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Agricultural Tractor Overturn Deaths: Assessment of Trends and Risk Factors

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Background *Tractor overturn deaths have been recognized as a public health concern for decades. Studies have reported on the hazards associated with tractor overturns, but none have reported on trends in tractor overturn fatality rates in the United States (US).*
Methods *Tractor overturn fatality data from the Bureau of Labor Statistics Census of Fatal Occupational Injuries were used in Poisson regression models to: identify risk factors associated with overturn fatalities; examine trends in tractor overturn fatality rates between 1992 and 2007; and assess trends in overturn fatality rates for specific risk factors.*
Results *Characteristics found to be associated with tractor overturn fatality rates were age, type of farm, region, and the victim's relationship to the farm ($P < 0.0001$). Older age groups, crop farms, farms in the Midwest and Northeast, and family workers all had higher fatal tractor overturn risks. Overall, tractor overturn fatality rates declined 28.5% between 1992 and 2007. Significant decreases in tractor overturn fatality rates were found for the Northeast and South regions, hired workers, crop farms, and in every age group except those less than 25 years of age.*
Conclusions *Tractor overturn fatality rates decreased between 1992 and 2007. These decreases were not consistent between different categories of the agricultural workforce or regions of the US. Changes in tractor overturn fatality rates may be partially explained by increases in the prevalence of ROPS on farm tractors in the US. ROPS promotion programs are needed to reduce tractor overturn fatalities, especially among those subpopulations at highest risk.* Am. J. Ind. Med. 53:662–672 2010. *Published 2009 Wiley-Liss, Inc.*†

KEY WORDS: tractor overturns; fatalities; Poisson regression; trends; risk factors

INTRODUCTION

Agricultural production is one of the most hazardous industries in the United States (US) as defined by the number and rate of occupational deaths. According to the Bureau of Labor Statistics (BLS), there were a total of 422 workers who died in the agricultural production sector in 2007, for an annual fatality rate of 24.2 deaths per 100,000 workers [BLS, 2009a]. The leading cause of these work-related deaths is the overturn of agricultural tractors [NIOSH, 2006]. Tractor overturns accounted for 1,412 deaths to farmers and farm workers between 1992 and 2005, or 18.7% of all agricultural production deaths during this time-period [NIOSH, 2008].

Agricultural tractor overturn deaths have been an identified problem since the 1920s [Arndt, 1971], and have been a recognized public health concern for decades [Karlson and Noren, 1979; NCASH, 1989; NIOSH, 1992; Swenson, 2004]. Numerous studies on farm-related fatalities have continued to identify tractors, and specifically tractor overturns as a common cause of fatal occupational injury for farmers and farm workers at both the state and national level

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[Karlson and Noren, 1979; Murphy, 1985; Purschwitz and Field, 1986; Bobick and Jenkins, 1992; Hayden et al., 1995; Fiedler et al., 1998; Myers et al., 1998; Hard et al., 1999, 2002; Meyer, 2005].

A common recommendation in these studies is the use of Rollover Protective Structures (ROPS). ROPS are of various designs, but essentially are roll bars or cabs developed to provide a protective zone for the tractor operator in the event of a tractor overturn. The tractor operator is required to use a seatbelt in conjunction with a ROPS to keep them inside the protective zone during an overturn [OSHA, 1976]. The effectiveness of ROPS and seatbelts has been well documented [Lehtola et al., 1994; Springfeldt et al., 1998; Thelin, 1998; Reynolds and Groves, 2000; Myers et al., 2008]. The National Institute for Occupational Safety and Health (NIOSH) has estimated that fatality rates due to tractor overturns could be reduced by a minimum of 71% [NIOSH, 1993] if all tractors were equipped with ROPS in the US.

The lack of progress in reducing the number and rate of tractor overturn deaths during the 1980's and 1990's became a major driving force in NIOSH establishing a National Agricultural Tractor Safety Initiative (NATSI) in collaboration with the NIOSH-funded Agricultural Research Centers [Swenson, 2004]. The purpose of the initiative was to: examine the existing research on preventing tractor-related injuries and deaths; identify surveillance, research, and intervention gaps; conduct research to fill the identified gaps; and work towards interventions to reduce fatal and non-fatal tractor-related injuries. Both NIOSH and the Agricultural Research Centers agreed to work collaboratively on the NATSI goals.

Recent studies related to the NATSI initiative have shown that the prevalence of ROPS on farm tractors has been steadily increasing since the 1990's [Loringer and Myers, 2008; Myers, 2008; NASS, 2008]. However, no studies have been conducted to date to assess how these increases have impacted tractor overturn fatality rates in the US. The purposes of this study were to: assess demographic characteristics that might be associated with overturn fatality rates; examine trends in occupational tractor overturn fatality rates in the US for the years 1992 through 2007; and assess trends in overturn fatality rates associated with the demographic characteristics.

METHODS

Fatality Data

Data on tractor overturn fatalities were obtained from the Census of Fatal Occupational Injuries (CFOI). CFOI was developed by the BLS for surveillance of work-related fatalities in the US. The fatality data cover all industries and occupations, and all ages. To be included in the database, cases must meet the following criteria: (1) the decedent was employed at the time of the event, and (2) engaged in a legal work activity or present at the site of the incident as a requirement of his or her job [BLS, 2009b]. Fatalities to volunteer and unpaid family workers who perform the same duties and functions as paid workers are also included in the counts.

CFOI data are compiled using a multi-source methodology (e.g., death certificates, workers' compensation files, medical examiner or coroner reports, police reports). Generally cases are only included in the database if two sources indicate a work relationship. Nature of injury, body part injured, source, and event were coded using the Occupational Injury and Illness Classification System (OIICS) [BLS, 1992]. BLS provided NIOSH with a detailed research file that includes variables such as specific age. The New York City Department of Health declined to release these more detailed data; therefore, data from New York City are excluded.

For this analysis, fatalities in the agricultural production sectors were selected by industry codes (Standard Industrial Classification Codes 1992–2002 [OMB, 1987] and North American Industry Classification System 2003–2007 [OMB, 2002]) for agricultural production in crops and livestock for the years 1992–2007. Tractor overturn fatalities were selected based both on a primary source code for tractor (OIICS source code = 853), and an event code that indicated the fatality was the result of a highway or non-highway overturn (OIICS event code = 4141 or 4233).

