Statistics and Epidemiology of Tractor Fatalities—A Historical Perspective

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

Abstract

Farm tractors have historically been identified as the leading source of work-related farming deaths in the U.S. While data from the National Safety Council show that tractor-related deaths and fatality rates have decreased since 1969, current surveillance data indicate that an average of 218 farmers and farmworkers die annually from tractor-related injuries. Of these deaths, approximately 120 are associated with tractor overturns. Most of these deaths occur to tractor operators 65 years of age and older. Roll-over Protective Structures (ROPS) have been identified as the single best method of preventing tractor overturn-related deaths, yet only 38% of all tractors used on farms in the U.S. were equipped with ROPS in 1993. A major issue associated with increasing the use of ROPS on farm tractors is the cost of retrofitting ROPS on older tractors. The average cost to retrofit tractors with ROPS in the U.S. was estimated at $937, and a cost of at least $4 billion nationally in 1993.

Keywords. Agriculture, Tractors, Overturns, Occupational fatalities.

Farm tractors have historically been identified as the most common source of fatal occupational injury in farming (NSC, 1969-96). In addition, farm tractors are known to be a common source of nonfatal injuries in farming as well (Hoskins et al., 1988; Myers, 1997).

The objective of this report is to provide a review of what is known about tractor-related deaths occurring in farming, and to examine recent surveillance data to describe the present characteristics of these events. In addition, data on farm tractors in use on U.S. farms are reviewed, as well as the use of these tractor data in estimating the cost of retrofitting tractors in the U.S. with Roll-Over Protective Structures (ROPS).

Methods

Fatal Tractor Injury Data

Historical data on tractor fatalities occurring in the agricultural production industry were obtained from the National Safety Council (NSC) annual publication

---

Article originally presented at the Tractor Risk Abatement and Control Policy Conference, 10-12 September 1997, University of Iowa, Iowa City, Iowa.

The authors are John R. Myers, MSF, Karl A Snyder, ASAE Member Engineer, PhD, David L. Hard , ASAE Member, PhD, Virgil J. Casini, BS, Rosemary Cianfrocco, Judy Fields, and Linda Morton, BS, NIOSH, Morgantown, W.Va.

Corresponding author: John R. Myers, NIOSH, 1095 Willowdale Rd., Morgantown, WV 26505; tel: (304) 285-6005; fax: (304) 285-6047; e-mail: jom5@cdc.gov.

Accident Facts (NSC, 1969-96). Information on deaths per 100,000 farm tractors were available starting in 1969. Information included estimates by different types of tractor-related fatal events.

Tractor fatality data for the years 1990 through 1995 were obtained from two occupational surveillance systems: the National Traumatic Occupational Fatalities (NTOF) surveillance system and the Census of Fatal Occupational Injuries (CFOI) surveillance system. Both the NTOF and the CFOI collect data on occupational fatalities occurring in the United States. However, the two systems differ in how these cases are identified.

The NTOF is a death certificate-based surveillance system maintained by the National Institute for Occupational Safety and Health (NIOSH). The NTOF represents a statistical census of all death certificates that meet the following criteria: the age of the victim is 16 years or older; the cause of death is external, as defined by the International Classification of Diseases, 9th Edition (ICD-9) E-codes; and, the injury at work item is marked "yes" on the death certificate. Because the NTOF is based solely on death certificates, it undercounts the true number of occupational fatalities occurring in the U.S. Additional details on the NTOF surveillance system can be found in Jenkins et al.(1993).

The CFOI is a multiple record-based surveillance system maintained by the Bureau of Labor Statistics (BLS). The CFOI also represents a statistical census; however, because multiple record sources are used to identify cases, the CFOI has a higher capture rate of occupational deaths than the NTOF. There are no age restrictions on the CFOI for including an occupational fatality, although two source documents are necessary to include a fatality in the data base. Information on the source of the injury and the type of injury event causing the fatality are defined using the BLS Occupational Injury and Illness Coding Structure (OIICS)(NSC, 1996b). Additional information on the CFOI has been published by the U.S. Department of Labor (1997).

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

Fatality rates were calculated using employment estimates for the agricultural production industry from the BLS Current Population Survey (CPS), which is based on a monthly survey of households across the U.S. (Department of Labor, 1992). Employment estimates were matched, by year, to the NTOF and CFOI fatality data. Employment figures only included information on workers who defined farming as their primary industry of employment. By only having primary occupation information, fatality rates for both the NTOF and the CFOI are slightly inflated. Additional information on the CPS is available from the Department of Labor (1992).

Tractor Data

Data for tractors used on U.S. farms were obtained from the NIOSH Traumatic Injury Surveillance of Farmers (TISF) survey (Myers, 1997). The TISF is based on a mail survey of farm operators in the U.S. and collected information on farm lost-time injuries for the years 1993 through 1995. In addition to injury information, the TISF survey included questions on farm tractors used on farms. Tractor data included hours of use, age, make and model information, and whether tractors were equipped with ROPS. Based on these data, it was possible to estimate what it would cost to retrofit ROPS on the most common tractors that did not have ROPS in 1993. Details on the tractor data and the cost estimates for retrofitting ROPS is provided in Myers and Snyder (1995).

