A Survey of Tractors and Rollover Protective Structures in Washington State

P. Spielholz, T. Sjostrom, R. E. Clark, D. A. Adams

ABSTRACT. *A survey of farms in Washington State was conducted to determine tractor characteristics and the presence of rollover protective structures (ROPS) in a state with more inclusive rules on tractor retrofitting than federal regulations. A total of 544 valid surveys were completed from a proportional random sample across different types of farms. Responders indicated that 58% of tractors overall were equipped with ROPS, and 42% of the tractors without ROPS were exempt from the state rules. Seatbelts on tractors equipped with ROPS were reportedly used "sometimes" or more 30% of the time, and 17% of these tractors had no seatbelt installed. Tractors used for row crop farming were significantly more likely to be equipped with ROPS than those used for tree, vine, or hops farming. Older tractors were used for fewer hours, were less likely to be ROPS-equipped, and were less likely to be operated while wearing a seatbelt. The results were consistent with a positive effect of the Washington State ROPS requirements, demonstrated by the increased percentage of ROPS-equipped pre-1976 tractors, as compared to other states, and by the difference between ROPS-equipped tractors in exempt and non-exempt types of farming. The results point to the need for prevention activities to increase seatbelt use on ROPS-equipped tractors, and for further development of practical protection for tractors operating under overhead obstacles.*

Keywords. *Rollover protective structures, ROPS, Survey, Tractor, Washington.*

Tractor rollovers remain one of the common fatal hazards present on farms in the U.S. It is estimated that between 75-150 agricultural workers die each year in tractor rollover incidents (NSC, 1993; NIOSH, 2004; CDC, 1993). Washington State Fatality Assessment and Control Evaluation (FACE) program data identified ten fatal tractor rollovers between 1998-2005. No farmer died during this period on a tractor that was equipped with a rollover protective structure (ROPS). The effectiveness of ROPS has been documented in Sweden by Thelin (1990) and in the U.S. by Lehtola et al. (1994), Myers et al. (2005), and Reynolds and Groves (2000). Researchers have calculated that tractor-related fatalities can be reduced in the U.S. if a funded campaign were introduced to retrofit existing tractors with ROPS (Myers and Snyder, 1995; Myers, 2000; Myers and Pana-Cryan, 2000). Studies have estimated that the cost of retrofitting tractors with ROPS would cost approximately $500,000 to $900,000 per life saved, which is comparable to other safety interventions (Pana-Cryan and Myers, 2000; Myers and Snyder, 1995).

Previous studies have shown that the majority of agricultural tractors used in the U.S. do not have rollover protection. A survey by Myers and Snyder (1995) found that 62% of tractors used on U.S. farms lacked ROPS, while a more recent survey by Helmkamp et al. (2004) found that 65% of tractors in West Virginia were equipped with ROPS. In

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The authors are **Peregrin Spielholz,** Principal Investigator, **Tom Sjostrom,** Field Investigator, **Randy E. Clark,** Surveillance Data Manager, and **Darrin A. Adams,** Data Manager, Washington Department of Labor and Industries, SHARP Program, Olympia, Washington. **Corresponding author:** Peregrin Spielholz, Box 44330, Olympia, WA 98504-4330; phone: 360-902-5691; fax: 360-902-5672; e-mail: spip235@lni.wa.gov.

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1997, results of surveys from four states were presented (CDC, 1997) covering the years 1992-1997. Across sampled farms from Iowa, New York, Kentucky, and Ohio, less than 40% were equipped with ROPS. More recent surveys also show that ROPS use for tractors manufactured before 1985 remains well below 50% (Marlenga et al., 2004; Wilkins et al., 2003).

The Occupational Safety and Health Administration (OSHA) has a rule requiring tractors manufactured after October 1976 to be equipped with ROPS unless it is not feasible due to different conditions of use. U.S. manufacturers were producing many tractors with ROPS as an optional feature by the 1970s. By voluntary agreement, manufacturers have been producing all tractors fitted with ROPS in the U.S. since 1985. Thus, a higher percentage of tractors are expected to be fitted with ROPS each year as older tractors without ROPS are retired and replaced with newer models. However, many older tractors are used on farms and will continue to be used for many years.

Washington State is unique in that it is the only state with a rule requiring farms to retrofit tractors with ROPS even if manufactured before 1976 (WAC, 1997). The Washington Industrial Safety and Health Act (WISHA) enforcement division also applies rules to farms with less than 11 employees, unlike OSHA. Like OSHA rules, certain tractors, such as those involved in tree, vine, or hops farming, are exempted when they demonstrate difficulties making ROPS compatible with low overhead clearances involved in these activities, or with accessory equipment.

