Injuries and Fatalities to U.S. Farmers and Farm Workers 55 Years and Older

John R. Myers, MS,*,† Larry A. Layne, MA, and Suzanne M. Marsh, MPA

Background *Previous studies have shown that older farmers and farm workers have been identified at high risk for farm fatalities, most notably involving tractor overturns. Older farmers also incur more severe non-fatal injuries.*

Methods *Data from two national surveillance systems are presented to describe fatal and non-fatal injuries occurring to older farmers 55+ years of age. Tractor-related fatality investigations for older farmers are examined for characteristics of the tractors not available in the injury surveillance systems.*

Results *Older farmers and farm workers averaged 26,573 lost-time injuries annually in 2001 and 2004, with an injury rate of 4.5 injuries/100 workers/year compared to an overall farming injury rate of 4.8 injuries/100 workers/year. Fatality data show that older farmers accounted for over half of all farming deaths between 1992 and 2004 (3,671 of 7,064 deaths), and had a fatality rate of 45.8 deaths/100,000 workers/year compared to the overall farming fatality rate of 25.4 deaths/100,000 workers/year. Most common mechanisms of fatal injury to older farmers were "tractors" (46%), "trucks" (7%), and "animals" (5%).*

Conclusions *Although older farmers and farm workers are at lower risk of overall injury compared to their younger counterparts, injuries to farmers 55 years and older tend to be much more severe. To effectively minimize the risk faced by older farmers, prevention programs must encourage safe work behaviors and practices and the implementation/installation of appropriate safety devices and equipment.* Am. J. Ind. Med. 52:185–194, 2009. © *2008 Wiley-Liss, Inc.*

KEY WORDS: production agriculture; farmer; older workers; traumatic injury

INTRODUCTION

The United States (U.S.) workforce and agricultural workforce are both aging, driven in large part by the ''baby-boom'' generation [Horrigan, 2004; Toosi, 2004, 2005]. Farmers are one of the most aged occupations in the U.S. workforce [Dohm, 2000]. The average age of farm operators has been increasing steadily since the late 1970s, moving from 50.3 years of age in 1978 to 55.3 years in 2002 [Allen and Harris, 2005].

The non-fatal injury burden to farmers has primarily shown a decreasing injury risk with increasing age [Hanford et al., 1982; Hoskin et al., 1988; Crawford et al., 1998; Lewis et al., 1998; Xiang et al., 1998; Hwang et al., 2001; Sprince et al., 2003]. In a study of older Colorado male farm operators, Xiang et al. [1999] found this same pattern of decreasing injury risk with age up until the age of 75 years when a dramatic increase in injury rates was observed. Park et al. [2001], looking at a limited prospective sample of farm operators in Iowa, observed an increasing injury risk of occupational farm injuries by age, although this trend was not statistically significant.

Two studies examining work-related farm injuries based on ED records and medical records generally agreed with

Division of Safety Research, NIOSH, Morgantown, West Virginia
†Health Statistician.
*Correspondence to: John R. Myers, Division of Safety Research, NIOSH, 1095 Willowdale Road (M/S H-1808), Morgantown, West Virginia 26505. E-mail: jrmyers@cdc.gov

Accepted 3 October 2008
DOI 10.1002/ajim.20661. Published online in Wiley InterScience (www.interscience.wiley.com)

most farm operator-based injury studies; these record-based studies reported decreasing injury risk with increasing age [Myers, 1990; Carstensen et al., 1995]. A third study, however, that detailed medical record surveillance on fall-related work injuries within a cohort of farmers in Wisconsin found a significant increasing risk of injury with increasing age [Nordstrom et al., 1996]. Data from this same cohort, looking specifically at farmers 65 years and older, found fall-related injury incidence rates tended to increase with age [Stueland et al., 1996]. One additional study based on a national probability sample looking at ED-treated work injuries to all workers 55 years of age and older found agricultural workers to be at higher risk for injuries than older workers in other industries [Layne and Landen, 1997].

Gelberg et al. [1999] reported that farmers 60 years old and older were more likely to be hospitalized by their injuries, using farm injury data from New York and Kentucky. Layne and Landen [1997] also found that agricultural workers 55 years and older had a higher proportion of hospitalized ED-treated work injuries than older workers in other industries. In a study of hospitalized injuries to Canadian farmers by Hartling et al. [1997], farmers over the age of 64 years were found to have 27% higher median hospital costs for their work injuries, as well as 75% longer median hospital stays. Two additional studies, using Canadian hospital discharge data, confirmed that older farmers do have a higher risk for hospitalized injuries when compared to younger farmers [Blahey and Alberg, 1993; Pickett et al., 2001].

The effect of age on permanently disabling or fatal work injury among farmers and farm workers is generally much clearer. In an analysis of large multiple state farm operator surveys, Hanford et al. [1982] and Hoskin et al. [1988] reported an increasing risk of permanent injuries with increasing age. Population-based studies for fatal work-related farm injuries consistently showed significant increases in fatality rates by age, beginning between the ages of 50 and 60 years [Hanford et al., 1982; Hoskin et al., 1988; Myers, 1989, 1990; Myers and Hard, 1995; Kisner and Pratt, 1997; Fiedler et al., 1998; Hard et al., 1999, 2002; Pickett et al., 1999; Voaklander et al., 1999; Mitchell et al., 2002; Meyer, 2005]. Older farmers are at higher risk for tractor-related fatal incidents, which account for nearly half of all fatalities among older farmers compared to about one-quarter of deaths among younger farmers [Hard et al., 1999]. Additionally, older farmers have a mortality rate ratio four times their younger counterparts for deaths resulting from tractor overturns [Myers et al., 1998].

In this study, two national injury surveillance systems are examined to describe fatal and non-fatal agricultural production injuries for older farmers and older farm workers. A review of tractor-related fatality investigations for older farmers is also provided to explore the machinery-related characteristics such as the age of tractor and whether the tractor was rollover protective structure (ROPS) equipped. While the primary intent is to describe the injury experience of older farmers, some results for younger farmers are provided in comparative analyses to further quantify the injury burden to older farmers.