Denominator Data

Employment estimates were derived from the Current Population Survey (CPS) micro-data files for the years 1992–2007. CPS is a monthly survey, conducted by BLS, of United States (US) households selected from a probability sample representative of the civilian non-institutionalized population [BLS, 2009c]. Demographic variables available in the CPS include the worker age, state of employment, relationship to the place of employment, and industry of employment.

Analysis of Trends and Risk Factors

Poisson regression was used to assess the overall trends in overturn fatality rates for this 16-year time-period. To better understand trends, four separate time periods were examined for the overall tractor overturn fatality rate: 1992–1995, 1992–1999, 1992–2003, and 1992–2007. Poisson regression was also used to assess the relationship between overturn death rates and potential risk factors associated with the overturn fatality. These included the victim's age group, employment in a primarily crop or livestock operation, relationship to the farm (i.e., family or hired), and geographic region of death. The geographic regions were the four major categories defined by the Bureau of the Census (Table I)

TABLE I. States in the Four U.S. Bureau of the Census Geographic Regions of the US

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

[BOC, 1975]. Analyses were limited to these four variables because they were the only ones with sufficient numbers of deaths to model trends over the entire 16-year time-period. All models were adjusted for over-dispersion of the variance by scaling all tests of significance using the Pearson Chi-square statistic. All Poisson regression models were conducted using the *GENMOD* procedure available from the SAS Institute [SAS, 2003].

RESULTS

Univariate Results for All Tractor Overturn Fatalities

Between the years 1992 and 2007, 1,538 agricultural production workers died from tractor overturns in the US, resulting in an annual average of 96 deaths. Crude overturn fatality rates by year are provided in Figure 1. Table II provides the univariate Poisson regression results for the independent categorical variables farm group, age group, relationship to the farm, and region of the US. All four independent variables were statistically significant.

Table III presents the unadjusted rates and rate-ratios for the univariate Poisson regressions for the same four categorical variables. When examining the data by region, the Midwest and Northeast had the highest rates for tractor overturn fatalities, with unadjusted rate-ratios nearly five times that of the West. The South also had a significantly higher tractor overturn fatality rate compared to the West. The unadjusted rate-ratio by age group showed the oldest age group (75 years and older) had the highest risk of overturn fatalities, with an unadjusted rate-ratio over 13 times that of 25- to 34-year olds, the age group with the lowest overturn fatality rate. All age groups older than the 25–34 years old comparison group had significantly higher fatality rates. Crop farms had an unadjusted overturn fatality risk 4.6 times that of livestock farms, while farm family members were found to have a rate of fatal tractor overturns nearly six times that of hired workers.

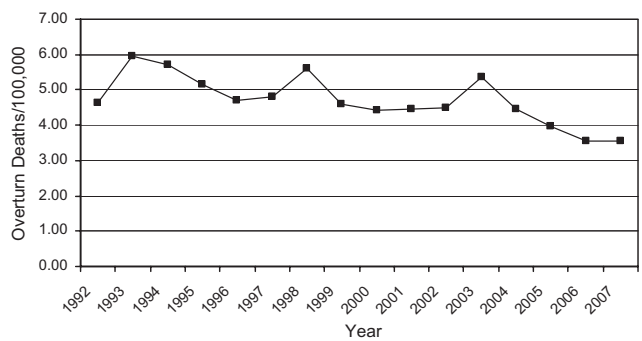

FIGURE 1. Crude tractor overturn fatality rates per 100,000 agricultural production workers by year, 1992–2007. (*This research was conducted with restricted access to BLS CFOI data (data excludes N.Y. City). Rates calculated by NIOSH and may differ from those published by BLS. The views expressed here do not necessarily reflect the views of the BLS.)

Univariate Trend Results

The overall univariate Poisson regression trend and estimate results for the 1992–2007 time-period are presented in Table IV by different levels of region, farm group, relation to farm, and age group. For the overall trend in tractor overturn fatality rates, the slopes were not statistically significant for the time periods 1992–1995 ($\beta = 0.0253$; $\Pr > \chi^2 = 0.20$), 1992–1999 ($\beta = -0.0112$; $\Pr > \chi^2 = 0.43$), or 1992–2003 ($\beta = -0.0119$; $\Pr > \chi^2 = 0.18$). The only significant slope estimate was for the time-period 1992 through 2007 (Table IV). This model indicated a decrease in tractor overturn fatality rates (Fig. 2), with an estimated decline of 28.5% (Table IV).

TABLE II. Univariate Poisson Regression Results for the Dependent Variable Tractor Overturn Fatality Rates and the Independent Variables Region, Farm Group, Relation to Farm, and Age Group, 1992–2007

Independent variable[a]	df	Type III χ^2	$\Pr > \chi^2$
Region	**3**	**198.55**	**<0.0001**
Farm group	**1**	**216.26**	**<0.0001**
Relation to farm	**1**	**558.11**	**<0.0001**
Age group	**6**	**789.13**	**<0.0001**

[a]Rows in bold are statistically significant at $\alpha = 0.05$.