The National Institute of Occupational Safety and Health (NIOSH) has adopted a national tractor safety initiative (NIOSH, 2004) that aims to identify solutions and promote interventions aimed at reducing tractor-related fatalities on U.S. farms. Identified as a part of this effort was the need to evaluate the impact of the Washington State tractor protection rules on the adoption of ROPS on tractors. In the absence of a preferred pre- and post-adoption comparison, a method for inferring a possible effect is to assess the presence of ROPS in Washington State and compare the results to those obtained in other states. This article presents a survey conducted by the Washington State FACE Program to assess the presence and use of tractors and ROPS in the state.

Method

Farms were identified by selecting businesses in North American Industrial Classification System (NAICS) codes 111 (crop production) and 112 (animal production) for those reporting hours or revenue during any quarter in the year 2003 to the Washington Department of Labor and Industries Industrial Insurance Program, Washington Department of Revenue, or the Employment Securities Department. The population for sampling was restricted to farms with a listed physical address and telephone number in Washington State, giving a total of 7,974 farms. A 15% proportional random sample of 1,238 farms was selected and stratified by 4-digit NAICS code. Several 4-digit sectors were collapsed together to form strata of more than 400 farms to ensure at least 30 completed surveys after the random sample was taken and both disqualifications and non-responders were taken into account (see table 1).

Questionnaires were mailed to addresses in the random sample by a third-party contracted to conduct the survey. A reminder postcard was mailed ten days later to non-responders. Telephone follow-up to all those not responding began ten days after the reminder postcard was mailed.

The survey instrument consisted of two pages and asked for information on up to six tractors. The respondents were asked to relate the number of employees, tractors, and rollover incidents on their farm. The make, model, year of manufacture, seat belt use, type

of ROPS, and hours used per year were asked for each agricultural tractor of 20 horsepower or more. Several questions about ROPS asked how many tractors on the farm were exempt from regulation, how many did not have ROPS, and the reasons why they were not equipped with ROPS. Prevention questions asked how the respondents preferred to receive safety information, how they usually obtain information, and what the largest safety issue is on their farm.

Data analysis and management was conducted in SPSS version 12.0.1 (SPSS, 2004). T-tests were used to evaluate differences between groups at a significance level of 0.05. ROPS availability was verified by using the on-line Guide to Agricultural Tractor Rollover Protective Structures (National Farm Medicine Center, 1997).

Results

A total of 544 valid surveys (230 mail returns, 314 phone interviews) were completed, for a response rate of 54%. During the survey administration, 238 possible farms were disqualified. Common reasons for disqualification were: not a farm, out of business, or bad address and/or telephone number. Another 115 respondents refused the survey, and 341 were either unreachable or gave no response. Table 1 details the sample of farms and survey responses by NAICS strata.

Farm operators responding to the survey, and having at least one tractor, reported having a mean of 3.7 (±3.4 std. dev., median 3.0) tractors, with a maximum of 50. Data were collected on 1,754 tractors overall. They were estimated to be used a mean of 430 (±264, median 400) hours per year. The average year of manufacture was 1983 (±13, median 1988), and the oldest reported tractor was from 1935. The most common make of tractor was John Deere at 38% of reported equipment. Ford and Massey Ferguson makes were each reported for 10% of the tractors. Eighty-seven farms reported a total of 180 tractors that had been retrofitted with a ROPS. One-hundred thirty-five farms reported 315 tractors that were, from their interpretation, exempt from Washington State ROPS regulations and were not equipped with ROPS.

Overall, 58% of tractors were reported to be equipped with ROPS. The predominant structure was a crush-proof cab on 30% of the tractors. These are tractors designed with the ROPS incorporated into the cab structure. Of the 42% not equipped with ROPS, about 42% of these were stated as exempt from ROPS requirements in Washington State. Figure 1 illustrates the reported presence of ROPS by type of structure.

Farms reported that 42% of tractors had no seatbelt installed, and overall 13% stated that the seatbelt was worn on a specific tractor at least “sometimes,” “most of the time,” or “always.” Figure 2 presents the frequency of reported seatbelt use across the

Table 1. Identified farms and survey responses by strata.