METHODS

Non-fatal farming injury estimates for adults were derived from the National Institute for Occupational Safety and Health (NIOSH) Occupational Injury Surveillance of Production Agriculture (OISPA) surveys for calendar years 2001 and 2004. Conducted for NIOSH by the U.S. Department of Agriculture, National Agricultural Statistics Service (NASS), the OISPA is a Computer Assisted Telephone Interview (CATI) survey of a random sample of U.S. farming operations. For the 2001 and 2004 surveys, a farm was defined as any operation with $1,000 or more of gross agricultural production within a calendar year. The NASS sampling frame covered all agricultural production operations, including both crop and livestock operations with the exception of large swine confinement operations, which were excluded. Participation in OISPA surveys was voluntary.

OISPA collected information on work-related farming injuries occurring to adults (defined as any person 20 years or older). An agricultural work-related injury was defined as an injury that (1) occurred while performing work on or for the farm business, and (2) resulted in four or more hours of restricted activity (e.g., the individual could not perform work or other normal duties, missed work, etc.) or required professional medical treatment. While the total number of work-related farm injuries was requested for the calendar years 2001 and 2004, descriptive information was collected only for the two most recent injury events in each of these 2 years. The survey excluded injuries to contractors working for the farm operation. The categorical injury variables for ''source of injury'' and ''event or exposure'' were coded from narrative injury descriptions using the BLS-developed Occupational Injury and Illness Classification System (OIICS) [BLS, 1992].

The OISPA sample size included 15,259 farms for which an interview was completed in 2001, and 16,239 farms in 2004. There were a combined total of 1,318 reports of work-related farm injuries involving adults 20 years and older in the two surveys. Response rates for the 2001 and 2004 surveys were similar, 61% and 65%, respectively. Sampling weights were calculated based on the number of farms responding by geographical region within three broad ''value of sales'' categories ($<$\$10,000; \$10,000–\$99,999; $\geq$\$100,000). The nine geographical regions were those defined by the U.S. Bureau of the Census (BOC) [BOC, 1975]. Farm counts within these 27 strata (3 value of sales $\times$ 9 regions) were obtained from farm numbers published by the NASS [2002, 2005]. For this study, the

data for 2001 and 2004 were combined and reported as an annual average. Statistical comparisons were made by performing t-tests on the differences between observed proportions.

Occupational fatality data were extracted from restricted access research files obtained from the BLS Census of Fatal Occupational Injuries (CFOI) for the years 1992–2004. Collected from various federal, state, and local sources, the CFOI data include fatal work injuries from all 50 states and the District of Columbia. The files used for this study, however, exclude all fatalities from New York City. BLS normally corroborates each workplace fatality using multiple source documents—including death certificates, workers' compensation reports, medical examiner reports, and police reports. A fatality is included if the decedent was employed at the time of the event and engaged in a legal work activity or present at a site as a job requirement. Data are collected for all public and private sector workers regardless of the size of the operation or worker age.

Detailed industry information in the CFOI data is coded based on the Standard Industrial Classification (SIC) Manual [Office of Management and Budget, 1987] for data years 1992–2002 and the North American Industrial Classification System (NAICS) [Office of Management and Budget, 2002] for data years 2003–2004. Fatalities occurring in the agriculture production industry were identified using the SIC major groups ''01'' and ''02'' (''agricultural production—crops''; ''agricultural production—livestock and animal specialties'') and the NAICS major groups ''111'' and ''112'' (''crop production''; ''animal production''). The event or exposure and the source that directly precipitated the fatality are coded based on the BLS-developed OIICS.

Tractor-specific data were derived from fatality investigations conducted through the NIOSH Fatality Assessment and Control Evaluation (FACE) program [NIOSH, 2003]. Through the FACE program, fatalities from specific causes of death including agricultural machines are investigated by NIOSH and NIOSH State partners. The FACE reports that involved agricultural operations were manually screened to identify tractor-related cases. Copies of these reports can be obtained on the FACE website [www.cdc.gov/niosh/injury/traumaagface.html].

For this particular study, an older worker is defined as anyone aged 55 years and older. Rates were calculated based on population data that were extracted from the BLS Current Population Survey (CPS), a monthly household survey [BLS, 2007]. The CPS provides information on the U.S. civilian, non-institutionalized population aged 15 years old or older and includes wage and salary workers, self-employed, part-time workers, and unpaid workers in family-oriented enterprises (e.g., farms and small businesses). Non-fatal injury incidence rates were calculated as the estimated number of injuries at the regional or national level divided by the estimated annual average working population in agricultural production. Non-fatal rates are expressed as the number of injuries/100 workers/year. Fatal injury rates were calculated as the number of fatalities divided by the estimated annual average working population; the rates are expressed as the number of fatal work injuries/100,000 workers/year. Numbers of fatal injuries are reported for all ages; fatality rates are reported for workers aged 16 years and older.

RESULTS

Non-Fatal Injuries in Agriculture Production

In 2001 and 2004, there were an estimated 83,940 non-fatal injuries per year among adults 20 years and older in agriculture production. The corresponding injury rate for the 2 years combined was 4.8/100 workers/year. Workers 55 years and older accounted for 32% (26,573) of the total injuries. Injury rates for the 20–54 year olds (4.6/100 workers/year) and 55 years and older (4.5/100 workers/year) age groups were similar. The south and midwest regions accounted for the largest number of injuries and highest injury rates for both the younger and older farmers (Table I).

Injuries were found to occur most often to adult farm family members and relatives (Table I). For workers 20–54 years old, family members and relatives accounted for 72% of the injuries. For the older age group, family members and relatives accounted for 88% of the injuries. Family and relatives 20–54 had the highest injury rate, followed by family and relatives 55 years of age and older, and hired workers 55 years of age and older.