TABLE III. Univariate Poisson Regression Annual Average Tractor Overturn Fatality Rates and Unadjusted Rate-Ratios for the Categorical Variables Region, Farm Group, Relation to Farm, and Age Group, 1992–2007*

Independent variable[a]	Overturn deaths 1992–2007	Deaths per 100,000[b]	Lower 95% rate	Upper 95% rate	Unadjusted rate-ratio (RR)	Lower 95% RR	Upper 95% RR
Region							
Northeast	**163**	**6.81**	**4.90**	**9.45**	**4.85**	**3.49**	**6.73**
Midwest	**760**	**6.83**	**5.22**	**8.94**	**4.86**	**3.72**	**6.37**
South	**497**	**4.77**	**3.61**	**6.30**	**3.40**	**2.57**	**4.49**
West	118	1.40	1.09	1.80	1.00	—	—
Farm group							
Crop	**1,187**	**7.80**	**6.20**	**9.82**	**4.60**	**3.65**	**5.78**
Livestock	291	1.70	1.38	2.09	1.00	—	—
Relation to farm							
Family	**1,352**	**7.54**	**6.29**	**9.05**	**5.95**	**4.96**	**7.13**
Hired	183	1.27	1.07	1.50	1.00	—	—
Age group							
<25 years	97	2.25	1.63	3.10	1.37	1.00	1.89
25–34 years	88	1.64	1.30	2.07	1.00	—	—
35–44 years	**154**	**2.29**	**1.71**	**3.06**	**1.40**	**1.04**	**1.87**
45–54 years	**233**	**3.78**	**2.88**	**4.96**	**2.31**	**1.76**	**3.03**
55–64 years	**319**	**6.09**	**4.69**	**7.92**	**3.72**	**2.86**	**4.83**
65–74 years	**381**	**11.53**	**8.91**	**14.92**	**7.04**	**5.44**	**9.10**
75 + years	**266**	**21.66**	**16.57**	**28.31**	**13.22**	**10.11**	**17.28**

*Source: This research was conducted with restricted access to BLS CFOI data (data excludes N.Y. City). Rates calculated by NIOSH may differ from those published by BLS. The views expressed here do not necessarily reflect the views of the BLS.
[a]Rows in bold have rate-ratios statistically different from the comparison group at $\alpha = 0.05$.
[b]Tractor overturn deaths per 100,000 agricultural production workers.

For trends within regions, the Northeast and the South both had significant decreasing trends in tractor overturn fatality rates (Table IV). Based on the region-specific regression models, the predicted rate of tractor overturn deaths decreased 63.9% in the Northeast over the 16-year period, while the predicted overturn fatality rates in the South decreased 52.7% (Table IV). The regression model for the West region was not significant, although the slope estimate was negative. For the Midwest region, the regression model was also not significant, but was the only region to show a positive slope estimate (i.e., a trend of increasing overturn fatality rates for the 16-year time-period). There was an estimated 32.7% decrease in tractor overturns rates for crop farms, while the regression model for livestock operations was not significant (Table IV). There was also a significant decreasing trend in tractor overturn fatality rates seen for hired farm workers during this 16-year time-period, with an estimated decrease of 57.5%; the regression model for family workers was not significant.

All age groups, except for the less than 25 years old group, had significantly decreasing fatality rates over this 16-year time-period (Table IV). The biggest estimated decrease in risk was seen for the 25–34 years old age group at 66.5%, followed by the 75 years and older age group (45.0%), the 45–54 years old age group (42.7%), the 35–44 years old age group (42.1%), the 65–74 years old age group (33.5%), and finally the 55–64 years old age group (31.2%) (Table IV).

Multivariate Results for All Tractor Overturn Fatalities

Table V presents the multivariate Poisson regression results for the independent variables examined previously in univariate models. The multivariate model found that all the independent variables were significant. For the continuous variable, year, the multivariate model continued to show a significant decreasing trend in the risk for tractor overturns during the 16-year time-period after adjusting for the four categorical variables in the model ($\beta = -0.0369$; $\Pr > \chi^2 < 0.0001$).

Table VI provides the adjusted rate-ratios for the categorical variables region of the US, farm group, relationship to the farm, and age group. The adjusted rate-ratios for region showed little change from the unadjusted rate-ratios provided in Table III for the Northeast and South, while the

TABLE IV. Univariate Poisson Regression Trends and Estimates for Tractor Overturn Fatality Rates for the Variables Year, Region, Farm Group, Relation to Farm, and Age Group, 1992–2007

Independent variable*	Slope (β)	Type III χ^2	Pr $> \chi^2$	Regression estimated rate[a], 1992	Regression estimated rate[a], 2007	Percent change
Year						
1992–2007	**−0.0224**	**14.48**	**0.0001**	**5.54**	**3.96**	**−28.52**
Region						
Northeast	**−0.0679**	**6.18**	**0.0129**	**10.79**	**3.90**	**−63.86**
Midwest	0.0122	1.62	0.2029	6.28	7.53	19.90
South	**−0.0499**	**41.23**	**<0.0001**	**6.61**	**3.13**	**−52.65**
West	−0.0201	1.31	0.2525	1.62	1.20	−25.93
Farm group						
Crop	**−0.0265**	**7.90**	**0.0049**	**9.39**	**6.32**	**−32.69**
Livestock	−0.0333	2.24	0.1343	2.11	1.27	−39.81
Relation to farm						
Family	−0.0105	2.15	0.1423	8.10	6.92	−14.57
Hired	**−0.0570**	**32.70**	**<0.0001**	**1.86**	**0.79**	**−57.53**
Age group						
<25 years	−0.043	3.40	0.0654	2.73	1.74	−36.26
25–34 years	**−0.0773**	**7.82**	**0.0052**	**2.51**	**0.84**	**−66.53**
35–44 years	**−0.0366**	**3.90**	**0.0484**	**2.90**	**1.68**	**−42.07**
45–54 years	**−0.0373**	**22.90**	**<0.0001**	**4.92**	**2.82**	**−42.68**
55–64 years	**−0.0266**	**9.67**	**0.0019**	**7.16**	**4.93**	**−31.15**
65–74 years	**−0.0271**	**4.77**	**0.0290**	**13.92**	**9.26**	**−33.48**
75 + years	**−0.0398**	**4.97**	**0.0258**	**29.39**	**16.18**	**−44.95**

*Rows in bold are statistically significant at $\alpha = 0.05$.
[a]Tractor overturn deaths per 100,000 agricultural production workers.

adjusted Midwest relative risk decreased 24.9%. For relation to farm, the adjusted rate-ratio for family members decreased 32.5% compared to the unadjusted rate-ratio. For the variable farm group, the adjusted rate-ratio for crop farms increased to 6.30, a 37% increase compared to the corresponding unadjusted relative risk estimate.

