Biddle (1992), Toscano (1993), the U.S. Department of Labor, Bureau of Labor Statistics (1997), and Murphy and Yoder (1998).

The NTOF and the CFOI are both considered a census and thus are not subject to sampling error, but both could have measurement error. Measurement error for the NTOF has been estimated at approximately a 20% undercount of all occupational fatalities (Stout and Bell, 1991). No assessment on possible measurement errors for the CFOI have been published.

At the time the study was undertaken, data for the years 1990 through 1993 were available from the NTOF for analysis. Agricultural production cases were determined by the Bureau of Census (BOC) industry code assigned to the NTOF record (U.S. Department of Commerce, 1992). Industry information on death certificates is available for a field labeled "usual industry". A NTOF case was included if it had a BOC industry code of 010 or 012 (i.e., agricultural crop or livestock production). Data from the CFOI were available for the years 1992 through 1995. Agricultural production cases in the CFOI were identified by the Standard Industrial Classification (SIC) code assigned to the CFOI record (Office of Management and Budget, 1987). Only CFOI cases with SIC codes in the range of 0100 through 0299 were analyzed (i.e., agricultural crop or livestock production). While the BOC and SIC coding systems have different codes, they are equivalent in identifying agricultural production operations (U.S. Department of Commerce, 1992). Finally, in order to make comparisons between the CFOI and the NTOF, NTOF cases were coded using the OIICS system for the source of injury and type of injury event.

Using a team approach, coding of cases was performed by personnel from various disciplines and branches within the Division of Safety Research (DSR), NIOSH. Training was given to these personnel on the OIICS coding and periodic meetings were arranged for accomplishing the coding. After individuals had coded their first 100 cases, these cases were then divided among the other coders. Initial analysis of inter-rater reliability was assessed at 91% for the two-digit level code and 72% for the four-digit level code. Additional comparisons were not made, as the periodic meetings were used to come to group consensus on difficult cases.

Fatality rates per 100,000 workers were calculated using employment estimates of the agricultural production industry from the BLS Current Population Survey (CPS), which is based on a monthly sample of households across the U.S.

Employment figures only included information on workers who defined farming as their primary industry of employment and were 15 years of age or older. Since the CPS is a sample, it is subject to sampling error. Sampling errors from the CPS are generally small (i.e., less than 6%) for agricultural employment estimates above 100,000 workers. Additional information on the CPS is available from the U.S. Department of Labor, Bureau of Labor Statistics (1992b).

Fatality rates for both the NTOF and the CFOI were determined for the year of occurrence, gender, race or ethnic origin, region of the United States, occupation, age group, source of fatal injury, and the type of fatal-injury event. For race or ethnic origin rates, Hispanics were handled as a unique group, regardless of their reported racial classification. This has the effect of making the race categories and the ethnic category of "Hispanic" mutually exclusive.

Fatality rates in the NTOF were calculated using employment estimates for workers 16 years of age and older as the denominator because of this age restriction in the NTOF. Fatality rates in the CFOI used employment for all workers 15 years of age and older as the denominator, which provided the best match to the CFOI data. It should be noted that CFOI includes deaths to workers under the age of 15 years, and while youth age-related information on the industry of agriculture as a whole was available (U.S. DOL/BLS, 1997), it was not possible to identify the deaths specific for agricultural production under the age of 15 years. Thus, the fatality rates for the CFOI are slightly inflated. This rate inflation would be expected to be minor for most rates, and only be of potential significance for the rates presented for the "<25 years of age" age group.

Results

Because of the difference in years compared in the two databases, the total number of agricultural production deaths varied between the two national systems. However, for reasons cited previously, had these been identical years, the numbers would probably still be different, as can be seen in table 1, when the years overlap. For the remainder of the article, the NTOF results will be listed first, followed by the CFOI results. The NTOF identified 1,705 total agricultural production fatalities during 1990 to 1993 and the CFOI identified 2,329 total agricultural production fatalities during 1992 to 1995 (table 1). The average annual agricultural production employment for 1990 to 1993 was 2,190,350 and for 1992 to 1995 it was 2,280,975. The weighted mean agricultural production fatality rates per 100,000 workers for the 4-year time period of each surveillance system were 19.5 and

Table 1. NTOF 1990-1993 and CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by year of death

	NTOF		CFOI	
Year	Deaths	Rate	Deaths	Rate
1990	420	19.1		
1991	430	18.9		
1992	429	19.2	572	25.3
1993	426	20.6	614	29.3
1994			615	26.0
1995			528	22.0
Total	1,705	19.5	2,329	25.5

25.5/100,000 workers, respectively, which compared to the overall total occupational fatality rate of 4.4/100,000 (NTOF) and 5/100,000 workers (CFOI).