NAICS Code Strata	Number Identified in Washington State	Proportional Sample	Valid Responses
1111 (oilseed and grain farming)	1408	209	98
1112 (vegetable and melon farming)	459	75	34
1113 (fruit and tree nut farming)	3286	492	206
1114 (greenhouse, nursery and floriculture)	544	95	37
1119 (other crop farming)	997	159	71
1121 (cattle ranching and farming)	792	122	67
1122-1129 (pig, poultry, sheep, goat, aquaculture, other farming)	488	86	31
Total	7974	1238	544

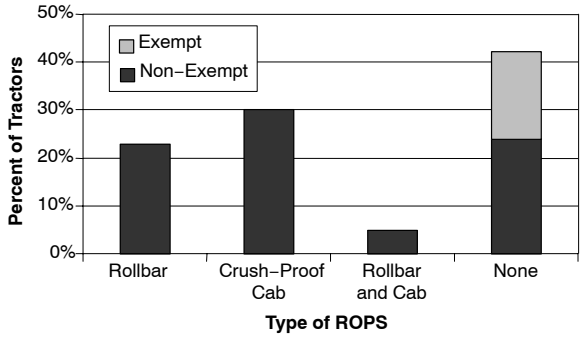

Figure 1. Type of ROPS reported for all surveyed agricultural tractors in Washington State.

ROPS-equipped tractors. Tractors without ROPS were reported as being operated with a seatbelt used at least "sometimes" or more 3% of the time, and 85% of the tractors without ROPS had no seatbelt installed. Tractors reported as having ROPS had no seatbelt installed 17% of the time.

A significant difference ($p < 0.05$) was found for both the hours used per year and the presence of ROPS by year of manufacture. Tractors built after 1984 were reported as being used about 80% more than the pre-1976 tractors on average. Tractors manufactured before 1976 were reported as having ROPS 30% of the time, while those manufactured after 1984 had ROPS 74% of the time. Overall, 15% of tractors were reported as being operated with ROPS and the seatbelt used "sometimes" or more. Table 2 presents ROPS, seatbelt use, and average hours used per year by year of manufacture for those responding to each of these questions. The total number of tractors was estimated based on extrapolation from the sample to the population by year range.

A significant difference ($p < 0.05$) was found for reports of ROPS presence as a function of primary use. More tractors used for row crop farming were equipped with ROPS than those used for either tree/vine/hops farming or utility work. The newer tractors, built after 1984, had ROPS 73% of the time, with 85% of row crop tractors equipped and 58% of tree/vine/hops farming tractors equipped. Table 3 presents the number and percentage of tractors with ROPS by year range and reported primary farming activity.

The primary tractors without ROPS that were not identified by the respondents as being exempt from ROPS requirements were entered into the National Farm Medicine

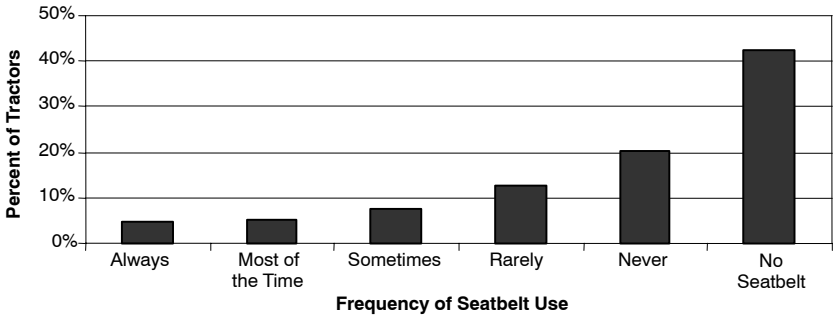

Figure 2. Reported frequency of seatbelt use across all surveyed agricultural tractors in Washington State.

Table 2. ROPS, seatbelt use, and average hours used per year by year of manufacture.

	Year of Manufacture							
	Pre-1976		1976-1984		1985 and Later		Overall[a]	
ROPS with seatbelt	21	6%	33	10%	212	26%	266	15%
ROPS without seatbelt	88	24%	142	44%	395	48%	625	36%
No ROPS	256	70%	145	45%	220	27%	621	35%
Average hours per year	281		388		504		430	
Estimated tractors in Washington State	5,350	24%	4,691	21%	12,122	55%	22,163	100%

[a] 14% did not know or did not respond.

Table 3. Number and percent of tractors with ROPS by year of manufacture and activity.