In 2001 and 2004, approximately 35% of the non-fatal injuries to older workers resulted from contact with objects and 30% from falls. Contact with objects were primarily struck by swinging or slipping objects (10% of the total) and struck by falling objects (5% of the total). Falls on the same level accounted for 15% of the total and falls from elevation accounted for 14%. Other categories with high numbers of non-fatal injuries were assaults by animals (10%), off-road non-collisions (7%), and overexertion (5%). For workers <55 years of age, contact with objects were the leading type of injury event (39%) and falls (20%), although falls were less common than for the older workers ($t = 3.522$, $P < 0.001$). Like older workers, the contact with objects for workers less than 55 years of age were primarily struck by swinging or slipping objects (7% of the total) and struck by falling objects (6% of the total). Falls from elevations were most common for this younger age group (13% of the total), while falls to the same level (4% of the total) were much lower than seen for older workers ($t = 5.528$, $P < 0.001$). By nature of injury, older workers experienced fractures (21%), sprains/strains (18%), multiple diagnoses (17%), cuts (16%), and bruises (10%). Younger farmers were less likely to have

TABLE I. Estimated Average Annual Non-Fatal Injuries and Injury Rates in Agriculture Production, U.S., 2001 and 2004

	20–54 years		55+ years		Age unknown
	Estimated no.	Rate[a]	Estimated no.	Rate[a]	Estimated no.
Total	52,715	4.6	26,573	4.5	4,652
U.S. regions					
Northeast	2,667	2.9	1,070	2.7	467
Midwest	18,678	5.3	9,516	4.3	1,119
South	20,220	5.7	11,766	5.5	874
West	11,152	3.2	4,222	3.8	2,192
Relation to farm					
Family and relative	37,920	5.9	23,271	5.2	517
Hired and other	14,776	2.1	3,131	2.7	682
Unknown	20	—	172	—	3,454
	Estimated no.	%	Estimated no.	%	
Nature of injury					
Fracture	9,222	17.5	5,449	20.5	87
sprain/strain	11,928	22.6	4,715	17.7	450
Multiple	4,980	9.5	4,556	17.2	195
Cut	8,220	15.6	4,277	16.1	286
Bruise	6,485	12.3	2,770	10.4	33
Other	11,880	22.5	4,806	18.1	3,601
Days of restricted work activity					
None	6,529	12.4	3,722	14.0	184
<1 day	7,731	14.7	3,111	11.7	50
1–6 days	16,952	32.2	5,205	19.6	257
7–13 days	3,977	7.5	1,651	6.2	0
14–27 days	2,786	5.3	1,952	7.4	39
1–3 months	7,626	14.5	5,447	20.5	41
>3 months	6,601	12.5	5,161	19.4	165
Unknown	513	1.0	323	1.2	3,916
Days hospitalized					
1–7 days	7,477	89.4	3,593	68.3	76
8–14 days	544	6.5	539	10.3	20
15–21 days	109	1.3	545	10.4	0
>21 days	0	0	164	3.1	0
Unknown	230	2.8	416	7.9	70

Source: NIOSH Occupational Injury Surveillance of Production Agriculture survey.
[a]Non-fatal injury rate/100 workers/year.

fractures or injuries involving multiple diagnoses, and were more likely to incur a sprain or strain (Table I).

Survey results indicate that non-fatal injuries to older workers were more severe (or disabling) than those for younger workers. Among older workers, nearly half (47%) of the injuries resulted in 14 or more restricted work days, compared to 32% for younger workers ($t = 4.787$, $P < 0.001$; Table I). About 20% of the injuries to older workers resulted in hospitalization compared to 16% for younger workers. For those who were hospitalized, nearly one quarter (24%) of older workers were hospitalized 8 or more days for injuries compared to 8% of workers 54 years and less ($t = 2.776$, $P = 0.007$) (Table I).

Adult farmers and farm workers on livestock operations incurred the most injuries (53,341) and had the highest injury rate (5.9/100 workers/year). Workers 20–54 years old accounted for 63% (33,637) of the injuries on livestock operations, with workers 55 years and older accounting for 32% (17,061). Workers 20–54 years old had a slightly higher injury rate on livestock operations than workers 55 years old and older (5.8/100 workers/year and 5.3/100 workers/year, respectively). Crop operations accounted for 29,365 injuries

and an injury rate of 3.5/100 workers/year. As with livestock farms, the highest number of injuries on crop farms was seen for the younger age group (63% vs. 30%). However, the injury rates for the two age groups were the same (3.3/100 workers/year).

Fatal Injuries in Agriculture Production

In the agriculture production industry for 1992–2004, there were 7,064 deaths to farmers and farm workers. The fatality rate was 25.4/100,000 workers/year. Farmers and farm workers 55 years and older accounted for 52% (3,671) of the deaths in agriculture compared to only 23% of all deaths occurring among workers 55 years and older in all industries.

From 1992 to 2004, older farmers and farm workers (55 years and older) had a fatality rate of 45.8/100,000 workers/year, which was 2.6 times greater than the rate for farmers and farm workers 54 years and younger. Figure 1 shows that a dramatic increase in the fatality rates begins around the ages of 65–70 years. A significant linear decline (slope $= -0.58$, $P = 0.0422$) was found in the fatality rates for workers 55 years and older but were not significant for farmers less than 55 years of age (Fig. 2).

As with non-fatal injuries, fatalities were found to occur most often to adult farm family members. Family members accounted for 85% (3,126) of the fatalities among older workers and 56% (1,888) of the fatalities to workers <55 years old. Family members 55 years of age and older had the highest injury rate (48.3/100,000 workers/year), followed by the older hired workers (35.2/100,000 workers/year). Family workers <55 years old followed with a rate of 22.0/100,000 workers/year, and the fatality rate for younger hired workers was the lowest at 13.9/100,000 workers/year.

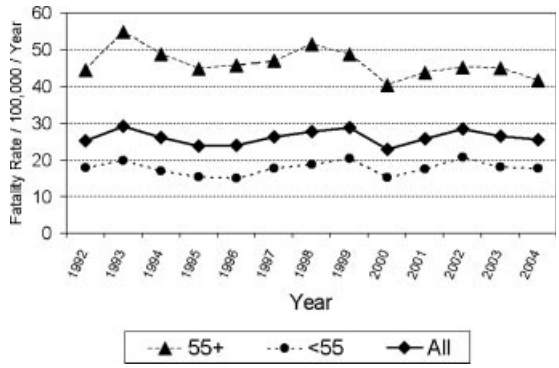

FIGURE 2. Agriculture production fatality rates by age and year, U.S. 1992–2004. *Source*: This research was conducted with BLS restricted access CFOI data (data excludes NY City). The views expressed here do not necessarily reflect the views of the BLS.