Results

Tractor-related Fatalities

Historical data on farming-related tractor fatalities per 100,000 tractors are provided in figure 1, covering the years 1969 through 1995. Data are provided for all tractor-related deaths, overturn deaths, and run-over deaths.

The main trend seen in these data is that farm-related tractor deaths have decreased over time in farming, falling from a high of 17.6 tractor deaths per 100,000 tractors in 1969 to a low of 6.8 deaths per 100,000 tractors in 1992. The same general pattern of decreasing deaths per 100,000 tractors was seen for both overturn deaths and run over deaths. However, the majority of the rate decrease for tractor deaths appears to have occurred between 1969 and 1981. The rate did not show a decreasing trend between 1981 and 1995, and may even have showed a slight increase during that 16-year time period.

Tractor fatality counts and fatality rates per 100,000 workers from the NTOF and the CFOI are presented in table 1. In general, the CFOI identified more tractor

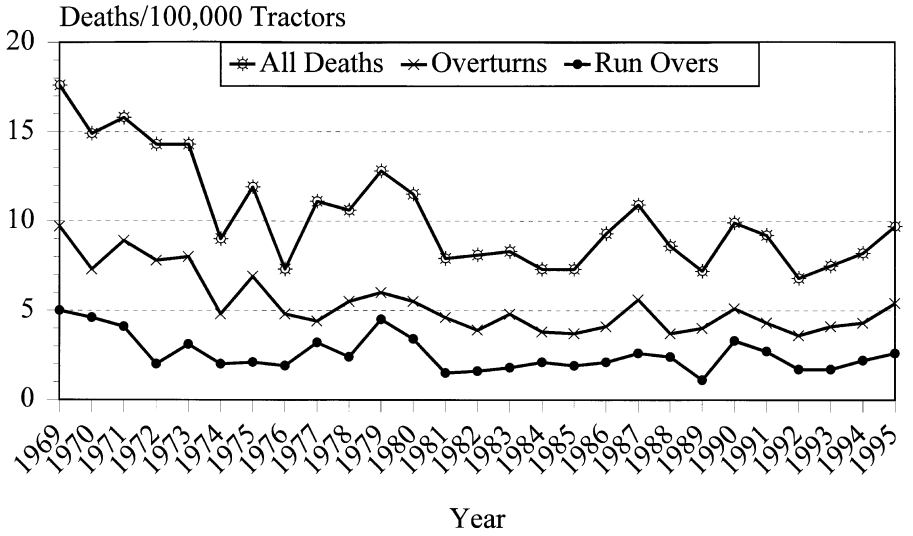

Figure 1–Tractor-related deaths per 100,000 tractors in use on agricultural operations, 1969-1995 (National Safety Council).

Table 1. Occupational farm tractor-related fatalities and rates per 100,000 workers based on the NTOF and CFOI surveillance systems by year of occurrence

	NTOF		CFOI	
Year	Deaths	Rate	Deaths	Rate
1990	119	5.3	---	---
1991	122	5.3	---	---
1992	123	5.4	190	8.4
1993	129	6.2	224	10.7
1994	---	---	251	10.8
1995	---	---	207	8.9
Average	123	5.5	218	9.7

fatalities in the agricultural production industry than the NTOF. For the years 1992 and 1993, the NTOF reported only 60.9% of the cases reported by the CFOI.

Despite the undercount of the NTOF, both surveillance systems indicated that farm tractors were the leading source of death within the farming industry. In the CFOI, farm tractors accounted for 37.5% of all agricultural production deaths between 1992 and 1995 (872 of 2,326 deaths), while the NTOF indicated that farm tractors accounted for 29.1% of all agricultural deaths identified between 1990 and 1993 (493 of 1,696 deaths).

Tractor Fatalities by Demographic Characteristics

The NTOF found that males were the most common victims of tractor-related deaths, accounting for 488 of the 493 deaths (99%), while the CFOI showed that males were the victims in 850 of its 872 tractor-related deaths (97.5%). Both systems showed that whites accounted for over 91% of all tractor-related deaths. African Americans accounted for 5% of the deaths in the NTOF and 4% of the deaths in the CFOI.

The distribution of farm tractor-related deaths by region of the United States is presented in table 2. The results from the NTOF and CFOI are similar in defining which region has the highest number of fatalities. The midwest and south regions of the U.S. clearly have the most fatalities. Fatality rates did differ between the two systems, however. Rates based on the CFOI found the northeast region of the United States had the highest incidence rate (15.4 deaths/100,000 workers), with the south and midwest regions having similar rates. The NTOF showed that the rates for the south, midwest, and northeast regions were essentially the same. Both systems found the western region of the United States to have the lowest fatality rates.

Table 2. Occupational farm tractor-related fatalities and rates per 100,000 workers, by region of the United States, based on the NTOF and CFOI surveillance systems*

	NTOF		CFOI	
Region	Deaths	Rate	Deaths	Rate
Northeast	33	5.8	88	15.4
Midwest	213	6.1	362	10.4
South	189	6.5	327	11.3
West	58	3.0	95	4.9

* NTOF data are for the years 1990-1993, and CFOI data are for the years 1992-1995.