	Year of Manufacture						
	Pre-1976		1976-1984		1985 and Later		Overall
Row crops	87	43%	136	77%	340	85%	65%
Tree/vine/hops	6	6%	14	13%	183	58%	36%
Livestock	3	30%	5	56%	31	91%	63%
Utility	12	34%	9	56%	34	59%	42%
Inside/stationary	1	6%	11	79%	19	79%	47%
Total	109	30%	175	55%	607	73%	58%

Center on-line database to determine if after-market ROPS were available for these machines. A total of 26 pre-1976 tractors were identified that did not have ROPS and were not exempt. Out of these, 13 models (50%) were listed in the database as having off-the-shelf ROPS available from vendors. Figure 3 presents the primary reasons given by respondents for not retrofitting tractors with ROPS. The primary reason was the type of work and overhead obstacles (59%), and second was that ROPS was not available or did not fit (25%). Another 9% stated that the ROPS was too expensive and 6% had mounted equipment on their tractors that was not compatible with ROPS.

In the last five years, six farms reported having one rollover incident, and two farms reported having two incidents, for a total of ten incidents. Respondents listed the largest safety problems with tractor use as: lack of training and experience (47%), working on

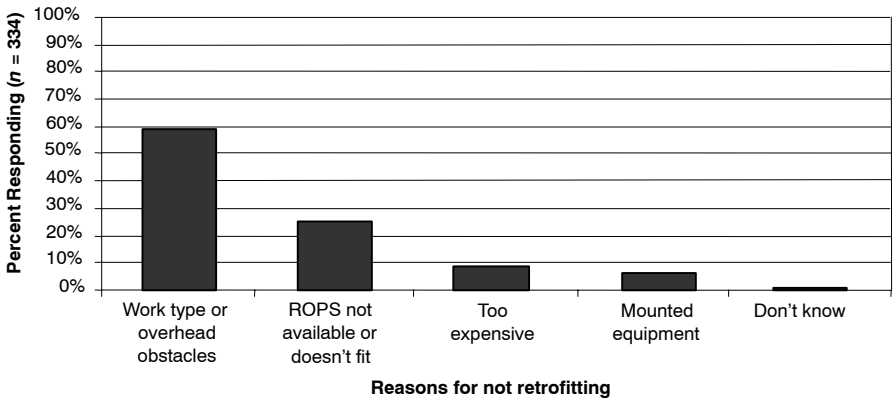

Figure 3. Primary reasons given by respondents for not retrofitting tractors that currently do not have ROPS.

slopes and uneven ground (37%), excess speed (11%), and lack of ROPS (2%). When asked about the different ways they preferred to receive material about tractors and preventing injuries, 79% listed regular mail as a good method, 14% listed video, 12% listed email or website, and 11% listed CD.

Discussion

The survey results from Washington State showed a much higher percentage of tractors equipped with ROPS than in previous surveys (Myers and Snyder, 1995; CDC, 1997; Marlenga et al., 2004; Wilkins et al., 2003; Browning et al., 1999) across states without the more protective rule for pre-1976 tractors and small farms. However, Helmkamp et al. (2004) found a higher overall percentage of tractors equipped with ROPS in their survey of West Virginia farms. The reasons for this are unclear but could be due to differences in the sampled farm population or the types of agricultural activities in West Virginia compared to Washington State.

The tractors used for row crops are largely not exempt from rules, and a much higher percentage were ROPS-equipped. A positive effect of the Washington State rule and feasibility issues were consistent with results showing that only 36% of tree/vine/hops tractors were reported as having ROPS, while 65% of row crop tractors were said to be equipped. Pre-1976 row crop tractors were equipped with ROPS 43% of the time, and 30% of all pre-1976 tractors were equipped. This is much higher than previous reports (Kelsey et al., 1996; Marlenga et al., 2004; Wilkins et al., 2003) of tractors of this age and could be a result of the Washington State rules.

Seatbelt use was much lower than even the levels of 20% to 35% found in other studies (Kelsey et al., 1996; Helmkamp et al., 2004). A tractor rollover fatality on a non-agricultural ROPS-equipped machine in Washington State in 2005 demonstrated the need for seatbelt use in conjunction with ROPS. Without seatbelt use, the operator could be crushed by either the tractor or the ROPS itself in the case of an overturn, unless an enclosed cab is used. However, some argue that the ROPS itself is the primary intervention and would protect a significant percentage of operators even if seatbelts were not worn (Baker, 1998).

Approximately 42% of all surveyed tractors did not have seatbelts installed, which was lower than that found overall by Browning et al. (1999) in Kentucky and similar to levels found by Helmkamp et al. (2004) in West Virginia. The majority of tractors equipped with ROPS were not being operated with a seatbelt worn. These findings are particularly important for focusing prevention resources. There is an apparent need for prevention activities and programs to promote the use of seatbelts on agricultural tractors.