Tractor-related incidents accounted for almost half (46%, 1,702) of the fatal work-related injuries to older farmers compared to 27% of the fatalities for farmers <55 years old. Of the tractor-related incidents in both age groups, nearly half resulted from overturns. Falling from and being struck accounted for another 13% of the tractor incidents for both age groups. Younger farmers had a slightly higher proportion of tractor incidents that involved collisions (17%) compared to older farmers (10%). Figure 3 demonstrates that the tractor-related fatality rates start increasing at about 40 years of age and increase more rapidly as age increases.

In addition to the tractor-related incidents, trucks (7%, 272), animals (5%, 201), agriculture harvesters (3%, 121), and agriculture mowers (3%, 117) were also common sources of injury among older farmers. For agricultural mowers, overturns and fall from and struck-by were the leading causes of fatal occupational injury (56% of the 117

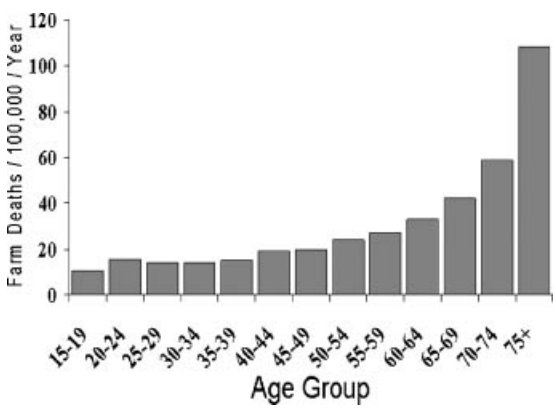

FIGURE 1. Agriculture production fatality rates by age group, U.S. 1992–2004. *Source*: This research was conducted with BLS restricted access CFOI data (data excludes NY City). The views expressed here do not necessarily reflect the views of the BLS.

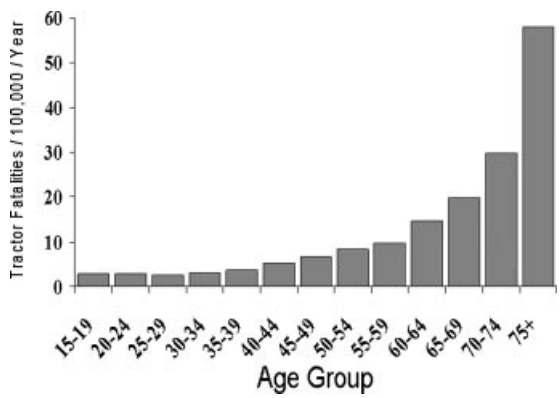

FIGURE 3. Tractor-related fatality rates in agriculture production by age group, U.S. 1992–2004. *Source*: This research was conducted with BLS restricted access CFOI data (data excludes NY City). The views expressed here do not necessarily reflect the views of the BLS.

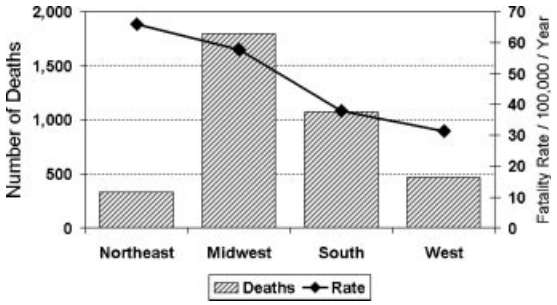

FIGURE 4. Number of deaths and fatality rates for farmers and farm workers 55+ years of age by region of the country, U.S. 1992–2004. *Source*: This research was conducted with BLS restricted access CFOI data (data excludes NY City). The views expressed here do not necessarily reflect the views of the BLS.

deaths). Truck-related deaths were most often highway collisions (52%), and deaths involving agriculture harvesters occurred most often as a result of being caught-in the equipment (40%). Among farmers younger than 55 years old, trucks accounted for 12% of the incidents, followed by harvesters (4%) and agriculture mowers (4%).

The largest number of deaths to farmers 55 years and older was in the midwest and south (Fig. 4). The highest fatality rate occurred in the northeast (66.0/100,000 workers/year), closely followed by the midwest (57.7/100,000 workers/year). Most (67% or 2,467) of the fatalities to farmers 55 years and older occurred on crop farms, and 28% (1,009) occurred on livestock farms (type of farm was unknown for 5% of the cases). The fatality rate for older farmers was three times higher on crop farms (70.3/100,000 workers/year) than on livestock farms (22.7).

Tractor-Related Field Investigations for Older Farmers

Tractor-related fatalities investigated through the NIOSH FACE program were reviewed to obtain additional information for tractor characteristics not otherwise available through OISPA or CFOI surveillance systems. Between 1992 and 2001, 44 deaths to farmers 55 years and older involving tractor rollovers were investigated. Of these 44 deaths, 40 of the tractors did not have a ROPS, two had a ROPS, and information was unavailable for the remaining two incidents. Of the rollover fatalities on tractors without ROPS, 15% of the tractors were manufactured in the 1940s or earlier; 50% in the 1950s and 1960s; 30% in the 1970s; and 5% in the 1980s. Of the two deaths that occurred on tractors with ROPS, one tractor had a cab but the farmer was not wearing a seatbelt; on the other tractor, the ROPS was folded over and not in the upright position. One of these ROPS-equipped tractors was manufactured in the 1960s and the second in the 1980s.

DISCUSSION

Data Summary

Based on a review of previous studies, a major finding was the lack of consistency in how older workers are defined. Previous studies have defined older workers as anyone as young as 50 years, but generally start at or around 60 years of age. Data sources for non-fatal injuries in these studies varied, including farm operator surveys, workers' compensation claims, emergency department records, and hospital discharge records. Sources of data for fatal work injuries were also variable, including death certificates, newspaper clippings, and medical examiner reports. Despite these differences in definitions and data sources, strong associations between age and work injuries emerged. In general, the risk for all occupational injuries decreases with age; however, this pattern levels out, then gradually reverses as the severity of the injury increases, culminating in a clear positive association between fatal work injury risk and age.