Agricultural production fatality rates per 100,000 workers grouped by Bureau of the Census (BOC) regions indicated similar trends between the two surveillance systems for the various regions, with the exception of the Northeast region, which was ranked lowest by the NTOF system for 1990 to 1993 (17.5/100,000). The CFOI system identified the Northeast region as having the highest fatality rate (32.8/100,000) for 1992 to 1995 (table 2). Additionally, there were differences in the range of rates between the two systems. The NTOF had a range of less than 4/100,000 deaths between the BOC regions while the CFOI had a range greater than 14/100,000 deaths between the BOC regions.

The majority of the decedents were male with the NTOF identifying 1,671 male deaths and the CFOI accounting for 2,267 male deaths (97 to 98% of the total deaths). In general, as age increased, the number and rate of fatalities also increased, until the highest fatality rate for gender in agricultural production was reached at 65+ years of age (56.4/100,000-NTOF and 78.8/100,000-CFOI) for males (table 3).

Fatality frequencies by race and ethnicity were as follows: Nonhispanic Whites accounted for 81, 86% of the total deaths; Blacks comprised 5, 3%; Hispanics were 13, 10%; and all other races accounted for 7, 6% of the total deaths. The highest single annual fatality rate for race was found among Blacks (1993, NTOF 37.7/100,000 and CFOI 31.8/100,000) and this race category had the highest average rate over the 4-year period in both the NTOF and the CFOI. The agricultural production fatality rate for Blacks and Whites were much more similar in the CFOI system (26.7/100,000 vs 26.6/100,000) during 1992 to 1995 than the NTOF for Blacks and Whites from 1990 to 1993 [23.6/100,000 vs 19.2/100,000 (table 4)]. With the finding that fatality rates increased with age, a more detailed analysis was conducted by the variable “Race” to determine if there were differences between race or ethnic origins. The NTOF indicated a curvilinear relationship between age and race among Hispanics, while Whites and Blacks held a general

Table 2. NTOF 1990-1993 and CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by region of the United States

	NTOF 1990-1993			CFOI 1992-1995		
Region	Employment	Deaths	Rate	Employment	Deaths	Rate
Northeast	560,300	98	17.5	628,800	206	32.8
North Central	3,415,800	717	21.0	3,481,700	991	28.5
South	2,871,600	553	19.3	2,952,900	756	25.6
West	1,913,700	337	17.6	2,060,500	376	18.2

Table 3. NTOF 1990-1993 and CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by age and gender

	Males				Females				Total			
	NTOF 1990-1993		CFOI 1992-1995		NTOF 1990-1993		CFOI 1992-1995		NTOF 1990-1993		CFOI 1992-1995	
Age	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
16-24	143	13.7			5	2.6			148	12.0		
or <25			224	19.5			4	1.7			228	16.6
25-34	232	15.9	251	18.7	5	1.4	9	2.5	237	12.8	260	15.2
35-44	246	17.2	322	21.9	7	1.7	13	2.7	253	13.6	335	17.2
45-54	255	23.8	308	28.2	6	1.9	10	2.3	261	18.3	318	20.8
55-64	287	25.5	395	38.2	3	1.1	14	1.2	290	20.3	409	29.8
65+	508	56.4	766	78.8	8	6.2	11	5.2	516	50.2	777	65.6
Total	1671	23.8	2267	32.1	34	2.0	62	3.0	1705	19.5	2329	25.5

Table 4. NTOF 1990-1993 and CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by race and year of death

	NTOF*†										CFOI†‡									
	White		Black		Hispanic		Other Race		Total		White		Black		Hispanic		Other Race		Total	
Year	D§	R‖	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R
1990	329	18.0	17	19.0	69	26.8	#	#	420	19.1										
1991	352	18.9	20	20.0	55	20.5	#	#	430	18.9										
1992	363	20.0	19	21.3	44	15.0	#	#	429	19.2	488	26.4	22	24.6	52	17.7	5	16.2	572	25.3
1993	340	19.8	26	37.7	55	21.2	5	22.5	426	20.6	530	30.4	22	31.8	54	20.7	#	9.0	614	29.3
1994											533	27.3	14	22.3	64	19.6	#	7.5	615	26.0
1995											443	22.6	13	29.0	58	15.7	4	14.4	528	22.0
Total	1384	19.2	82	23.6	223	20.7	12	10.4	1705	19.5	1994	26.6	71	26.7	228	18.2	13	12.1	2329	25.5