Tractor-related Fatalities by Type of Event

The analysis of both surveillance systems gave the same general information on the type of events that lead to the tractor-related fatalities (table 3). For both data sets, tractor overturns were the leading type of injury event, followed by run overs. The CFOI data set identified vehicle collisions as being the third most common event, followed by victims being caught in or between objects, while the NTOF data set identified falling from vehicles as the third most common event. However, it is clear from both that the risk for tractor-related deaths drops dramatically after accounting for overturn and run over deaths.

These data also indicate that there are a high number of tractor-related fatalities occurring on public roadways. In the CFOI, 113 of the 872 tractor deaths were defined as highway transportation events (13%), while in the NTOF, 62 of the 493 deaths were highway transportation events (12.6%). Both systems found that tractor overturns were the leading type of injury event occurring on roadways: 63 deaths in the CFOI, and 34 deaths in the NTOF.

Overturn-related Fatalities

Because overturn fatalities consistently account for over 50% of all tractor related deaths, data related to these fatalities were examined in more detail. Table 4 provides NTOF and CFOI overturn deaths and rates per 100,000 workers by year. As with the numbers for all tractor fatalities, the overturn results show a pattern of numbers and rates that do not change greatly from year to year within a specific surveillance system. The fatality rate within production agriculture ranged from an annual

Table 3. Occupational farm tractor-related fatalities and rates per 100,000 workers, by type of injury event, based on the NTOF and CFOI surveillance systems*

	NTOF		CFOI	
Event*	Deaths	Rate	Deaths	Rate
Overturn (highway & non-highway)	265	3.0	475	5.3
Run over (highway & non-highway)	114	1.3	210	2.3
Fall from vehicle (highway & non-highway)	20	0.2	18	0.2
Caught in between objects	15	0.2	38	0.4
Vehicle collisions (highway & non-highway)	14	0.2	39	0.4
Collision with train	7	0.1	9	0.1
Collision with object (highway & non-highway)	4	<0.1	17	0.2
Other	54	0.6	66	0.7

* NTOF data are for the years 1990-1993, and CFOI data are for the years 1992-1995.

Table 4. Occupational farm tractor overturn fatalities and rates per 100,000 workers based on the NTOF and CFOI surveillance systems by year of occurrence

	NTOF		CFOI	
Year	Deaths	Rate	Deaths	Rate
1990	66	2.9	---	---
1991	58	2.5	---	---
1992	68	3.0	104	4.6
1993	73	3.5	124	5.9
1994	---	---	133	5.7
1995	---	---	114	4.9
Average	66	2.9	119	5.3

average 2.9 deaths per 100,000 workers using the NTOF to 5.3 deaths per 100,000 workers using the CFOI. The higher fatality rate seen for the CFOI is due to better identification of work-related cases by the CFOI, not because of any changes in employment in the agricultural production industry. As with tractor deaths in general, most overturn fatalities occurred to males (over 97% in both surveillance systems), and most victims were white (91% in the NTOF and 94% in the CFOI).

Regional figures for tractor overturn deaths also mirrored the general tractor fatality data (table 5). However, both the NTOF and the CFOI identified the Northeast region of the U.S. as the area with the highest fatality rate for tractor overturn deaths (3.9 deaths per 100,000 workers from the NTOF and 8.4 deaths per 100,000 workers the CFOI). Both identified the Western region of the U.S. as having much lower fatality rates from overturns compared to the other regions of the U.S.

Table 6 provides NTOF and CFOI overturn numbers and fatality rates by age groups. Both NTOF and CFOI show the same general trend of an increasing fatality rate from overturns with increasing age. Workers 65 years of age and older accounted for the highest number of fatalities and had the highest fatality rates in both surveillance systems. This age group accounted for approximately 40% of all overturn deaths, and had fatality rates 3.4 to 3.8 times the overall rate for overturn fatalities, suggesting that major reductions in overturn fatalities in the farming industry would be possible by preventing deaths to older farmers and farm workers.

Run-over-related Fatalities

Run-over events were mostly associated with the victim falling from the farm tractor and being run over by the tractor (105 deaths in the CFOI, and 51 deaths in the NTOF). The next most common event was pedestrians (i.e., bystanders run over

Table 5. Occupational farm tractor overturn fatalities and rates per 100,000 workers, by region of the United States, based on the NTOF and CFOI surveillance systems*

	NTOF		CFOI	
Region	Deaths	Rate	Deaths	Rate
Northeast	23	3.9	48	8.4
Midwest	116	3.3	211	6.1
South	103	3.5	180	6.2
West	23	1.2	36	1.9

* NTOF data are for the years 1990-1993, and CFOI data are for the years 1992-1995.

Table 6. Occupational farm tractor overturn fatalities and rates per 100,000 workers, by age group, based on the NTOF and CFOI surveillance systems

	NTOF		CFOI	
Age Group	Deaths	Rate	Deaths	Rate
16-24 years	17	1.4	32	2.6
25-34 years	28	1.5	40	2.1
35-44 years	32	1.7	53	2.8
45-54 years	31	2.2	69	4.8
55-64 years	45	3.2	91	6.3
65 years +	112	10.9	190	18.1

* NTOF data are for the years 1990-1993, and CFOI data are for the years 1992-1995.