The findings presented here agree well with the overall view of the association between age and occupational injury risk. The results of the OISPA survey confirm previous studies of non-fatal injuries, showing that older workers overall are at somewhat lower or equal risk of non-fatal injuries, but have an increasing risk as the severity of the injury increases [Root, 1981; Hanford et al., 1982; Hoskin et al., 1988; Mitchell, 1988; Blahey and Alberg, 1993; Castillo and Rodriguez, 1997; Hartling et al., 1997; Layne and Landen, 1997; Alexander et al., 1999; Gelberg et al., 1999; Turner et al., 2000; Pickett et al., 2001; Hartman et al., 2004; Layne and Pollack, 2004]. Major types of injury causes for older farmers and farm workers identified in the current study also agree with previously published literature, with animals and falls being common issues for older workers [Hanford et al., 1982; Carstensen et al., 1995; Murphy and Ambe, 1996; Nordstrom et al., 1996; Layne and Landen, 1997; Browning et al., 1998; Lewis et al., 1998; Gelberg et al., 1999; Xiang et al., 1999; Hwang et al., 2001; Park et al., 2001; Pickett et al., 2001; Sprince et al., 2003; Hartman et al., 2004]. In the current study, animal-related incidents accounted for 10% of the non-fatal injuries and the non-fatal injury rate among older farmers on livestock operations (5.3/100 workers/year) was higher than the injury rate for crop operations (3.3/100 workers/year). Thirty percent of the non-fatal injuries were falls with 15% of the total classified as falls to the same level and 14% as falls from height.

For fatal injuries, the results presented here reaffirm the findings of previous researchers that report a clear increase in the risk of fatal injury with age in the agricultural production industry [Hanford et al., 1982; Hoskin et al., 1988; Myers, 1989, 1990; Myers and Hard, 1995; Kisner and Pratt, 1997; Fiedler et al., 1998; Hard et al., 1999, 2002; Pickett et al., 1999; Voaklander et al., 1999; Mitchell et al., 2002; Meyer,

2005]. In addition, the identification of farm tractor overturns as the single most common cause of fatal occupational injury for farmers and farm workers 55 years and older agrees with most prior studies of work-related farm deaths [Murphy, 1985, 1990; Purschwitz and Field, 1986; Field and Purschwitz, 1987; Myers, 1989; Hayden et al., 1995; Myers and Hard, 1995; Murphy and Ambe, 1996; Kisner and Pratt, 1997; Fiedler et al., 1998; Gelberg et al., 1999; Hard et al., 1999; Pickett et al., 1999; Voaklander et al., 1999; Murphy and Kassab, 2001; Hard et al., 2002; Mitchell et al., 2002; Meyer, 2005].

Although the results of this study support the long-standing need to focus prevention efforts on machine safety, fall prevention, and safe animal handling strategies, older workers present unique issues for injury intervention and prevention. One such issue is the fact that studies suggest that older farmers are not as likely as their younger counterparts to use protective devices and are often unwilling to make changes to improve the safety of farm operations [Wadud et al., 1998; Pickett et al., 1999; Hwang et al., 2000]. Witte et al. [1992–1993] reported that although farmers recognize the potential severity of equipment-related incidents, they believe themselves to be invulnerable. In another study, 83% of older farmers agreed that tractor-related injuries are severe, and 88% agreed that ROPS is effective in tractor overturns, but only 26% said the cost of installing a ROPS outweighed the safety benefits [Whitman and Field, 1995]. Over half of these older farmers believed that their knowledge and experience compensated for any age-related physical disabilities, with 56% reporting that their personal knowledge compensated for loss of physical ability due to age and 33% disagreeing that they were at greater risk when operating a tractor compared to people 20 years their junior [Whitman and Field, 1995]. Other studies have noted discordance between the perceived risk of particular work tasks or machines and the proportion of fatalities attributable to each [Fiedler et al., 1998], and that older workers are less likely to make safety-related changes to their work routines (e.g., the use of different chemicals or changes to equipment for safety purposes) [Hwang et al., 2000]. Zwerling et al. [2001] reported that middle-aged (45–64 years) and older (65 years and older) male farmers were less likely to report using a seatbelt than non-farmers, but reported no difference for female farmers.

The resistance to the use of protective devices is amplified by studies showing older farmers are more likely to operate older tractors [Gelberg et al., 1999; Voaklander et al., 1999; Sanderson et al., 2006]. Older tractors typically lack ROPS, especially those manufactured prior to 1976 [Myers and Snyder, 1995]. Tractor longevity indicates that many older farmers will continue operating older tractors without ROPS for decades into the future rather than purchasing newer equipment. New cost-effective rollover protective structure (CROPS) designs that can be installed for half the cost of standard ROPS retrofits are currently being developed. It has been estimated that the installation of CROPS retrofits instead of the standard ROPS would reduce the net cost of preventing an injury by nearly 75% [Owusu-Edusei and Biddle, 2007a,b]. It is unknown whether the reduced costs of a CROPS will increase the prevalence of retrofitting older tractors.

Although the true impact of aging on occupational capacity is unclear [Wegman, 1999], studies have shown that injury outcomes become more severe and the ability to recover from an injury is greatly reduced as age increases [Purschwitz and Field, 1986; Personick and Windau, 1995; Pickett et al., 1999; Voaklander et al., 1999; Pransky et al., 2005]. Prior injuries may also increase the risk of future injuries [Browning et al., 1998; Voaklander et al., 2006]. Likely risk factors include physical changes such as decreased vision, hearing, and musculoskeletal functioning that occur as a result of an injury or as part of the natural aging process [Karlovich et al., 1988; Rossignol, 1994]. Both agricultural and non-agricultural studies have suggested that these physical changes may slow reaction time and negatively impact dexterity, crucial characteristics in most farm settings [Murphy, 1985; Zwerling et al., 1995]. Furthermore, researchers have shown that the risk of farming-related injury increases for those with existing physical or musculoskeletal impairment, disease, or other health problems [Purschwitz and Field, 1986; Zwerling et al., 1995, 1996, 1997; Lewis et al., 1998; Voaklander et al., 1999; Xiang et al., 1999; Hwang et al., 2001; Sprince et al., 2003]. Unless these problems are brought on quickly by disease or injury, most of these changes occur slowly and may be ignored until they progress to a disabling state [Murphy, 1985; Wadud et al., 1998].