* Five deaths were unclassified for race.
† Hispanics were excluded from "White", "Black", and "Other Race".
‡ 19 deaths were unclassified for race.
§ Deaths.
‖ Rate.
Less than three deaths.

linear trend of increasing fatality rates with age (fig. 1). The CFOI did not indicate this trend, although these data indicated the highest occupational fatality rate by race and age (110.7/100,000) was among the 65 years of age and older Hispanics (fig. 2).

Agricultural production fatalities were analyzed by occupation and race (table 5a,b). The NTOF did not allow as much detail on occupation as the CFOI. The occupational group which accounted for the largest number of fatalities in the agricultural production sector was the occupational group of "farmers" which accounted for 87% of the total deaths in the NTOF and 51% in the CFOI. The highest fatality rates by race and occupation in the NTOF were Black farmers (114.2/100,000) followed by Hispanic farmers (63.0/100,000) and then Hispanic farm workers (39/100,000). For the CFOI it was White supervisors (99.8/100,000) followed by Black truck drivers (92.8/100,000) and then Black farmers (77.4/100,000). The most common occupational category of victim was a "farmer" and for victims of other races, the most common occupational group was being a "farmworker".

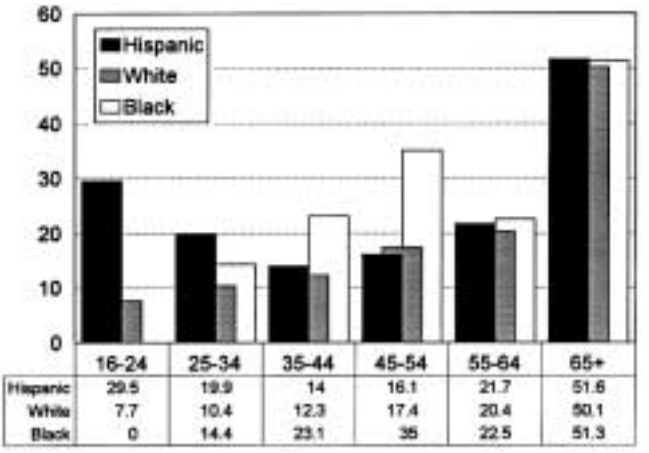

Figure 1–NTOF 1990-1993: Fatality rates per 100,000 workers by race/ethnic origin and age group.

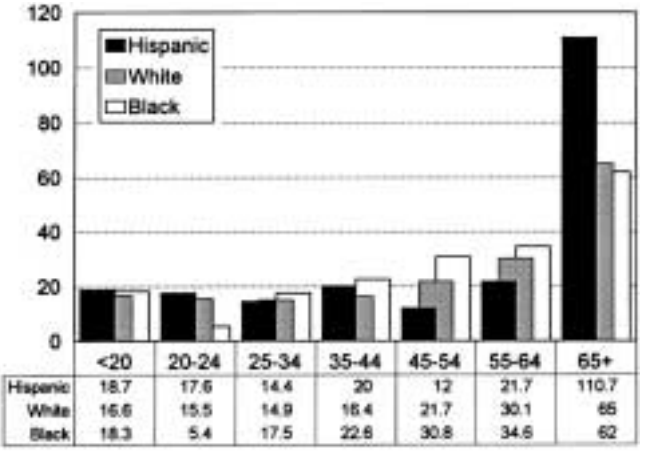

Figure 2–CFOI 1992-1995: Fatality rates per 100,000 workers by race/ethnic origin and age group.

Table 5(a). NTOF 1990-1993 agricultural production fatalities and fatality rates per 100,000 workers by race and occupation

	White		Black		Hispanic		Other Races	
Occupation	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
Farmers	1147	28.4	36	114.2	26	63.0	4	16.2
Farm managers	24	5.4	0	0.0	7	39.0	0	0.0
Farmworkers	140	6.9	35	13.4	171	20.7	6	12.8

Table 5(b). CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by race and occupation

	White		Black		Hispanic		Other Races	
Occupation	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
Farmers	982	22.1	18	77.4	19	40.9	*	
Farm managers	282	60.9	*	*	7	32.4	*	
Supervisors	78	99.8	*	*	7	15.0	*	
Farmworkers	569	30.4	34	16.9	172	17.7	9	20.3
Truck drivers	19	30.4	5	92.8	7	28.3	*	

* Less than three deaths.