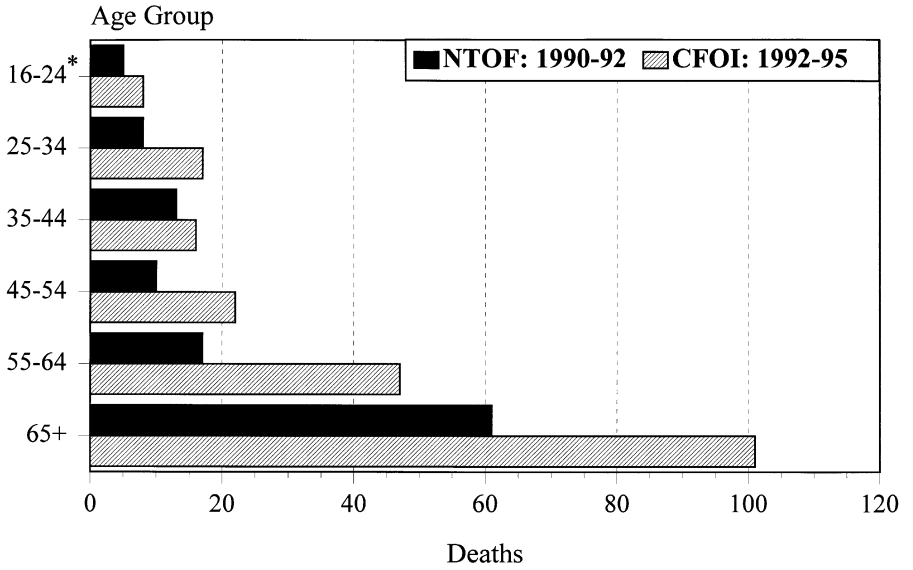

Figure 2–Agricultural deaths due to tractor run overs by age group based on the NTOF and CFOI surveillance systems.

by tractors which they were not operating) being run over by tractors in a non-highway setting (56 deaths in the CFOI, 42 deaths in the NTOF).

Figure 2 provides run over fatalities by age group for the two surveillance systems. Both surveillance systems found workers 65 years of age and older accounted for the most run over deaths. In both the NTOF and CFOI, these older workers accounted for the most pedestrian deaths, deaths due to victims falling from and being run over by the tractor, and deaths caused by tractors running over the victim when the tractor was not in normal use (e.g., being run over when a parked tractor rolls unexpectedly, being run over while by-pass starting the tractor).

Farm Tractor Demographics

Farm tractor demographic information from the NIOSH TISF survey were previously presented by Myers and Snyder (1995). One finding included that there were an estimated 4.8 million farm tractors in use on U.S. farms in 1993. This corresponded to an average of 2.3 tractors per farm. The average age of tractors was 22.8 years, and each tractor was used an average of 307 h per year.

Of these tractors, 1.8 million had Roll-Over Protective Structures (ROPS) in 1993. Of the remaining 3.0 million tractors that lacked ROPS, approximately 600,000 tractors had no commercial ROPS designs available based on reports from ROPS manufacturers in 1993. Figure 3 provides the distribution of tractors by age groups, and the proportion of tractors within an age group that had ROPS, as reported by the farm operator in 1993. It is clear from this graph that ROPS use decreased dramatically with the age of the farm tractor. Less than half of all farm tractors 20 to 24 years of age had ROPS in 1993, while tractors over 30 years of age were essentially without ROPS. A second observation from this graph is the longevity of farm tractors. Over 600,000 tractors, 40 years of age or older, were still in use on farms in 1993, of which nearly 90,000 were over 50 years of age.

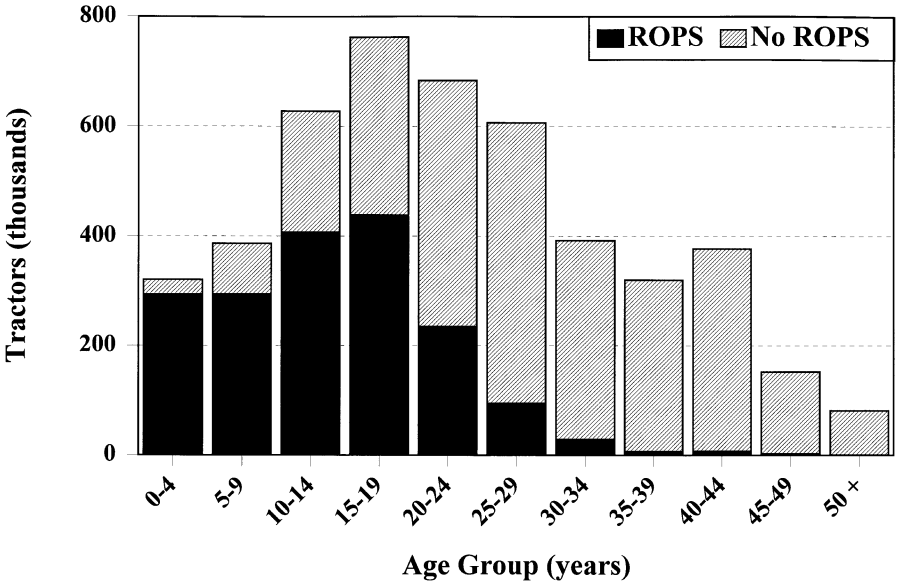

Figure 3–Number of tractors in use on agricultural production operations, by age group and presence of ROPS, 1993 (NIOSH).