Larger changes were seen between the adjusted and unadjusted rate-ratios for the independent variable age group. The adjusted rate-ratios for all age groups older than the 25–34 years old referent group decreased after accounting for the other independent variables in the model, with the 35–44 years old age group becoming not statistically different from the 25–34 years old comparison group. The biggest overall decreases were seen for the 55–64 years old, 65–74 years old, and 75 years and older age groups. These three age groups all had decreases ranging between 43% and 49% compared to their corresponding unadjusted rate-ratios. The adjusted rate-ratio for the 45–54 years old age group was 32% lower than its corresponding unadjusted rate-ratio, but was still significantly higher than the referent group. The only higher adjusted rate-ratio was seen with the less than 25 years old age group, which increased 31.4% from the univariate result. The increase was enough to make this age group statistically different than the referent group.

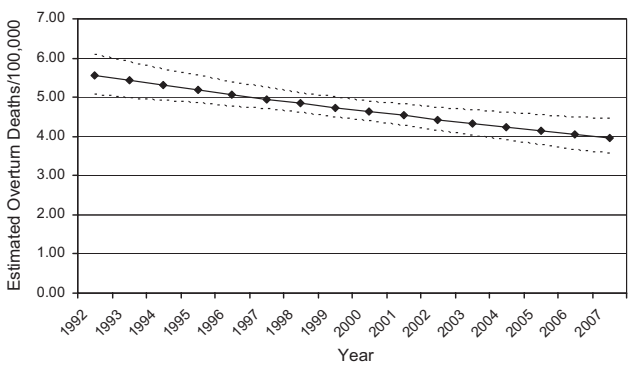

FIGURE 2. Unadjusted Poisson regression tractor overturn fatality rates per 100,000 agricultural production workers with 95% CI bounds.

DISCUSSION

Trends in Overall Overturn Fatality Rates

The results of the Poisson regression analyses indicate that there was an estimated 28.5% decline in the tractor

TABLE V. Multivariate Poisson Regression Results for the Dependent Variable Tractor Overturn Fatality Rates and the Independent Variables Year, Region, Farm Group, Relation to Farm, and Age Group, 1992–2007

Independent variable[a]	df	Type III χ^2	Pr $> \chi^2$
Year	**1**	**22.08**	**<0.0001**
Region	**3**	**135.21**	**<0.0001**
Farm group	**1**	**540.48**	**<0.0001**
Relation to farm	**1**	**165.28**	**<0.0001**
Age group	**6**	**238.13**	**<0.0001**

[a]Rows in bold are statistically significant at $\alpha = 0.05$.

overturn fatality rate on US farms between 1992 and 2007 (Fig. 2). This decline in the overturn fatality risk was even greater after controlling for the variables age group, region, relation to the farm, and farm group, with the slope for the variable year, increasing from −0.0224 in the univariate Poisson model to −0.0369 in the adjusted model. The decrease in fatality rates corresponds to an increase in the number of tractors equipped with ROPS on US farms (Fig. 3). Between 1993 and 2006, the ROPS prevalence rate for farm tractors increased from 38% to 59% [Myers and Snyder, 1995; NASS, 2008]. Using the predicted Poisson regression fatality rates (Fig. 2), there was an average decrease of 0.07 deaths per 100,000 workers in the tractor overturn fatality rate for every 1% increase in ROPS prevalence for the time-period 1993 through 2006.

TABLE VI. Multivariate Poisson Regression Tractor Overturn Adjusted Rate-Ratios for the Categorical Variables Region, Farm Group, Relation to Farm, and Age Group, 1992–2007

Independent variable[a]	Adjusted rate-ratio (RR)	Lower 95% RR	Upper 95% RR
Region			
Northeast	**5.07**	**3.64**	**7.05**
Midwest	**3.60**	**2.73**	**4.75**
South	**3.17**	**2.39**	**4.20**
West	1.00	—	—
Farm group			
Crop	**6.30**	**5.28**	**7.52**
Livestock	1.00	—	—
Relation to farm			
Family	**4.01**	**3.17**	**5.09**
Hired	1.00	—	—
Age group			
<25 years	**1.80**	**1.20**	**2.70**
25–34 years	1.00	—	—
35–44 years	1.09	0.76	1.58
45–54 years	**1.57**	**1.12**	**2.27**
55–64 years	**2.13**	**1.53**	**2.98**
65–74 years	**3.56**	**2.56**	**4.95**
75 + years	**6.47**	**4.58**	**9.14**

[a]Rows in bold have rate-ratios statistically different from the comparison group at $\alpha = 0.05$.

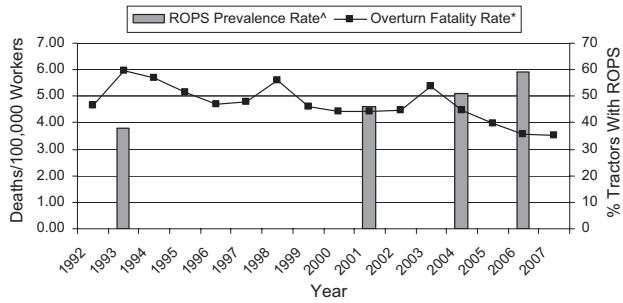

FIGURE 3. Tractor overturn fatality rates compared to ROPS prevalence rates. (*This research was conducted with restricted access to BLS CFOI data (data excludes N.Y. City). Rates calculated by NIOSH and may differ from those published by BLS. The views expressed here do not necessarily reflect the views of the BLS.–Sources: Myers and Snyder [1995]; Loringer and Myers [2008]; NASS [2008].)

This decrease in fatality rates only became statistically significant when the years 2004 through 2007 were added to the Poisson regression models, coinciding with the time-period when the overturn fatality rates fell below 4 deaths per 100,000 workers for the first time (Fig. 1). The Poisson regression models examined here for earlier time periods found no statistically significant decreases in overturn fatality rates, despite the steady increases in ROPS equipped tractors during the 1990's and the turn of the 21st century [Myers and Snyder, 1995; NASS, 2008]. Tractor overturn data from the National Safety Council covering the years 1969 through 1995 suggest that tractor overturn fatality rates were also stable throughout the 1980's and mid-1990's [Myers et al., 1998].