The use of medications may also adversely affect reaction times and dexterity, thus increasing the risk of injury. Studies confirm a significant association between injury and the use of medication [Voaklander et al., 1999, 2006; Xiang et al., 1999; Sprince et al., 2003]. Farmers experiencing limited mobility as a result of injury or joint pain [Sprince et al., 2003; Voaklander et al., 2006] may use medication to alleviate or reduce symptoms; however, these medicines have been shown to reduce attention to the surrounding environment, thus elevating the risk of injury [Voaklander et al., 2006].

Addressing these often complex issues to more effectively reduce the risk of injuries among older workers is difficult. For this reason, reaching farmers to communicate and convey safety information must use non-traditional venues such as farm magazines and equipment dealers [Ambe and Murphy, 1995; Whitman and Field, 1995; Wadud et al., 1998]. For example, Ambe and Murphy [1995] suggest that effective training programs for tractor operators should specifically include input from aged operators, their families, and the institutions that serve them from initial planning

stages to program delivery. These revised prevention models could be broadly applied to all older farmers, not just tractor operators.

Study Limitations

There are several limitations to the results presented from the OISPA surveys. The first limitation is that there is some degree of undercounting associated with the OISPA due to an injury recall period of up to 15 months, reluctance of the farm operator to report an injury, and the exclusion of contract farm labor. A second limitation is that non-response bias was not assessed as it was not possible to make a second contact to farm operators who refused to participate in the survey.

FACE data also have several limitations. The case-based surveillance approach of FACE does not lend itself to the investigation of all occupational deaths. As such, it represents a convenience sample of occupational deaths that meet priorities set by NIOSH or the states conducting investigations of these deaths. Still, investigations are valuable in providing a depth of detail not available through other surveillance approaches. Here, much of the FACE conclusions are supported by other data sources, suggesting these results are valid, if somewhat incomplete.

The CPS industry and occupation items used in this study are based on the ''primary industry'' of the employed person, which most likely undercounts part-time farmers. There is also some degree of subjectivity for self-reported industry and occupation information compared to using payroll data. Additionally, because the CPS is administered by telephone, it undercounts farm workers who do not have a telephone, or are transient in nature. Finally, this study calculated employment based on the number of workers rather than actual hours worked. Ruser [1998] previously reported that incident rates for older workers would be underreported for older workers if based on number of workers. If hours worked were used in this study, the rates of non-fatal and fatal injuries for those workers 55 years of age and older would have been slightly higher, while rates for those <55 years old would have been slightly lower. These slight derivations would not have significantly changed the main findings presented in this study.

CONCLUSION

Although the evidence from this study and many previously published studies have found that older farmers and farm worker have lower overall injury risk compared to workers <55 years of age, the findings from this and other studies strongly suggest that injuries in this aging farm work force appear to be much more severe. In addition, the literature repeatedly identifies causes of fatal and non-fatal injury such as tractor overturns, falls, struck by incidents, and assaults by animals as major issues faced by older workers. Effectively minimizing the impact of these risks requires a much more thorough understanding of older workers' beliefs, values, and motivations, and the adoption of non-traditional prevention programs that encourage safe work behaviors and practices and the implementation/installation of appropriate safety devices and equipment including ROPS retrofits which are now available for a majority of older tractors.

ACKNOWLEDGMENTS

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of CDC, NIOSH.

REFERENCES

Alexander BH, Franklin GM, Fulton-Kehoe D. 1999. Comparison of fatal and severe nonfatal traumatic work-related injuries in Washington State. Am J Ind Med 36(2):317–325.

Allen R, Harris G. 2005. What we know about the demographics of U.S. farm operators. USDA website: http://www.nass.usda.gov/census/census02/otheranalysis/demographicpaper022505.htm. Last accessed May 14, 2007.

Ambe F, Murphy DJ. 1995. Injury prevention programming for aged tractor operators. J Agric Saf Health 1(2):105–116.

Blahey GG, Alberg N. 1993. Manitoba (Canada) injury reporting. Paper no. 935013. 1993 *International Summer Meeting of the ASAE and CSAE*, June 20–23, 1993, Spokane, WA. St. Joseph, MI: American Society of Agricultural Engineers.

BLS. 1992. Occupational injury and illness classification manual. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics.

BLS. 2007. Chapter 1: Labor Force Data Received from the Current Population Survey. In: BLS handbook of methods. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. BLS website: http://www.bls.gov/opub/hom/homch1_a.htm. Last accessed October 2, 2007.

BOC. 1975. The methods and materials of demography. Vol. 1. Washington, DC: Shryrock, Siegal, and Associates.

Browning SR, Truszczynska H, Reed D, McKnight RH. 1998. Agricultural injuries among older Kentucky farmers: The Farm Family Health and Hazard Surveillance Study. Am J Ind Med 33(4):341–353.

Carstensen O, Lauritsen J, Rasmussen K. 1995. The West-Jutland study on prevention of farm accidents, phase 1: A study of work specific factors in 257 hospital-treated agricultural injuries. J Agric Saf Health 1(4):231–239.

Castillo DN, Rodriguez R. 1997. Follow-back study of oldest workers with emergency department-treated injuries. Am J Ind Med 31(5):609–618.

Crawford J, Wilkins JR, III, Mitchell GL, Moeschberger ML, Bean TL, Jones LA. 1998. A cross-sectional case control study of work-related injuries among Ohio farmers. Am J Ind Med 34(6):588–599.

Dohm A. 2000. Gauging the labor force effects of retiring baby-boomers. Mon Labor Rev 123(7):17–25.

Fiedler D, Von Essen S, Morgan D, Grisso R, Mueller K, Eberle C. 1998. Causes of fatalities in older farmers vs. perception of risk. J Agromedicine 5(3):13–22.