Table 7. The 10 most common farm tractors in use on U.S. farms without ROPS, 1993

Make/Model of Farm Tractor	Estimated Number Without ROPS
John Deere 4020	100,300
Farmall M	76,800
Ford 8N	67,700
Farmall H	65,900
John Deere 3020	56,000
Ford 3000	43,000
Allis Chalmers D17	41,000
Ford 4000	39,900
Massey Ferguson 135	38,600
Farmall 560	35,000

Table 7 presents farm tractor estimates, by the make and model, for the 10 most commonly used tractors without a ROPS for the calendar year 1993. In this list, five tractor models date from the 1940s and 1950s (Allis Chalmers D17, Farmall H, Farmall M, Farmall 560, and Ford 8N). The remaining models were manufactured in the 1960s or early 1970s. These 10 makes and models accounted for approximately 19% of all tractors used on farms that were not fitted with ROPS.

Table 8 presents farm tractor estimates, by the make and model, for the 10 most commonly used tractors not fitted with a ROPS, and which did not have a ROPS commercially available in 1993. As with table 7, these tractors are relatively older models that date back to the late 1930s through the mid-1950s. These 10 tractors represent 8% of all tractors in use on farms which did not have ROPS in 1993.

These data are based on 1993 information and do not reflect changes that have occurred in ROPS availability in recent years. For example, the Ford 9N and the Case 930 listed on table 8 now have ROPS designs available for them, based on

Table 8. The 10 most common farm tractors in use on U.S. farms not fitted with a ROPS, and do not have a commercial ROPS design available for them, 1993

Make/Model of Farm Tractor	Estimated Number Without ROPS
Allis Chalmers D17	41,000
Farmall 560	35,000
Allis Chalmers WD45	31,800
Allis Chalmers WD	22,200
John Deere A	21,800
John Deere B	21,600
Ford 9N	16,200
Case 930	15,300
John Deere 730	15,300
John Deere 60	15,000

information from a new ROPS guide (National Farm Medicine Center, 1997). However, it should be noted that the Farmall M and Farmall H listed on table 7, which were reported as having a ROPS available in 1993, do not have a ROPS design listed in the 1997 guide. In general, while an estimated 30,000 to 40,000 tractors have ROPS available based on 1997 ROPS listings which did not have ROPS in 1993, nearly 200,000 tractors no longer have ROPS available today that were identified as having a ROPS available in 1993.

Cost of Retrofitting Farm Tractors With ROPS

Because farm tractor overturns have remained the leading cause of occupational deaths in the agricultural production industry for several decades, much emphasis has been placed on prevention methods for these deaths. The main prevention method is the use of a Roll-Over Protective Structure (ROPS). ROPS, when used in conjunction with seat belts, have been shown to be highly effective in preventing deaths to tractor operators during an overturn event (Hanson, 1966; Thelin, 1990). However, based on 1993 tractor estimates presented earlier, 3 million farm tractors (62.5%) are not equipped with ROPS.

Myers and Snyder (1995) used the TISF tractor data to estimate the cost of retrofitting tractors in the U.S. based on the calendar year 1993. In addition, they estimated the cost per life saved of retrofitting a large number of tractors. The cost estimates and number of lives saved by retrofitting tractors were limited to those specific makes and models of farm tractors for which an estimated 10,000 units, or more, existed without ROPS.

The results of this analysis showed that there were an estimated 1.6 million tractors in use in 1993, without ROPS, that met the criteria for the study (Myers and Snyder, 1995). Of these tractors, 1.3 million were identified as having a commercial ROPS design available. The average price for a ROPS for these tractors was $937.00, which would require an investment of $1.2 billion to retrofit these 1.3 million tractors. Additionally, the cost per life saved for retrofitting these farm tractors was estimated at $825,000 (Myers and Snyder, 1995).

Discussion and Conclusions

Trends of Tractor-related Deaths

The statistics from the National Safety Council (fig. 1) clearly show a reduction of tractor-related fatality rates in the agricultural production industry during the 1970s, yet seem to indicate that no substantial rate reductions have occurred since

the beginning of the 1980s. This lack of change in tractor-related deaths through the 1980s is reflected in the overall fatality rate for agricultural production during that decade. Based on the NTOF surveillance system, agricultural production fatality rates remained fairly constant between 1980 and 1989 (Myers and Hard, 1995). A similar pattern was reported in the Accident Facts publication produced by the National Safety Council for this same time period.

What is not clear is why the dramatic decreases that occurred during the 1970s did not continue into the 1980s and 1990s. The 1970s did represent a good economic time for farms (U.S. Department of Agriculture, 1998). This dynamic time in U.S. agriculture included a general expansion of farm size, changes in the way farming was conducted (e.g., increased use of herbicides for weed control rather than cultivating), and tax incentives to invest in farming operations. This resulted in an increase in the purchase of new farm equipment during these years. This increase in tractor purchases is reflected in the high number of tractors 15 to 19 years of age (i.e., tractors manufactured between 1974 and 1978) seen in figure 3. These farm tractors tend to be large, both in size and horsepower, have wide-set wheels on their front ends, and an increased likelihood of being equipped with ROPS (fig. 3). They replaced older tractors (most likely those manufactured in the 1940s and 1950s) that were smaller, consisting of a mix of wide front-end and tricycle designs, and were almost completely without ROPS. Thus, tractors manufactured and purchased during the 1970s may have contributed to the decrease in tractor-related fatality rates during this decade.