This discordance between the increasing use of ROPS on farm tractors and lack of a statistically significant decrease in overturn fatality rates prior to adding the 2004–2007 time-period into the Poisson regression, mirrors results seen in Sweden [Springfeldt et al., 1998; Thelin, 1998]. The Swedish data found that overturn fatality rates remained stable when ROPS prevalence rates were between 40% and 75%. The findings from a number of European countries suggest that ROPS prevalence rates between 75% and 80% are required before tractor overturn fatality rates fall near zero [Springfeldt, 1996; Springfeldt et al., 1998; Thelin, 1998]. The recent decline in overturn fatality rates suggest that ROPS prevalence rates on US farm tractors (now likely over 60%) are nearing the point where these deaths may decline more quickly, if indeed the European experience holds true in the US.

Of additional importance was that overturn fatality rates appeared to decrease across a wide range of subgroups within

the agricultural production industry. All of the slope estimates for the various independent variable subgroups examined were negative, with the exception of the Midwest region (Table IV). While not all these estimates were statistically significant, the high proportion of negative slope estimates suggests that the reduction in risk for tractor overturn deaths was broad-based.

Age of the Operator

A strong risk factor identified in this study is the age of the victim. While the adjusted rate-ratios for the all the age groups above the 25–34 years old comparison group decreased significantly from the unadjusted counterparts, the adjusted rate-ratios are still elevated, especially for individuals over the age of 55 years (Table VI). The increasing risk of death with increasing age of the farmer or farm worker has been reported for the general US agricultural production industry by several researchers previously [Hanford et al., 1982; Hoskin et al., 1988; Myers, 1990; Myers and Hard, 1995; Fiedler et al., 1998; Hard et al., 1999, 2002; Meyer, 2005; Myers et al., 2009]. Tractor rollovers have been identified as accounting for the largest proportion of deaths among farmers over the age of 55 years [Myers et al., 1998; Hard et al., 1999; Meyer, 2005], with Myers et al. [1998] reporting a similar pattern of increasing risk for tractor overturn deaths with increasing age.

Studies have found that as injury outcomes become more severe, older workers have a decreased ability to recover from the trauma [Purschwitz and Field, 1986; Personick and Windau, 1995; Pickett et al., 1999; Voaklander et al., 1999; Pransky et al., 2005]. A common explanation is the physical changes that occur as individual's age that reduce the body's ability to heal, but such explanations ignore the role of other risk factors that may have contributed to the injury event itself [Rossignol, 1994]. These risk factors include physical (e.g., decreased vision, hearing, and musculoskeletal functioning) as well as medicinal-related impairment [Rossignol, 1994; Voaklander et al., 1999, 2006; Xiang et al., 1999; Sprince et al., 2003]. These physical and medication risk factors are thought to slow reaction time and reduce a worker's dexterity, which are crucial to operating a farm tractor [Murphy, 1985; Zwerling et al., 1995].

The age-related pattern seen for overturn fatality risk has also been reported for the prevalence of non-ROPS-equipped tractors on farms in the US, with farm operators more than 65 years of age having the highest proportion of their tractors unequipped with ROPS [Loringer and Myers, 2008]. The same age-related pattern was also seen for racial minority farm operators [Myers, 2009]. The finding that older farm operators are more likely to have a higher percentage of non-ROPS-equipped tractors than young farmers has also been observed in other studies [Whitman and Field, 1995; Wilkins et al., 2003; May et al., 2006; Sanderson et al., 2006].

Economics and the changing nature of family farms likely play a role in these observations for older farmers. The traditional image of farming in the US is that of ''succession farming'' whereby a farmer hands the farm operation down to the next generation of family members. However, Gale [1994] found that this image of the generational farm family was the exception, with the majority of older farmers scaling back farming operations prior to retirement, and ultimately liquidating the farm. Data from the 2002 Census of Agriculture found that older farmers tend to operate smaller farms and have significantly lower farm incomes compared to their middle-aged counterparts, even after accounting for farm subsidy payments [Allen and Harris, 2005].

This scaling back of farm activities prior to retirement suggests that older farmers are less likely to invest in new capital equipment, such as tractors and machinery [Gale, 1994]. This may partially explain the findings of others suggesting older farmers are more likely to own and operate older tractors [Gelberg et al., 1999; Sanderson et al., 2006].

The longevity of tractors also is important. The average age of a farm tractor in 1993 was 23 years [Myers and Snyder, 1995], increasing to 26 years by 2001 [Myers, 2003]. These findings suggest that the productivity of farm tractors does not significantly diminish with age, allowing them to perform useful farm work for decades. This long-term productivity provides an additional incentive for older farmers to not invest in new equipment as the farmer nears retirement. Unfortunately, it is these older tractors that likely pose the greatest risk for fatalities from tractor overturns [Cole et al., 2007], and are the least likely to be fitted with ROPS [Myers, 2003].

The attitudes and beliefs of older farm operators must be taken in to account. Whitman and Field [1995], in a study of senior farmers over the age of 60 years, found that many older farmers do not see the necessity or cost benefit of having ROPS on their farm tractors. These older farmers were found to believe that they faced only a moderate risk by operating tractors without a ROPS because their experience as a tractor operator could prevent a serious tractor-related incident. While 88% of senior farmers stated they considered ROPS to be effective in preventing injuries, only 26% believed the safety benefits of ROPS outweighed the costs of a ROPS. Fiedler et al. [1998], in a study of Nebraska farm operators 55 years old and older, found that they did not perceive tractors as their most important safety concern despite data showing tractors to be the leading cause of death for this group. Arcury [1997], in a study of Black farmers from Kentucky, Mississippi, North Carolina, and Tennessee, came to many of the same conclusions: Black farmers understood the value of safety equipment like ROPS, but did not see the need to have them on their older tractors. He also found that these Black farmers primarily used older tractors and farm machinery that were not equipped with modern safety devices such as ROPS.

The significant decreases in overturn fatality rates within all of the age groups, except victims less than 25 years of age, is promising (Table IV), although estimated overturn fatality rates for farmers and farm workers over the age of 55 years of age are still high. Recent data from the USDA show that the average age of US farm operators continues to increase, going from 55.3 years in 2002 to 57.1 years in 2007. The number of operators 75 years and older grew 20% since 2002, while the number of operators under 25 years of age decreased 30% over the same time-period [NASS, 2009a]. Thus, those farm operators at highest risk for a tractor overturn fatality are increasing.