The leading source of fatal injury identified by both national surveillance systems was farm tractors, which accounted for 46% (NTOF) and 53% (CFOI) of the total deaths in production agriculture (table 6a,b). Both surveillance systems identified the top three sources of injury as being farm tractors, trucks, and harvesting equipment, accounting for two-thirds of the fatalities in the NTOF and almost three-quarters of the total agricultural production fatalities in the CFOI. A somewhat surprising finding by the CFOI system was the identification of "bullets" as a top 10 source of injury, accounting for 3% of the total number of deaths in agricultural production.

The leading source of fatal injury for females found in the NTOF was "animals" closely followed by "tractors," which together accounted for about 65% of the total female fatalities. The CFOI identified "tractors" as accounting for one-half of the

Table 6(a). NTOF 1990-1993 agricultural production fatalities and fatality rates per 100,000 workers by source of injury

	Male		Female	
Source of Injury	Deaths	Rate	Deaths	Rate
Farm tractors	488	7.0	5	0.3
Trucks	150	2.1	*	0.1
Ag. harvesting machines	67	1.0	0	0.0
Animals	56	0.8	6	0.4
Trees, logs	47	0.7	0	0.0
Automobiles	47	0.7	0	0.0
Liquids (e.g., water)	37	0.5	*	0.1
Ag. power take-offs	37	0.5	0	0.0
Conveyors, augers	36	0.5	*	0.1
Ag. machine unspecified	34	0.5	0	0.0
Loaders	33	0.5	*	0.1
Ground	33	0.5	*	0.1
Total	1065		17	

* Less than three deaths.

Table 6(b). CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by source of injury

	Male		Female	
Source of Injury	Deaths	Rate	Deaths	Rate
Farm tractors	851	12.0	22	1.1
Trucks	224	3.2	*	< 0.1
Ag. harvesting machines	109	1.5	*	< 0.1
Mowing machinery	82	1.2	3	0.1
Other ag. machines	72	1.0	7	0.3
Animals	70	1.0	7	0.3
Ground	60	0.8	0	0.0
Bullets	49	0.7	*	0.1
Loaders	44	0.6	0	0.0
Trees, logs	42	0.6	0	0.0
Total	1603		43	

* Less than three deaths.

total female fatalities (similar to the male experience) which corresponded to a rate three to ten times the next highest sources of injury. Both “animals”, and “other agricultural machines” were tied for the second leading fatal injury source, either of which together with “tractors” accounted for 67% of the total female fatalities in the CFOI. The fatality rate for females in agriculture production for the NTOF was 2/100,000 and the CFOI was 3/100,000. These compared to the total female fatality rate for all industries in the NTOF of 0.67/100,000 and 1/100,000 female workers for the CFOI, indicating female agricultural production workers have about a three-fold greater risk of death than their counterparts in all other industries. As a proportion of deaths from the top 10 fatality sources, deaths occurring to females due to animals were seven- (NTOF) to four- (CFOI) times greater than for males. However, males still had a two-fold or higher risk of death by animals than females and had a much greater frequency of death associated with animals. Otherwise, when there were fatalities reported, they were similar for gender by source of injury.

Analyzing the three leading sources of injury in agricultural production by age groups, one finds the persistent trend of increasing deaths with increasing age

(table 7). For 65 years of age and older, the NTOF indicates almost a three-fold fatality rate increase due to tractors (23.1/100,000) from the next highest age category (55 to 64 years old, 8.0/100,000). The CFOI shows more than double the rate for 65 years of age and older due to tractors (38.1/100,000) than the next highest age category (55 to 64 years old, 16.3/100,000).