The agricultural economy declined during the 1980s (U.S. Department of Agriculture, 1998), which likely lead to the decreased demand for new farm equipment. This is seen in the reduced number of farm tractors reported in the zero to 9 years of age groups shown in figure 3. While a number of new tractors entered the tractor population during the 1980s, they were primarily larger tractors, again equipped with cabs, and may have been replacing large, cab-equipped tractors bought in the 1970s. Since the large tractors from the 1970s already had a large percentage of ROPS, their replacement by large tractors manufactured in the 1980s may have had less impact on reducing tractor-related fatalities in the 1980s and 1990s.

Smaller utility tractors, which traditionally are fitted with ROPS frames rather than cabs, did not begin to have a large number of ROPS placed on them until the late 1980s (Myers and Snyder, 1995). Thus, their contribution to the tractor-related fatality risk would likely have remained unchanged since the 1960s, suggesting that much of the tractor overturn risk is associated with these smaller tractors. Limited data from Georgia (Smith et al., 1983) and Iowa (Lehtola, 1992) do suggest that older, smaller horsepower tractors are associated with most tractor overturn deaths. If these data are representative of the national experience, then it may take several years for the number of ROPS-equipped utility tractors to become large enough to have a major impact on tractor-related fatalities in the U.S.

Current Statistics

Surveillance information from the NTOF and CFOI surveillance systems suggest that the CFOI is more sensitive in identifying occupational tractor-related fatalities. Because the CFOI uses multiple records to identify cases, it includes cases that would not be identified solely with a death certificate (the only source used by NTOF). In addition, CFOI cases are coded to the current occupation and industry of the victim, whereas NTOF is coded to the usual occupation and industry. This improves the likelihood of a victim who was farming, but held a previous job, being correctly

identified as a farming-related death. Finally, CFOI has no age restrictions which allows for the identification of deaths to farm workers less than 16 years of age.

Despite the better case ascertainment of the CFOI, both surveillance systems provide the same general conclusions about tractor-related fatalities occurring in the agricultural production industry.

Both systems identified tractor overturns as the leading cause of death, with run overs being second. Both systems indicated the same general proportion of overturn deaths that occurred on public roadways. The CFOI and the NTOF found the same general patterns with respect to the age of the victim and their relative risk for tractor overturn fatalities. Finally, both systems found the same general patterns for run over fatalities: the leading event involving victims falling from tractors and being run over by the tractor and towed equipment, followed by pedestrians being run over by tractors.

Overturn-related Fatalities

Deaths due to tractor overturns have long been identified as a major concern for the agricultural production industry. The identification of the problem dates back to at least 1923 (Hoffman, 1923), while the physical dynamics of the problem were described by McKibben in the late 1920s (1927). Actual documentation of farming-related deaths due to tractor overturns were described by Forney in the early 1930s (1931). The magnitude of the problem has been tracked by the NSC since the late 1960s (fig. 1), and there have been many State reports documenting the frequency of tractor overturn deaths during the 1980s and 90s (Lehtola, 1992; Murphy, 1990; Wilkinson and Field, 1990; Murphy, 1985; Purschwitz and Field, 1986; Smith et al., 1983).

Current surveillance data from the NTOF and CFOI show that overturns continue to be the leading cause of occupational farming deaths for the years 1990 through 1995. These data also make it clear that tractor overturn fatalities are a major hazard for older tractor operators. Farmers and farm workers 65 years of age or older account for the largest portion of these overturn deaths (approximately 40%). If workers 55 years of age or older are included, older farmers account for nearly 60% of all overturn deaths (table 6). Similar findings were reported in State-level studies (Murphy, 1985; Purschwitz and Field, 1986; Smith et al., 1983).

Given the dominance of older workers in these data, tractor overturn prevention programs will need to target this special population to help produce significant reductions in tractor overturn fatalities. In addition, better information is needed to clarify why these older operators are at such high risk. While there have been hypotheses for the increased risk of older tractor operators (e.g., physical limitations of the operator, medication effects reducing equipment operation skills, task assignment of older workers, older equipment use by older workers), no clear data exists to define the effects of these potential factors on the actual risk of these workers. Determining the effects of these issues on the risk of older tractor operators will require well-planned epidemiologic studies.

Run-over-related Fatalities

Run-over fatalities occur predominately to workers 65 years of age and older (fig. 2), as do overturn deaths. The CFOI surveillance data found 47.9% of run over deaths were to workers 65 years of age and older, while NTOF found this age group accounted for 53.5% of tractor run over deaths. If workers 55 years of age and older are considered, these percentages rise to 70.1% and 68.4% respectively.

The most common cause of these run over deaths is the operator, or in some instances an extra rider, falling off the tractor and being struck by the tractor, or some towed implement. Preventing these types of fatalities requires the operator of the tractor to wear a seat belt. However, tractor manufacturers do not recommend operators wear a seat belt on a tractor unless it is equipped with a ROPS (Bellinger, 1994). A person wearing a seat belt on a tractor without ROPS increases his risk of fatal injury should the tractor overturn.