Field WE, Purschwitz MA. 1987. Injury in the agricultural workplace. Agri-Med '87 Conference, February 24, 1987, St. Vincent Hospital, Indianapolis, IN.

Gelberg KH, Struttmann TW, London MA. 1999. A comparison of agricultural injuries between the young and elderly: New York and Kentucky. J Agric Saf Health 5(1):73–81.

Hanford WD, Burke JW, Fletcher WJ, Hoskin AF, Miller TA. 1982. 1982 Farm accident survey report. Chicago, IL: National Safety Council.

Hard DL, Myers JR, Snyder KA, Casini VJ, Morton LL, Cianfrocco R, Fields J. 1999. Identifying work-related fatalities in the agricultural production sector using two national occupational fatality surveillance systems, 1990–1995. J Agric Saf Health 5(2):155–169.

Hard DL, Myers JR, Gerberich SG. 2002. Traumatic injuries in agriculture. J Agric Saf Health 8(1):51–65.

Hartling L, Pickett W, Dorland J, Brison RJ. 1997. Hospital costs associated with agricultural machinery injuries in Ontario. Am J Ind Med 32(5):502–509.

Hartman E, Frankena K, Oude Vrielink H, Nielen M, Metz J, Huirne R. 2004. Risk factors associated with sick leave due to work-related injuries in Dutch farmers: An exploratory case-control study. Saf Sci 42:807–823.

Hayden GJ, Gerberich SG, Maldonado G. 1995. Fatal farm injuries: A five year study utilizing a unique surveillance approach to investigate the concordance of reporting between two data sources. J Occup Environ Med 37(5):571–577.

Horrigan MW. 2004. Employment projections to 2012: Concepts and context. Mon Labor Rev 127(2):3–22.

Hoskin AF, Miller TA, Hanford WD, Landes SR. 1988. Occupational injuries in agriculture: A 35 state summary. NIOSH Contract Report No. DSR-87-0942. Morgantown, WV: National Institute for Occupational Safety and Health.

Hwang SA, Gomez MI, Stark AD, St. John TL, Pantea CI, Hallman EM, May JJ, Scofield SM. 2000. Safety awareness among New York farmers. Am J Ind Med 38(1):37–81.

Hwang SA, Gomez MI, Stark AD, St. John TL, May JJ, Hallman EM. 2001. Severe farm injuries among New York farmers. Am J Ind Med 40(1):32–41.

Karlovich RS, Wiley TL, Tweed T, Jensen DV. 1988. Hearing sensitivity in farmers. Public Health Rep 103(1):61–71.

Kisner SM, Pratt SG. 1997. Occupational fatalities among older workers in the United States: 1980–1991. J Occup Environ Med 39(8):715–721.

Layne LA. 2004. Occupational injury mortality surveillance in the United States: An examination of census counts from two different surveillance systems, 1992–1997. Am J Ind Med 45(1):1–13.

Layne LA, Landen DD. 1997. A descriptive analysis of nonfatal occupational injuries to older workers using a national probability sample of hospital emergency departments. J Occup Environ Med 39(9):855–865.

Layne LA, Pollack KM. 2004. Nonfatal occupational injuries from slips, trips, and falls among older workers treated in hospital emergency departments, United States 1998. Am J Ind Med 46(1):32–41.

Lewis MQ, Sprince NL, Burmeister LF, Whitten PS, Torner JC, Zwerling C. 1998. Work-related injuries among Iowa farm operators: An analysis of the Iowa Farm Family Health and Hazard Surveillance Project. Am J Ind Med 33(5):510–517.

Meyer S. 2005. Fatal occupational injuries to older workers in farming, 1995–2002. Mon Labor Rev 128(10):38–48.

Mitchell OS. 1988. The relation of age to workplace injuries. Mon Labor Rev 111(7):8–13.

Mitchell RJ, Franklin RC, Driscoll TR, Fragar LJ. 2002. Farm-related fatal injury of young and older adults in Australia, 1989–1992. Aust J Rural Health 10:209–219.

Murphy DJ. 1985. Pennsylvania farm fatalities during 1980–84. Special Circular 319. University Park, PA: The Pennsylvania State University.

Murphy DJ. 1990. Pennsylvania farm fatalities during 1985–89. University Park, PA: The Pennsylvania State University.

Murphy DJ, Ambe F. 1996. Pennsylvania farm fatalities during 1990–1994. University Park, PA: The Pennsylvania State University.

Murphy DJ, Kassab C. 2001. Pennsylvania farm fatalities during 1995–99. University Park, PA: The Pennsylvania State University.

Myers JR. 1989. The national traumatic occupational fatalities: A surveillance tool for agricultural work-related deaths. Paper no.89-9. National Institute for Farm Safety 1989 Summer Meeting, June 18–22, 1989, Monterey, CA. Columbia, MO: National Institute for Farm Safety.

Myers JR. 1990. National surveillance of occupational fatalities in agriculture. Am J Ind Med 18(2):163–168.

Myers JR, Hard DL. 1995. Work-related fatalities in the agricultural production and services sector, 1980–1989. Am J Ind Med 27(1):51–63.

Myers JR, Snyder KA. 1995. Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993 J Agric Saf Health 1(3):185–197.

Myers JR, Snyder KA, Hard DL, Casini VJ, Cianfrocco R, Fields J, Morton LL. 1998. Statistics and epidemiology of tractor fatalities–A historical perspective. J Agric Saf Health 4(2):95–108.

NASS. 2002. Farms and land in farms, February 2002. Washington, DC: U.S. Department of Agriculture, National Agricultural Statistics Service Report No. Sp Sy 3 (02).

NASS. 2005. Farms, land in farms, and livestock operations 2004 summary, January 2005. Washington, DC: U.S. Department of Agriculture, National Agricultural Statistics Service Report No. Sp Sy 4 (05).

NIOSH. 2003. NIOSH FACE program. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2003-146.

Nordstrom DL, Layde PM, Olson KA, Stueland D, Follen MA, Brand L. 1996. Fall-related occupational injuries on farms. Am J Ind Med 29(5):509–515.

Office of Management and Budget. 1987. Standard industrial classification manual. Washington, DC: Executive Office of the President, Office of Management and Budget.