The most frequent fatal injury event in agricultural production for both surveillance systems was "non-highway overturn" (table 8a,b). This injury event was

Table 7. NTOF 1990-1993 and CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 male workers by top three source of injury and age group

Age Group	Tractors				Trucks				Ag Harvesters			
	NTOF		CFOI		NTOF		CFOI		NTOF		CFOI	
Males	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
16-24	27	2.6			11	1.1			3	0.3		
or <25			52	4.5			31	2.7			9	0.8
25-34	45	3.1	64	4.8	31	2.1	29	2.2	8	0.5	15	1.1
35-44	59	4.1	87	5.9	21	1.5	42	2.9	13	0.9	16	1.1
45-54	59	5.5	109	10.0	30	2.8	30	2.7	12	1.1	22	2.0
55-64	90	8	169	16.3	25	2.2	38	3.7	11	1.0	15	1.5
65+	208	23.1	370	38.1	32	3.6	54	5.6	20	2.2	32	3.3

Table 8(a). NTOF 1990-1993 agricultural production fatalities and fatality rates per 100,000 workers by type of injury event

	Male		Female	
Type of Injury Event	Deaths	Rate	Deaths	Rate
Non-highway overturn	262	3.7	*	0.1
Caught in running equipment	142	2.0	3	0.2
Stuck by falling object	123	1.7	0	0.0
Non-highway pedestrian	83	1.2	3	0.2
Highway overturn	61	0.9	0	0.0
Assault by animal	54	0.8	5	0.3
Non-highway, fall from vehicle and run over	56	0.8	0	0.0
Caught between objects NEC	46	0.7	*	0.1
Highway collision unspecified	41	0.6	0	0.0
Struck by rolling object	37	0.5	3	0.2
Drowning	37	0.5	*	0.1
Total	942		18	

* Less than three deaths.

Table 8(b). CFOI 1992-1995 agricultural production fatalities and fatality rates per 100,000 workers by type of injury event

	Male		Female	
Type of Injury Event	Deaths	Rate	Deaths	Rate
Non-highway overturn	484	6.9	7	0.3
Non-highway, fall from vehicle and run over	162	2.3	7	0.3
Caught in running equipment	151	2.1	9	0.4
Stuck by falling object	123	1.7	0	0.0
Highway overturn	108	1.5	*	<0.1
Non-highway pedestrian	101	1.4	6	0.3
Struck by rolling object	71	1.0	*	<0.1
Assault by animal	58	0.8	7	0.3
Caught between objects NEC	42	0.6	*	<0.1
Highway collision unspecified	42	0.6	*	<0.1
Total	1343		40	

* Less than three deaths.

almost double the second highest injury event for the NTOF and about three times the next highest injury event for the CFOI. The top three injury event categories in the NTOF were "non-highway overturn", "caught in running equipment", and "struck by falling object". For the CFOI, the top three categories were "non-highway overturn", "non-highway: fall from vehicle and run over", and "caught in running equipment". For females, the NTOF identified the leading fatal injury event as "assault by animal" with females having almost a five-fold greater proportion of deaths due to intentional injuries inflicted by animals than did males. The second leading cause-of-death events for females in the NTOF were "caught in running equipment", "non-highway, pedestrian", and "struck by rolling object". The CFOI identified "caught in running equipment" as the leading injury event for females and females had double the proportion of deaths by this injury event than males. Three injury event categories, "assault by animal," "non-highway-fall from vehicle and run over" and "non-highway overturn", shared the second-most-frequently occurring injury event categories in the CFOI (table 6a,b). The CFOI found females had a four-fold greater proportion of deaths due to being killed by an "assault by animal" than did males.

Discussion

While every effort was made to make comparisons between the two national occupational fatality surveillance systems as similar as possible, the fact remains that different years were utilized and direct comparisons by year cannot be made (with the exceptions of 1992 and 1993). Therefore, this study is best viewed as a descriptive analysis of occupational fatalities occurring during 1990-1995 in agricultural production using two national occupational fatality surveillance systems utilizing time-line data which are chronologically similar and in some cases overlapping.

As noted earlier, workers in the agriculture industry, and specifically in the agriculture production sector, are at high risk of death from traumatic injury. This analysis of two national occupational fatality surveillance systems reinforces this point. The agricultural production sector fatality rate for the NTOF and the CFOI was nearly five times the average annual rate of all industrial sectors for the years studied.

While general trends in fatality rates by BOC regions were similar for the NTOF and the CFOI, the Northeast region had the lowest fatality rate among the BOC regions in the NTOF and the highest rate in the CFOI. Generally, the CFOI had higher rates than the NTOF, which could be explained by utilizing multiple records to capture more agricultural production occupational fatality cases or by coding the industry at time of death and not the usual industry of the deceased. Since the Northeast has historically had smaller farms and smaller farms have more off-farm income (USDA, ERS, 1997; U.S. Department Commerce, 1995) it may be that the CFOI captured more cases of agricultural production fatalities from part-time farmers while the NTOF would have designated the case to the usual industry (that industry which was the usual occupation of the deceased).