Tractors manufactured after 1985 were reported as being equipped with ROPS 73% of the time, which is lower than that reported by Wilkins et al. (2003) but similar to other studies (Marlenga et al., 2004; Kelsey et al., 1996). According to the USDA National Agricultural Statistics Service, Washington State's largest agricultural crop is apples. Fruit and tree nut farms account for approximately 40% of the farms in the state. These farms were expected to operate tractors exempt from ROPS rules due to the presence of overhead obstacles. The results supported this hypothesis, as only 58% of post-1985 tractors used for tree or vine crops had ROPS, while 85% of post-1985 row crop tractors were equipped with ROPS. The technical feasibility of automatically deploying ROPS has been demonstrated; however, cheap off-the-shelf solutions do not yet exist for tractors that frequently operate in these conditions (Powers et al., 2001). This disparity in protection points to the need for additional development of low-cost, feasible solutions to rollover protection for tractors operating in low overhead clearance situations.

An interesting fact is that seatbelt use is very low, yet no fatalities have been recorded in Washington State between 1998-2005 for ROPS-equipped agricultural tractors. It could be expected that some operators would be crushed by the ROPS in rollover incidents where the seatbelt was not used. This may not be occurring as frequently because over one-third of tractors have crush-proof cabs, which may more effectively prevent fatalities without seatbelt use. This may also not be as common an incident as some may perceive.

There were several limitations to this study. A prospective comparison of ROPS presence or purchases in Washington State before and after the rule was not possible, as this study was initiated after adoption. This makes a cross-sectional comparison to other states and between farming sectors, and an analysis of fatalities, the only methods of inferring an effect. A comparison of pre- and post-rule rollover-related injuries in Washington State was investigated but was deemed to problematic for this study due to concerns of data integrity with older data and lack of reporting for smaller farms. Future studies of injuries and near-misses related to tractor overturns could be valuable. Response verification was not performed for any of the survey answers, and responders were not asked questions relating to knowledge of ROPS requirements or whether regulations influenced equipping tractors with ROPS. The use of fold-down ROPS on tractors in orchards and other farms was not included in the survey. It is assumed that responders classified these tractors as being equipped with rollbar-type ROPS. This follow-up work, further demographic information on the respondents, and additional questions were not collected due to resource limitations.

Attention was paid to capture a representative cross-section of farms in Washington State. However, issues were encountered in identifying actual farm entities. Farms were identified in available data sources only if they had employed workers and reported wages or hours, or if they had retail income and reported this to the state. The USDA National Agricultural Statistics Service states that there were 35,500 farms in Washington State in 2003. Of these, 19,700 had crop incomes of less than $10,000. So it is likely that these farms were both small and less-frequent tractor users. Data extraction from available state databases could only identify 7,974 farms in the state that had reported worker hours, wages, or retail income. It is possible that the surveyed farms under-sampled small, family farms, despite care to include this group. This should be considered when evaluating the summary data.

Convincing farmers that retrofitting tractors is important can be a challenge (Hallman, 2005). Fold-down ROPS exist for some tractors that can be used in orchards and other types of farming or activities that require operating under overhead obstacles. In addition, many tractors used in tree fruit or hops farms may not actually be used in overhead-constrained situations. Such tractors should be equipped with ROPS in these cases, but they often are not. WISHA in Washington State enforces and issues citations for non-exempt tractors that are found to be not ROPS-equipped. However, regulation enforcement officers can only visit a small percentage of farms. The ROPS rule does appear to have had a positive effect on the protection of tractors, and other routes of reaching farmers may be needed to increase the number of people protected. Significant incentives and/or education campaigns may be necessary to improve the rate of ROPS adoption on farms with higher rollover fatality risk.

Conclusion

The results of this survey support the hypothesis that regulating ROPS on agricultural tractors increases the percentage of tractors fitted with ROPS. This is demonstrated by

the higher levels of ROPS in older tractors and in the disparity between exempt and non-exempt tractors. The findings also point to two important needs: (1) prevention activities aimed at increasing seatbelt use, and (2) development of effective protection for tractors operating under overhead obstacles such as trees. Work is ongoing in several agricultural safety and health centers around the U.S. to improve tractor safety. It is hoped that these findings will help direct research and policy to provide the appropriate resources needed to prevent future fatalities and serious injuries in the farming community from tractor rollovers.

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