Type of Farm

Results from the BLS CFOI have consistently reported that crop operations have higher overall fatality rates than livestock operations [BLS, 2009d], a finding that also holds true for tractor overturn deaths specifically. The underlying reasons for these large differences in risk between crop and livestock operations have not been addressed in the literature, but may be related to tractor-use patterns between these two broad categories of farms.

Loringer and Myers [2008] found that crop operations had higher ROPS prevalence rates in both 1993 and 2004 (41% in 1993 and to 53% in 2004) compared to livestock operations (34% in 1993 and 49% in 2004). Myers [2009] found the same result for farms operated by racial minorities during 2003 (52% for crop operations and 48% for livestock operations). However, certain types of crop operations have been found to have a low prevalence of ROPS-equipped tractors: ''Vegetable, Fruit, and Nut'' operations, ''Nursery'' operations, and ''Tobacco'' operations [Myers and Snyder, 1995; Loringer and Myers, 2008; Myers, 2009]. This is due in part to exemptions in both the Occupational Safety and Health Administration ROPS standard [OSHA, 1976] and the American Society of Agricultural Engineers voluntary ROPS standard for tractors used in low-clearance areas [ASAE Standards, 1985]. It is not possible with the data examined here to assess whether these specific types of farming operations have higher overturn fatality rates than other types of crop operations.

The finding that the risk for tractor overturn fatalities has significantly decreased for crop farms during this 16-year time-period is encouraging (Table IV), but the estimated Poisson regression fatality rate for crop farms was still high in 2007. While crop operations do have a higher prevalence of ROPS-equipped tractors than livestock operations [Loringer and Myers, 2008], this has not led to an overall lower rate of overturn fatalities for crop farms. More research is needed to better identify the specific types of crop farms and other risk factors associated with these high tractor overturn fatality rates.

Region of the US

With regards to regional differences in tractor overturn fatality rates, Myers et al. [1998] reported that, for the years 1992 through 1995, the highest overturn fatality rates were found in the Northeast (8.4 deaths/100,000 workers), followed by the South (6.2 deaths/100,000 workers), and the Midwest (6.1 deaths/100,000 workers), with the lowest in the West (1.9 deaths/100,000 workers). These earlier results, coupled with those reported in Table III, support the regression findings that overturn fatality rates are decreasing over time in the Northeast and South regions of the US, but are unchanged, or slightly increasing in the Midwest (Table IV). These findings also make it clear that overturn fatality rates in the West region of the US have been historically lower than rates seen in other parts of the US.

The two regions that were found to have significant decreases in tractor overturn fatality rates, the Northeast and the South, correspond to the two regions that had the greatest increase in the prevalence of ROPS equipped tractors over a similar time-period. Using ROPS prevalence estimates from Myers [2008] for the years 1993–1995 and ROPS prevalence estimates for 2006 [NASS, 2008], the Northeast went from 29% of the farm tractors equipped with ROPS in 1993, to 51% in 2006. For the South, the ROPS prevalence rates went from 38% to 65% over this same 14-year period. For this same time-period, the ROPS prevalence rate in the Midwest increased from 40% to 56%, while in the West, the prevalence rate increased from 41% to 60%.

Relationship to the Farm

The finding that farmers and farm family members are at a higher risk for fatal tractor overturns than hired workers has not been previously reported in the literature. Meyer [2005] did report that the majority of occupational fatalities among farming occupations occurred to family members (55% of deaths for those less than 55 years of age, and 85% for those 55 years of age and older). Most farms in the US do not use hired labor. According to the 2002 Census of Agriculture, 26% of farms in the US reported using hired workers, with only 10% hiring workers for more than 150 days per year [NASS, 2004]. This had decreased to 22% and 9%, respectively, by 2007 (NASS, 2009b). These hired workers are mostly employed in the states of California, Florida, Texas, Oregon, and Washington [NASS, 2009b].

The use of hired workers appears to be protective with respect to having ROPS-equipped tractors on a farm in the US. Myers [2008] found that farms with no hired workers had an odds ratio two times that of farms with 26 or more hired workers with respect to the percentage of tractors used on the farm without ROPS. The farms with no hired workers had odds ratios 1.72 higher than farms with 11–25 hired workers, and 1.27 times higher than farms with 1–10 hired workers

with respect to the percentage of tractors used on the farm without ROPS. The concentration of hired labor on an increasingly small number of farms, coupled with the higher ROPS prevalence rate on those farms using hired workers suggests the lower risk for hired workers is due in part to a lower exposure of hired farm workers to tractors without ROPS, and may explain the continued decrease in the risk of tractor overturn deaths for hired farm workers seen in Table IV.

Future Directions for Prevention of Tractor Overturn Deaths

Based on results from Europe, decreasing the rate of tractor overturn deaths in the US can be accomplished by increasing the number of ROPS-equipped tractors used on farms in the US. Studies specific to the US have also shown that such an approach would be cost effective [Kelsey and Jenkins, 1991; Myers and Snyder, 1995; Pana-Cryan and Myers, 2000; Owusu-Edusei and Biddle, 2007]. Unfortunately, there is no nationally organized program in place to do this.

Proposals have been presented to address this issue using a variety of methods [Karlson and Noren, 1979; NCASH, 1989; Kelsey and Jenkins, 1991; Myers and Snyder, 1995; Donham et al., 1998; Freeman, 1999; Reynolds and Groves, 2000; Harris et al., 2002, 2005; Swenson, 2004; Hallman, 2005; Sorensen, 2006; Owusu-Edusei and Biddle, 2007; Virginia Farm Bureau, 2008]. The most effective approach attempted to date is in the state of New York, which has developed a social marketing campaign linked to an economic incentive program that includes a ROPS locator service for farm operators [Sorensen, 2006; May, 2008]. A more limited incentive program is also being conducted in Virginia [Virginia Farm Bureau, 2008]. Programs such as these show promise in encouraging farm operators to retrofit older farm tractors. The one major hurdle to expanding social marketing-based incentive programs on a large scale is the cost. Assuming an incentive of $600 per retrofitted tractor, as in New York [May, 2008], a national program would require $1,033,200,000 to retrofit the approximately 1.72 million tractors without a ROPS in the US [NASS, 2008].