Gender fatality results were generally consistent with past studies, identifying the overwhelming majority of decedents to be male (NIOSH, 1993; Knestaut, 1994; Myers and Hard, 1995; Knestaut, 1996). Male and female fatal injury experience was usually similar, with tractors being an important source of death in the NTOF and CFOI for males and females. If one groups tractors and other machinery/equipment sources found in the leading injury sources (table 6a,b),

which would intuitively make sense as these are often related activities, these could be loosely viewed as "agricultural machinery or equipment" deaths. In the NTOF this grouping accounts for about 65% of the male deaths and about 41% of the female deaths. In the CFOI, this grouping accounts for about 77% of the male deaths and about 72% of the female deaths. This would indicate the seriousness of working with self-propelled agricultural machinery or equipment typically powered by tractors.

Gender differences should be interpreted somewhat cautiously, as females had much lower rates and frequencies of death associated with the sources and events of agricultural production fatalities. However, as noted previously, both the NTOF and the CFOI identified proportional differences in the source of injury by gender, with animals accounting for seven to four times as many deaths of females than animal-related deaths incurred by males. This could be due to the fact that women often care for newborn animals and it is recognized that maternal animals are more aggressive when they have offspring (Ensminger, 991; Beno et al., 1992; Bean, 1992). Another potential factor contributing to the higher proportion of female deaths due to animals is that women are generally of a smaller physique than men. When there is an animal/female interaction, females may incur more serious injuries than do males (Stueland and Gunderson, 1997). Additionally, employment figures indicate women were slightly more likely to be involved in livestock production than in crop production, which could potentially influence the exposure and thus the risk. Also, there were gender differences by the injury event, with females being identified as being more likely to have been killed by an "assault by animal" (NTOF) or "caught in running equipment" (CFOI). Females had a five (NTOF) to four-fold (CFOI) greater proportion of deaths due to assault by animals than males. In addition, the CFOI found more than double the proportion of deaths due to "caught in running equipment" for females than males.

The highest fatality rate for race (table 4) was found among Black agricultural production workers in both the NTOF (23.6/100,000) and the CFOI (26.7/100,000), which is similar to previous studies (Myers, 1989; Myers and Hard, 1995; Richardson, 1997). The NTOF identified a closer range for fatality rates for Black and Hispanic workers while the CFOI identified a closer range for Black and White agricultural production workers. In looking at agricultural production fatalities by race and occupation (table 5a,b), the highest rate in the NTOF was Black farmers (114.2/100,000) followed by Hispanic farmers (63.7/100,000). In the CFOI White supervisors had the highest fatality rate (99.8/100,000) followed by Black truck drivers (92.8/100,000) and then Black farmers (77.4/100,000). The fact that Black agricultural production workers are identified by both national surveillance systems as having the highest occupational agricultural fatality rate and Black farmers are identified as either having the highest fatality rate or the third highest rate for an occupation, heightens the need to reduce the fatality risks for this population. The most common occupation of victims found by both surveillance systems was the occupation "farmer", which is not surprising considering the agricultural production sector would be primarily composed of persons in this occupation.

The curvilinear association found in the NTOF between age and fatality rate for Hispanic agricultural production workers may be due to the fact that a greater influx of younger workers has been coming to work in the U.S. the past seven years (Mines et al., 1997); or it may be an aberration of the denominator used. It is a recognized difficulty to contact and accurately enumerate Hispanic households and since the BLS Current Population Survey (CPS) relies on household surveys for

determining the employment, this ethnic group may be underestimated (Cattan, 1993; McKay, 1993). Thus, a general trend of increasing numbers of young Hispanic migrant workers who are not captured in the denominator of workers could create an artificially high rate for young Hispanic workers. However, the higher rate may also be a reflection of younger workers being at higher risk for injury and fatality, as has been evidenced by other studies (Cotten, 1997; Pratt and Hard, 1996; Rivara, 1997; Ruser, 1998). The elevated young Hispanic fatality rate deserves more detailed investigation and follow-up.

The identification by the CFOI of bullets as a top 10 source of injury indicates that life on the farm may not be as idyllic as many believe it to be. These fatalities could be due to suicides, as has been identified by others (Pylka and Gunderson, 1992) or homicides. By reviewing the event codes associated with these deaths, 26 were identified as homicides, 19 were suicides, and 5 were listed as accidental. Thus, violent death by firearms is a distinct possibility for agricultural production workers.