A second means of preventing such fatalities is to not permit extra riders on the farm tractor because there typically is not a seat provided for the extra rider on the tractor. Not having a seat increases the extra rider's risk of falling from the moving equipment (Bellinger, 1994). At this point, alternative solutions to the extra rider issue include the use of additional seats in tractors with cabs. However, this is a controversial solution (National Institute for Farm Safety, 1994).

Other causes of run over deaths include victims by-pass starting farm tractors while the tractor is in gear. This involves starting the tractor by contacting a piece of metal across the terminals of the tractor starter. When this is done, all safety systems that prevent the tractor from starting while it is in gear are by-passed (Bellinger, 1994). If the tractor is in gear, it will move forward and run over the person doing the by-pass start. Tractor manufacturers have provided retrofit starter covers to prevent by-pass starting, and have developed educational campaigns to warn farmers of the risk of by-pass starting. However, there are no data to indicate how successful these programs have been.

ROPS Use and the Cost of Retrofitting ROPS on Farm Tractor

With tractor overturns presenting a major risk to tractor operators, an emphasis was placed on identifying an effective engineering control to eliminate or reduce this risk (Arndt, 1971). This emphasis led to an interest in Roll-over Protective Structures (ROPS) during the 1950s. The interest in ROPS was not limited to the U.S., with the first designs and test methods for ROPS cabs coming from Sweden (Moberg, 1959). The Swedish efforts resulted in the first mandatory implementation of ROPS on new tractors sold in that country in 1959. A later requirement of ROPS use on all agricultural tractors in Sweden has nearly eliminated overturn deaths in that country (Thelin, 1990).

ROPS development in the U.S. also gained momentum in the late 1950s. The first real application of ROPS, however, did not occur in the agricultural production industry. It occurred in North Dakota during the early 1960s as a means of preventing overturn deaths to tractor operators mowing highway banks and median strips. Based on this North Dakota Department of Highways initiative, the usefulness of ROPS were clearly demonstrated (Hanson, 1966). This demonstration led to the first voluntary ROPS standard by the American Society of Agricultural Engineers (ASAE) in 1967 (ASAE, 1967).

Since the initial ASAE ROPS standard, ROPS have been promoted as the single best method of preventing tractor overturn-related deaths. Yet, this engineering intervention is clearly not being used universally in the U.S. Data for 1993 show the general lack of ROPS use on U.S. farm tractors, with nearly two out of every three tractors not having ROPS (Myers and Snyder, 1995). These data also show that tractors over 20 years of age in 1993 were almost completely without ROPS. While data have not been analyzed completely, these older tractors appear to be primarily under 60 horsepower, which are the tractors that present the greatest risk for overturn fatalities (Lehtola, 1992; Smith et al., 1983).

Suggested reasons for the low percentage of ROPS use on U.S. farm tractors include a perception that ROPS interfere with typical agricultural operations, that ROPS prevent tractors from entering certain buildings, or that the operator does not perceive the benefit from having the ROPS on the tractor. An additional major factor is the cost of retrofitting older tractors with ROPS.

Published cost estimates (based on the cost of the ROPS only) for retrofitting farm tractors range from $652 to $937 (Kelsey and Jenkins, 1991; Myers and Snyder, 1995). Both of these estimates exclude cost estimates for retrofitting tractors that do not have a ROPS design commercially available. The ROPS prices for tractors that lack commercially available designs would be expected to be higher than for those tractors which already have commercial ROPS available. Given these ROPS cost estimates, farm operators may continue to view retrofitting tractors as too expensive.

Tractor manufacturers have been addressing the issue of placing ROPS on tractors and the cost of ROPS for old tractors. In 1985, ASAE adopted a voluntary standard to include ROPS on all new tractors manufactured in the U.S., excluding tractors designed for low clearance applications (ASAE, 1985). The impact of this standard is seen in figure 3, with ROPS use on tractors zero to 5 years of age being nearly 92%. Since the mid-1990s, all major manufacturers of farm tractors have implemented programs that provide ROPS at cost for older tractor models that were originally designed for ROPS. These initiatives should increase use of ROPS over time, although it is unclear whether the price reductions and other financial incentives for retrofitting ROPS will be sufficient to motivate farmers to retrofit older tractors (Lawrence and Bean, 1992).

Despite the installation of ROPS on new tractors and cost incentives to retrofit older tractors with ROPS, tractor overturns continue to be a major cause of mortality for farmers and farm workers. While progress has been achieved since 1969, overturn-related fatality rates have not decreased during the 1990s. This lack of improvement in fatality rates, coupled with the large number of older tractors in use without ROPS, and the cost of retrofitting ROPS, suggest that it is unlikely tractor fatalities will decrease substantially in the near future unless some method is found to retrofit the nearly 3 million tractors that are still operated without ROPS on U.S. farms.

References

ASAE Standards, 15th Ed. 1967. S305.2. St. Joseph, Mich.: ASAE.

_____. 1967. S206.2. St. Joseph, Mich.: ASAE.

ASAE Standards, 33rd Ed. 1985. S318.10, Section 9. Tractor roll-over protection. St. Joseph, Mich.: ASAE.