Limitations

The CPS used as the denominator in this study has some limitations. First, these employment estimates were based on the ''primary industry'' of the employed person, which undercounts part-time farmers and farm workers who work on a farm as a secondary job. Second, because the CPS is administered by telephone, it likely undercounts farm workers who do not have a telephone, or are transient in nature. The impact of these undercounts is not readily apparent.

Another limitation is that this study calculated employment based on the average annual number of workers rather than the number of hours worked. Ruser [1998] previously reported that incident rates for older workers would be under estimated if based on the number of workers because older workers tend to work less hours. If hours worked were used in this study, the rates and rate-ratios for workers 55 years of age and older would likely be higher, suggesting that the relative risks presented here for these older workers are conservative.

The regional comparisons provided in this work also have some underlying limitations. The regions encompass several states, and the overall regional rate may mask large differences in overturn fatality rates between states within each region. Finally, these analyses do not reflect farm workers hired through farm labor contractors. Because these workers are not directly hired by farm operators, contract workers are captured under the agricultural services industry, not the agricultural production industry. It is possible that contract farm workers have a higher tractor overturn fatality risk than observed for farm workers directly hired by farm operators.

Summary

The results of this study suggest that farm family members, farmers and farm workers over the age of 55 years, farmers and farm workers on crop farms, or farmers and farm workers located in the Northeast, South, and Midwest regions of the US have a higher risk of fatal tractor overturns. Future interventions, such as ROPS retrofit incentive programs, should consider these high-risk populations. Finally, more research is needed to identify those factors that continue to place farmers and farm workers on crop farms at higher risk for tractor overturn deaths compared to that seen on livestock operations.

REFERENCES

Allen R, Harris G. 2005. What we know about the demographics of U.S. farm operators. USDA website: http://www.agcensus.usda.gov/Publications/2002/Other_Analysis/index.asp. Last accessed May5, 2009.

Arcury TA. 1997. Occupational injury prevention knowledge and behavior of African-American farmers. Hum Org 56(2):167–173.

Arndt JF. 1971. Roll-over protective structures for farm and construction tractors—A 50-year review. In: Society of Automotive Engineers, Earthmoving Industry Conference, Peoria, IL, 5–7 April.

ASAE Standards. 1985. S318.10. Tractor roll-over protection, 32nd edition. 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. 2009a. Fatal Occupational injuries, employment, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, 2007. Washington DC: Department of Labor, Bureau of

Labor Statistics. BLS Website: http://www.bls.gov/iif/oshwc/cfoi/cfoi_rates_2007.pdf. Last accessed May6, 2009.

BLS. 2009b. Chapter 9: Part III, Census of Fatal Occupational Injuries. In: BLS handbook of methods. Washington, DC: Department of Labor, Bureau of Labor Statistics. BLS website: http://www.bls.gov/opub/hom/pdf/homch9.pdf. Last accessed May5, 2009.

BLS. 2009c. Chapter 1: Labor force data from the Current Population Survey. In: BLS handbook of methods. Washington, DC: Department of Labor, Bureau of Labor Statistics. BLS website: http://www.bls.gov/opub/hom/pdf/homch1.pdf. Last accessed May5, 2009.

BLS. 2009d. Census of Fatal Occupational Injuries news releases: Years 1994-2002 (USDL-95-288, USDL-96-315, USDL-97-266, USDL-98-336, USDL-99-208, USDL-00-236, USDL-01-261, USDL-02-541, USDL-03-488). Washington DC: Department of Labor, Bureau of Labor Statistics. BLS website: http://www.bls.gov/iif/osh_nwrl.htm#cfoi. Last accessed May5, 2009.

Bobick TG, Jenkins EL. 1992. Agricultural-related fatalities: 1986–1988. In: Kumar S, editor. Advances in industrial ergonomics and safety IV. Philadelphia, PA: Taylor and Francis. p 121–128.

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

Cole HP, Myers ML, Westneat SC. 2007. Frequency and severity of injuries to operators during overturns of farm tractors. J Agric Saf and Health 12(2):127–138.

Donham K, Osterburg D, Myers M, Lehtola C. 1998. Tractor risk abatement and control: The Policy Conference, September 10–12. Final Report. Iowa City: University of Iowa.

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.

Freeman SA. 1999. Potential impact of a ROPS retrofit policy in central Iowa. J Agric Saf Health 5(1):1–18.

Gale HF Jr. 1994. Longitudinal analysis of farm size over the farmer's life cycle. Rev Agric Econ 16:113–123.

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.

Hallman E. 2005. ROPS retrofitting: Measuring effectiveness of incentives and uncovering inherent barriers to success. J Agric Saf Health 11(1):75–84.

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.

Harris JR, McKenzie EA Jr, Etherton JR, Cantis DM. 2002. Designing cost effective rollover protective structures (CROPS) at NIOSH. Proc NIFS Annual Conference. National Institute for Farm Safety.

Harris JR, Cantis DM, McKenzie EA Jr, Etherton JR, Ronaghi M. 2005. Commercialization of cost effective rollover protective structures (CROPS). Proc NIFS Annual Conference. National Institute for Farm Safety.

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.

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.

Karlson T, Noren J. 1979. Farm tractor fatalities: The failure of voluntary safety standards. Am J Public Health 69(2):146–149.

Kelsey TW, Jenkins PL. 1991. Farm tractors and mandatory roll-over protection retrofits: Potential costs of the policy in New York. Am J Public Health 81(7):921–923.

Lehtola CJ, Marley SJ, Melvin SW. 1994. A study of five years of tractor related fatalities in Iowa. Appl Eng Agric 10(5):627–632.

Loringer KA, Myers JR. 2008. Prevalence of ROPS-equipped tractors on US farms, 2001 and 2004. J Saf Res 39(5):509–517.