Overwhelmingly, the leading source of injury was farm tractors, which accounted for almost half of all the agricultural production deaths. Trucks and agricultural harvesting equipment were identified as rounding out the top-three leading sources of injury, which altogether accounted for two-thirds (NTOF) and three-quarters (CFOI) of all the deaths in production agriculture. Also, the rising fatality rate of agricultural production deaths as age increases has been shown in previous studies (Bobick and Jenkins, 1992; Myers and Hard, 1995; Personick and Windau, 1995). Older agricultural production workers bear the brunt of the farm tractor fatality injury problem. These workers were between four (NTOF) to two (CFOI) times as likely to be killed by a tractor as their next youngest age-group counterparts and have more than eight times the fatality rate of the lowest age group. They also constitute a large share of the actual number of tractor fatalities.

The most frequent injury event was "non-highway overturn" for both the NTOF and the CFOI. Older farm workers have a higher number and rate of injuries involving tractors with a large portion of these fatalities due to older workers operating a tractor off the highway and having it overturn. This scenario may be due in part to aging effects, both physical and mental, and the fact that farmers older than the normal retirement age of 65 are often found working in production agriculture (Ambe and Murphy, 1995). Reduced reaction time due to slower reflexes, hearing and vision problems are potential factors associated with increased injury experience for older farmers (Browning et al., 1998; Lewis et al., 1998; Panek, 1994; Park, 1994; Steel, 1994). It has also been proposed that older farmers may tend to use older equipment, which may not be as safe as newer equipment. There were some differences in the ranking of the second and third leading injury event categories between the NTOF and the CFOI. The NTOF identified machinery entanglement (caught in running equipment) and "struck by falling object" while the CFOI identified "nonhighway-fall from vehicle" and "caught in running equipment" or machinery entanglement.

Clearly, machinery hazards are still a concern for agricultural production workers, being ranked either second or third, depending on the surveillance system. Due to the large number of machines and equipment used on farms, machinery hazards have been and are still clearly a hazard (Etherton et al., 1991). The "nonhighway-fall from vehicle" events may be due to extra riders on tractors falling off or the operator being knocked or thrown from the seat by objects or rough terrain.

There were some differences among gender in the injury event category, since the NTOF identified females as being more likely to be killed by an "assault by an animal" and the CFOI identified females as being more likely to be killed when

"caught in running equipment" or machinery entanglement. Males were most likely to have been killed during a "nonhighway overturn" event. However, both surveillance systems identified females to proportionally sustain between five (NTOF) to four (CFOI) times the fatalities due to an "animal assault" (attack) than did males and in the CFOI females had twice the proportion of deaths due to "caught in running equipment" than did males, although males had higher rates and frequencies of deaths due to these events. While rates and frequencies are invaluable in determining the extent and magnitude of the problem, proportions can be useful in assessing differences between populations for tailoring interventions.

Conclusions

The data clearly demonstrate that older agricultural workers (65+ years of age) are at increased risk for death from agricultural tractors and that the likely event is a nonhighway overturn. Since agricultural tractor fatalities constitute almost one-half of all the agricultural production fatalities and this age group accounts for almost one-half the tractor fatalities, emphasis on decreasing the fatalities of this segment of the agricultural production population could significantly decrease the overall number of fatalities. A concentrated, concerted, effective prevention effort with this group would have a dramatic impact on the overall agricultural production fatality rate.

Black workers in the agricultural production industry, and the occupation of black farmers in particular, were identified as having high fatal injury rates. Future research should emphasize the development of a better understanding of the risk factors involved with these workers and their tasks. Interventions should be identified or developed and initiated, where appropriate.

Young Hispanic agricultural production workers also exhibited a higher fatality rate. Research should be undertaken to determine whether this higher rate is an anomaly of the data or a true representation of what is occurring in this population.

Farm tractors are a leading source of injury resulting in death for males and females. However, there were gender differences in other fatality sources and events. Females, while accounting for 2 to 3% of the total fatalities in agriculture production, have a proportionally higher number of deaths due to animals and animal assaults than do men, as well as being "caught in running equipment". Research is needed to determine the risk factors for the highest sources and causes of death to agricultural production workers and develop interventions to prevent these deaths, as well as realizing there may need to be differences in interventions due to gender.