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

Bellinger, P. L. 1994. 4th Ed. Farm and Ranch Safety Management. Moline, Ill.: Deere and Company.

Department of Commerce. 1992. 1990 Census of Population and Housing: Alphabetic Index of Industries and Occupations. Washington, D.C.: Bureau of the Census.

Department of Labor. 1992. BLS handbook of methods. Bulletin 2414. Washington, D.C.: Bureau of Labor Statistics.

_____. 1997. Fatal workplace injuries in 1995: A collection of data and analysis. Report No. 913. Washington, D.C.: Bureau of Labor Statistics.

Forney, R. L. 1931. Accident hazards in agriculture. Agricultural Engineering.

Hanson, W. I. 1966. Experiences in North Dakota with safety frames on highway tractors. In FIEI-NIFS Engineering Seminar. Park Ridge, Ill.: Farm and Industrial Equipment Institute.

Hoffman, A. H. 1923. The tendency of tractors to rise in front; causes and remedies. Univ. of California College of Agriculture Circular No. 267. Davis, Calif.: Univ. of California.

Hoskins, A. F., T. A. Miller, W. D. Hanford, and S. R. Landes. 1988. Agricultural tractor-related injuries: A 35-state summary. NIOSH Contracted Report DSR-87-0941. Morgantown, W. Va.: NIOSH.

Jenkins, E. J., S. M. Kisner, D. E. Fosbroke, L. A. Layne, N. A. Stout, D. N. Castillo, P. M. Cutlip, and R. Cianfrocco. 1993. Fatal Injuries to Workers in the United States, 1980-1989: A Decade of Surveillance-National Profile. DHHS (NIOSH) Pub. No 93-108. Cincinnati, Ohio: NIOSH.

Kelsey, T. W., and P. L. Jenkins. 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.

Lawrence, T. J., and T. L. Bean. 1992. Rewards and regulations: Motivating farmers to adopt ROPS. ASAE Paper No. 92-5508. St. Joseph, Mich.: ASAE.

Lehtola, C. J. 1992. An investigation of tractor-related farm accidents in Iowa during 1988-1990. PhD thesis. Ames, Iowa: Iowa State University.

McKibben, E. G. 1927. Kinematics and dynamics of the wheel type tractor: Part V, Stability. Agricultural Engineering.

Moberg, H. A. Son. 1959. Tractor safety cabs, test methods and experiences gained during ordinary farm work in Sweden. Uppsala, Sweden: National Swedish Testing Institute for Agricultural Machinery.

Murphy, D. J. 1985. Pennsylvania farm fatalities during 1980-84. Pennsylvania State Univ. Extension Circular 319. University Park: Pennsylvania State Univ.

_____. 1990. Pennsylvania farm fatalities during 1985-89. Pennsylvania State Univ. Extension Circular 390. University Park: Pennsylvania State Univ.

Myers, J. R., and D. L. Hard. 1995. Work-related fatalities in the agricultural production and services sectors, 1980 through 1989. Am J Industrial Med 27(1): 51-63.

Myers, J. R., and K. A. Snyder. 1995. Roll-Over Protective Structure use and the cost of retrofitting tractors in the United States, 1993. J Agric Safety and Health 1(3): 185-197.

Myers, J. R. 1997. Injuries among farm workers in the United States, 1993. DHHS (NIOSH) Publication No. 97-115. Cincinnati, Ohio: NIOSH

National Farm Medicine Center. 1997. A Guide to Agricultural Tractor Rollover Protective Structures. Marshfield. Wis.: National Farm Medicine Center.

National Institute for Farm Safety. 1994. Panel presentation of the tractor passenger seat sub committee. Presented at the National Institute for Farm Safety 1994 Summer Meeting, Bloomington, Ill., 12-16 June.

National Safety Council. 1969-96 Ed. 1969-96. Accident Facts. Itasca, Ill.: National Safety Council.

_____. 1996. ANSI Z16.2-1995. American national standard for information management for occupational safety and health. Itasca, Ill.: National Safety Council.

Office of Management and Budget. 1987. Standard Industrial Classification Manual — 1987. Washington, D.C.: Office of Management and Budget.

Purschwitz, M. A., and W. E. Field. 1986. Farm-related fatalities involving persons 60 years of age and older. NIFS Paper No. 86-6. Columbia, Mo.: National Institute for Farm Safety.

Smith, J. D., D. L. Rogers, and R. K. Sikes. 1983. Farm-tractor associated deaths — Georgia. Morbidity and Mortality Weekly Report 32(37): 1.

Thelin, A. 1990. Epilogue: Agricultural occupational and environmental health policy strategies for the future. Am J Industrial Med 18: 523-526.

U.S. Department of Agriculture. 1998. All farm index: prices received and prices paid, all items, U.S., 1976-1998, Annual (http://www.usda.gov/nass/aggraphs/allprpd.htm). Washington, D.C.: National Agricultural Statistics Service.

Wilkinson, T. L., and W. E. Field. 1990. Summary of Indiana's farm work-related fatalities for 1980-1989 with comparison to 1970-1979. NIFS Paper No. 90-4. Columbia, Mo.: National Institute for Farm Safety.