May JJ. 2008. Addressing the problem of tractor overturn fatalities. Sixth International Symposium: Public Health and the Agricultural Rural Ecosystem, October 19-23, 2008, Saskatoon, SK (Can). Saskatoon, SK (Can): Canadian Centre for Health and Safety in Agriculture.

May JJ, Sorensen JA, Burdick PA, Earle-Richardson GB, Jenkins PL. 2006. Rollover protection on New York tractors and farmers' readiness for change. J Agric Saf Health 12(3):199–213.

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

Murphy DJ. 1985. Pennsylvania farm fatalities during 1980–1984. Special Circular 319. University Park, PA: The Pennsylvania State University.

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

Myers JR. 2003. Tractor occupational safety and health update. Record of the tractor related injury and death meeting, Pittsburgh, PA, February 13–14, 2003. Morgantown, WV: National Institute for Occupational Safety and Health, p 5–23.

Myers JR. 2008. Tracking the use of Rollover Protective Structures on US farm tractors, 1993 to 2004. Sixth International Symposium: Public Health and the Agricultural Rural Ecosystem, October 19-23, 2008, Saskatoon, SK (Can). Saskatoon, SK (Can): Canadian Centre for Health and Safety in Agriculture.

Myers JR. 2009. Prevalence of ROPS-equipped tractors on minority operated farms in the US. Am J Ind Med 52(5):408–418.

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.

Myers ML, Cole HP, Westneat SC. 2008. Projected incidence and cost of tractor overturn-related injuries in the United States. J Agric Saf Health 14(1):93–103.

Myers JR, Layne LA, Marsh SM. 2009. Injuries and fatalities to U.S. farmers and farm workers 55 years and older. Am J Ind Med 52(3):185–194.

NASS. 2004. 2002 Census of Agriculture: United States Summary and State Data, Volume 1, Geographic Area Series Part 51–Table 55. Summary by Size of Farm: 2002. Washington, DC: US Department of

Agriculture, National Agricultural Statistics Service Report No. AC-02-A-51.

NASS. 2008. 2006 farm and ranch safety survey. Washington, DC: US Department of Agriculture, National Agricultural Statistics Service Report No. Sp Cr 3-1 (1-08).

NASS. 2009a. 2007 Census of Agriculture Demographics. Washington, DC: US Department of Agriculture, National Agricultural Statistics Service. USDA website: http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Fact_Sheets/demographics.pdf. Last accessed May 5, 2009.

NASS. 2009b. 2007 Census of Agriculture: United States Summary and State Data, Volume 1, Geographic Area Series Part 51–Table 7. Hired Farm Labor-Workers and Payroll: 2007. Washington, DC: US Department of Agriculture, National Agricultural Statistics Service.

NCASH. 1989. Agriculture at Risk, A Report to the Nation—Agricultural Occupational and Environmental Health: Policy Strategies for the Future. Iowa City, IA: Institute of Agricultural Medicine and Occupational Health, University of Iowa. Available at: http://www.public-health.uiowa.edu/AgAtRisk/. Last accessed May 5, 2009.

NIOSH. 1992. Papers and Proceedings of the Surgeon General's Conference on Agricultural Safety and Health. Cincinnati OH: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Pub. No. 92–105.

NIOSH. 1993. Public health focus: Effectiveness of rollover protective structures for preventing injuries associated with agricultural tractors. Morb Mortal Wkly Rep 42(3):57–59.

NIOSH. 2006. NIOSH Agriculture, Forestry, and Fishing Program National Academies Review, December 2006. Cincinnati OH: National Institute for Occupational Safety and Health. Available at: http://www.cdc.gov/niosh/nas/agforestfish/. Last accessed May 5, 2009.

NIOSH. 2008. NORA AgFF Sector Council National Agriculture, Forestry, and Fishing Agenda. Washington, DC: NIOSH. Available at: http://www.cdc.gov/niosh/nora/comment/agendas/AgForFish/. Last accessed July 24, 2009.

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

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

OSHA. 1976. Part 1928, Occupational Safety and Health Standards for Agriculture, Subpart C—Roll-over Protective Structures. Washington, DC: Department of Labor, Occupational Safety and Health Administration.

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

Pana-Cryan R, Myers ML. 2000. Prevention effectiveness of rollover protective structures—Part III: Economic analysis. J Agric Saf Health 6(1):57–70.

Personick ME, Windau JA. 1995. Characteristics of older workers' injuries. In: Fatal workplace injuries in 1993: A collection of data and analysis. Washington, DC: 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.

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.

Reynolds SJ, Groves W. 2000. Effectiveness of roll-over protective structures in reducing farm tractor fatalities. Am J Prev Med 18(1):63–69.

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.

SAS. 2003. SAS Version 9.1. Cary, NC: SAS Institute, Inc.

Sorensen J. 2006. A partnership to save lives—Rollover protection rebate program launched for New York farmers. Available at: http://www.nycamh.com/news/entry_detail.asp?article=139. May 5, 2007.

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.

Springfeldt B. 1996. Rollover of tractors—International experiences. Saf Sci 24(2):95–110.

Springfeldt B, Thorson J, Lee BC. 1998. Sweden's thirty-year experience with tractor rollovers. J Agric Saf Health 4(3):173–180.

Swenson E. 2004. National Agricultural Tractor Safety Initiative. Seattle, WA: Pacific Northwest Agricultural Safety and Health Center. Available at: http://depts.washington.edu/trsafety/files/Tractor_Initiative.pdf. Last accessed May 5, 2009.

Thelin A. 1998. Rollover fatalities—Nordic perspectives. J Agric Saf Health 4(3):157–160.

Virginia Farm Bureau. 2008. VFB Safety Programs: Farm Tractor Rollover Protective Structure (ROPS) Incentive. Available at: http://www.vafb.com/programs/safety/rops.htm. Last accessed May 5, 2009.

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.

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

Wilkins JR, Engelhardt HL, Bean TL, Byers MV, Crawford JM. 2003. Prevalence of ROPS-equipped tractors and farm/farmer characteristics. J Agric Saf Health 9(2):107–118.

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.