The two national occupational surveillance systems for agricultural production fatalities generally identified similar sources, events and trends in the data. As typical of previous studies of agricultural production fatalities, this study did not identify a clear downward trend for agricultural production fatalities, as has been seen in the general work population. While this study helps to elucidate the areas of highest risk for agricultural production workers, it cannot tell us how to make this sector safer for these workers. Only further research can do this. It is imperative that resources and efforts be brought to bear to prevent such tragedies from occurring. The decade of the 90s is fast becoming history and without action, the legacy for agricultural production workers in the new millennium will be business and death as usual.

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Foreword

The 4th International Symposium: "Rural Health and Safety in a Changing World" was held 18-22 October 1998 in Saskatoon, Saskatchewan, Canada. Organized by the Centre for Agricultural Medicine, University of Saskatchewan and partners, the Symposium sought to provide the opportunity for discussion of science and advancement of ideas on a diversity of topices designed to capture the full extent of agricultural safety and rural health issues. Four companion conferences completed the spectrum: The Conference on Industrial Hygiene (organized with the Institute for Rural and Environmental Health, University of Iowa); the First International Conference on Rural Nursing (organized with the College of Nursing, University of Saskatchewan); the Conference on the Health and Safety Needs of Rural Children (organized with the National Farm Medicine Center, Marshfield Medical Clinic); and the Fourth Annual Meeting of the Canadian Coalition Agricultural Safety and Rural Health. All of the NIOSH Agricultural Health Centers in the United States participated.

With some 445 participants from 20 countries, the Canadian, American, and world picture on health and safety in agriculture and rural health emerged. The results clearly demonstrated that the remarkable gains being made in research programming and outreach capability in the agricultural industries were the springboard for a new vision of health and safety in rural areas. The presentations provided striking evidence that the lessons learned from agriculture could be applied broadly across rural areas, and that other primary industries in rural areas shared many of the issues that confront a safe workplace and healthy lifestyle in agriculture. With the commonality of distance, culture and often scarce health-care resources, the discussions clearly identified the universal issues in rural health and safety.

In this edition, and those to follow, a selection of peer-reviewed articles arising from the Symposium are presented. These articles provide the flavor and substance of the Symposium. A complete set of abstracts from the Symposium will be available on the website of the Centre for Agricultural Medicine at http://www.usask.ca/medicine/agmedicine.

We would like to express our most sincere thanks and debt of gratitude to the agencies that provided the financial support necessary to undertake a symposium of this scope and magnitude. These were in order of contribution: the National Institute for Occupational Safety and Health; industry partners through the Founding Chairs Program of the Centre for Agricultural Medicine; Agriculture and Agri-Food Canada through the Canadian Agriculture Safety Program; the National Cancer Institute; the Saskatchewan Workers' Compensation Board; the National Farm Medicine Center, Marshfield Clinic, Wis.; the Great Plains Center for Agricultural Health, University of Iowa; the Northeast Center for Agricultural and Occupational Health, Cooperstown, N.Y.; Western Co-operative Fertilizers Ltd., Westco, Calgary; Levitt Safety Ltd.; 3M Canada; and Flexi-Coil Ltd., Saskatoon. We recognize with appreciation the outstanding efforts of Dr. Karen Semchuk, Ms. Sueli de Freitas, Ms. Donna Leddingham, Ms. Vera Ljubovic, Ms. Ruth Day, and Ms. Donna Zaleschuk on organizing the Symposium.

We thank all those who made the Symposium possible by coming to Saskatoon to share their science, their views, there energy, and their humor. Our previous emphasis was on health and safety for farmers, their families, and others in a variety

of industries related to agriculture. We think that in the future, rural people, researchers, and policymakers will enhance their vision from that starting point to a future vision of "Rural Health and Safety in a Changing World".

Dr. James Dosman, MD
Director, Centre for Agricultural Medicine
University of Saskatchewan
103 Hospital Drive
Saskatoon S7N 0W8
Canada

Dr. Donna Rennie, PhD
Assistant Professor
College of Nursing & Centre for Agricultural Medicine
University of Saskatchewan
103 Hospital Drive
Saskatoon S7N 0W8
Canada

Dr. Ambikaipakan Senthilselvan, PhD
Professor
Department of Community Health and Epidemiology
& Centre for Agricultural Medicine
University of Saskatchewan
103 Hospital Drive
Saskatoon S7N 0W8
Canada

Dr. Stephen A. Olenchock, PhD
Senior Scientist for Agricultural Research
National Institute for Occupational Safety and Health (NIOSH)
Morgantown, West Virginia