Office of Management and Budget. 2002. North American Industry Classification System United States, 2002. Washington, DC: Executive Office of the President, Office of Management and Budget.

Owusu-Edusei K, Jr, Biddle EA. 2007a. Installing a cost-effective rollover protective structure (CROPS): A cost-effectiveness analysis. J Agric Saf Health 13(2):165–176.

Owusu-Edusei K, Jr, Biddle EA. 2007b. A stable dynamic cohort analysis of installing cost-effective rollover protective structures (CROPS). J Agric Saf Health 13(2):177–187.

Park H, Sprince NL, Lewis MQ, Burmeister LF, Whitten PS, Zwerling C. 2001. Risk factors for work-related injury among male farmers in

Iowa: A prospective cohort study. J Occup Environ Med 43(6):542–547.

Personick ME, Windau JA. 1995. Characteristics of older workers' injuries. In: Fatal workplace injuries in 1993: A collection of data and analysis. Washington, DC: U.S. Department of Labor. Bureau of Labor Statistics Report No. 891. p. 23–27.

Pickett W, Hartling L, Brison RJ, Guernsey JR. 1999. Fatal work-related farm injuries in Canada, 1991–1995. Can Med Assoc J 160(13):1843–1848.

Pickett W, Hartling L, Dimich-Ward H, Guernsey JR, Hagel L, Voaklander DC, Brison RJ. 2001. Surveillance of hospitalized farm injuries in Canada. Inj Prev 7(2):123–128.

Pransky GS, Benjamin KL, Savageau JA, Currivan D, Fletcher K. 2005. Outcomes in work-related injuries: A comparison of older and younger workers. Am J Ind Med 47(2):104–112.

Purschwitz MA, Field WE. 1986. Farm-related fatalities involving persons 60 years of age and older. Paper no. 86-6. National Institute for Farm Safety 1986 Summer Meeting. June 15–19, 1986, Orlando, FL. Columbia, MO: National Institute for Farm Safety.

Root N. 1981. Injuries at work are fewer among older employees. Mon Labor Rev 104(3):30–34.

Rossignol M. 1994. The case-fatality rate of occupational injuries: The effect of aging (Letter to the Editor). Am J Public Health 84(10):1696–1697.

Ruser JW. 1998. Denominator choice in the calculation of workplace fatality rates. Am J Ind Med 33(2):151–156.

Sanderson WT, Madsen MD, Rautiainen R, Kelly KM, Zwerling C, Taylor CD, Reynolds SJ, Stromquist AM, Burmeister LF, Merchant JA. 2006. Tractor overturn concerns in Iowa: Perspectives from the Keokuk County Rural Health Study. J Agric Saf Health 12(1):71–81.

Sprince NL, Zwerling C, Lynch CF, Whitten PS, Thu K, Logsden-Sackett N, Burmeister LF, Sandler DP, Alavanja MCR. 2003. Risk factors for agricultural injury: A case–control analysis of Iowa farmers in the Agricultural Health Study. J Agric Saf Health 9(1):5–18.

Stueland DT, Nordstrom DL, Layde PM, Follen MA, Olson KA, Brand LM, Gunderson PD. 1996. Case control study of agricultural injuries to older farmers in central Wisconsin (Letter to the Editor). J Am Geriatr Soc 44(4):475–476.

Toosi M. 2004. Labor force projections to 2012: The graying of the U.S. workforce. Mon Labor Rev 127(2):37–57.

Toosi M. 2005. Labor force projections to 2014: Retiring boomers. Mon Labor Rev 128(11):25–44.

Turner JA, Franklin G, Turk DC. 2000. Predictors of chronic disability in injured workers: A systematic literature synthesis. Am J Ind Med 38(6):707–722.

Voaklander DC, Hartling L, Pickett W, Dimich-Ward H, Brison RJ. 1999. Work-related mortality among older farmers in Canada. Can Fam Physician 45:2903–2910.

Voaklander DC, Kelly KD, Rowe BH, Schopflocher DP, Svenson L, Yiannakoulias N, Pickett W. 2006. Pain, medication, and injury in older farmers. Am J Ind Med 49(5):374–382.

Wadud SE, Kreuter MW, Clarkson S. 1998. Risk perception, beliefs about prevention, and preventive behaviors of farmers. J Agric Saf Health 4(1):15–24.

Wegman DH. 1999. Older workers. Occup Med State Art Rev 14(3):537–557.

Whitman SD, Field WE. 1995. Assessing senior farmers' perceptions of tractor and machinery-related hazards. J Agric Saf Health 1(3):199–214.

Witte K, Peterson TR, Vallabhan S, Stephenson MT. 1992–1993. Preventing tractor-related injuries and deaths in rural populations: Using a persuasive health message framework in formative evaluation research. Int Q Community Health Educ 13(3):219–251.

Xiang H, Stallones L, Chiu Y, Epperson A. 1998. Non-fatal agricultural injuries and risk factors among Colorado female farmers. J Agromedicine 5(4):21–33.

Xiang H, Stallones L, Chiu Y. 1999. Nonfatal agricultural injuries among Colorado older male farmers. J Aging Health 11(1):65–78.

Zwerling C, Sprince NL, Wallace RB, Davis SC, Whitten PS, Heeringa SG. 1995. Occupational injuries among agricultural workers 51 to 61 years old: A national study. J Agric Saf Health 1(4):273–281.

Zwerling C, Sprince NL, Wallace RB, Davis CS, Whitten PS, Heeringa SG. 1996. Risk factors for occupational injuries among older workers: An analysis of the Health and Retirement Study. Am J Public Health 86(9):1306–1309.

Zwerling C, Whitten PS, Davis CS, Sprince NL. 1997. Occupational injuries among workers with disabilities: The National Health Interview Survey, 1985–1994. J Am Med Assoc 278(24):2163–2166.

Zwerling C, Merchant JA, Nordstrom DL, Stromquist AM, Burmeister LF, Reynolds SJ, Kelly KM. 2001. Risk factors for injury in rural Iowa: Round one of the Keokuk County Rural Health Study. Am J Prev Med 20(3):230–233.