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Farm Tractors, and the Use of Seat Belts and Roll-over Protective Structures

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Roll-over protective structures (ROPS) on farm tractors could significantly reduce the rate of fatal occupational injury on farms, but comparatively few tractors have them. Many of the policy discussions have focused on trying to identify the percentage of tractors that do not have ROPS, even though such a focus probably does not accurately represent effective protection by ROPS. This study investigates whether including differences in hours of usage, tractor activities, and seat belt use affects estimates of farm operators' protection by ROPS. In general, tractors used more hours a year were more likely to have ROPS. ROPS status also varied by tractor activity. When adjusting for seat belt use, effective ROPS protection is much less than when considering just ROPS status. Measures of the effective coverage of ROPS and policy responses should reflect these differences in hours, activities, and seat belt use. © *1996 Wiley-Liss, Inc.*

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INTRODUCTION

Agricultural safety and occupational health specialists have long recognized that roll-over protective structures (ROPS) can make a significant impact in the rate of fatal occupational injury on farms [e.g., Knapp, 1968; Karlson and Noren, 1979; Myers and Snyder, 1995]. Many U.S. farm tractors currently do not have ROPS, however, and thus provide little protection to their operator in case of roll-over. Various proposals have been made to mandate that all tractors have ROPS [Karlson and Noren, 1979; Merchant et al., 1989; Stoskopf and Venn, 1985], a policy that successfully reduced roll-over deaths in Sweden [Thelin, 1990].

Many of the policy discussions have focused on trying to identify the percentage of tractors that do not have ROPS, both as a way of predicting the number that would need to be retrofitted and as a method of measuring farmers' exposure to roll-over risk. For example, Huizinga and Murphy [1989] found that 81% of tractors in Pennsylvania did not have a ROPS. A later eight-state survey estimated that 65% of all tractors do not have ROPS [NIOSH, 1993], which is close to a more recent national estimate of 62% of all tractors [Myers and Snyder, 1995].

Such focus on mere tractor numbers, however, does not accurately represent tractor operators' protection by ROPS. Older tractors, for example, which are more likely to be without ROPS than newer tractors, may be used less frequently than newer ROPS-equipped tractors. Simply considering tractor numbers ignores the vital question of how many hours of tractor operation are done, both with and without ROPS protection.

Myers and Snyder [1995] did calculate risk exposure on the basis of hours of operation and estimated that 53.2% of total tractor operating hours were protected by ROPS. This compares to their calculation that only 38% of tractors have ROPS. Clearly, considering hours of operation is important if risk exposure is to be known.

Hours of operation, however, may not be enough. The task being performed is also important, because some farm activities have more roll-over risk than others. A tractor being used to power a silo loader, for example, sits stationary while it is operating, with very little chance of roll-over. If tractors without ROPS are more likely to be used for these

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less risky activities than tractors with ROPS, the percentage of time operators are exposed to risk could be much different from those earlier estimates.

Seat belt use may also be relevant to consider within this context. Much of the anecdotal evidence of the efficacy of ROPS suggests that ROPS are less effective if the tractor operator does not wear a seat belt. During a roll-over, an operator can be thrown beneath the tractor unless a seat belt holds them within the protective structure of the ROPS. Seat belts also can be important for rollover protection in tractors with cabs, depending on whether the cab is enclosed or open.

This study investigates whether including differences in tractor activities, and seat belt use affects calculations of farm tractor operators' protection by ROPS. The potential influence of different activities on ROPS use estimates is calculated first, using data from a survey of randomly selected New York farmers. Seat belt use is then addressed, using the same survey data, before exploring the implications for future research and policy.

MATERIALS AND METHODS

In 1994, a telephone survey of 201 randomly selected farms was conducted by the New York Department of Agriculture and Markets. The sample frame was drawn from the Department's official list of farms, and was intended to be representative of farms in the state. The farmers in the sample were sent an introductory letter to let them know to expect a telephone call, and then were called several weeks later. Respondents were asked a variety of questions about their farms and their tractors, with particular attention to the ROPS status of the tractors and how the tractors were used.

For the purposes of this study, tractor operation was divided into three separate activities: field use (e.g., tillage, spreading manure, harvesting, and transporting wagons), stationary use (e.g., blowing silage, or powering a buzz saw), and inside use (e.g., scraping, or feeding from bunkers inside a barn). Farmers were asked to identify the percent of the total operation time each tractor was used on these three activities. The total percent across all three had to equal 100, accounting for all operation time.

RESULTS

Interviews were completed with the operators of 171 of the 201 farms. One was not a farm, so was excluded from the analysis. The overall response rate was thus 85%. The respondents represent the diversity of farms in New York, although dairy farms are overrepresented in the final sample. About 56.6% of the respondents were dairy farmers, while such farms only account for about 30% of all farms in the state (U.S. Department of Commerce). Other livestock farms were the most underrepresented (12.0% in the sample versus 20.9% statewide), as were noncash grain field crops (7.8% in the sample versus 15.2% statewide).

TABLE I. ROPS Status by Year of Manufacture*

ROPS status	Year of Manufacture				
Row % (Column %)	1985+	75–84	65–74	64–	Total
No ROPS	8.0%	18.0%	27.8%	46.2%	
	(31.9%)	(47.4%)	(72.7%)	(95.9%)	(66.9%)
ROPS	34.5	40.4	21.1	4.0	
	(68.1)	(52.6)	(27.3)	(4.2)	(33.1)
Type of ROPS					
Rollbar	45.6	22.8	25.3	6.3	
	(31.9)	(10.5)	(11.6)	(2.3)	(11.7)
Crushproof cab	28.7	46.1	22.6	2.6	
	(29.2)	(31.0)	(15.1)	(1.4)	(17.1)
Rollbar and cab	27.6	65.5	3.5	3.5	
	(7.1)	(11.1)	(0.6)	(0.5)	(4.3)
Total	16.8	25.4	25.6	32.2	100.0

*n = 673. Chi-square = 176.8; p = 0.001.

There were a total of 677 tractors on the 170 farms. The typical farm used about 4 tractors (SD = 2.4). The average tractor was 23.3 years old (SD = 13.4) and was used 285.1 hr/year (SD = 287.7). Hours of operation did vary dramatically, ranging from 5 to 2,112 hr/year.

ROPS Status

Overall, 33.1% of all tractors had ROPS (SE = 1.8). Newer tractors were much more likely to have them than were older tractors (Table I). Only 4.2% of tractors manufactured in 1964 or earlier had ROPS (SE = 1.4), while 68.1% of tractors manufactured since 1984 have ROPS (SE = 4.4).

In general, tractors used more hours a year were more likely to have ROPS (Table II). Only 20.1% of tractors used less than 100 hr/year had ROPS (SE = 3.2), compared to 50.3% of those used 400 hr or more (SE = 3.1). The average tractor with ROPS was operated 373.1 hr/year, compared to only 242.2 hr for those without ROPS (t-statistic = 5.62).

About 85.6% of tractor operation time was spent doing field work, 5.1% was spent on stationary tasks, and 8.0% was spent on inside work (this does not add to unity, due to rounding). Older tractors in general were slightly more likely to be used primarily for stationary or inside activities than were newer tractors (Table III), although these differences were not large. Contrary to expectations, it did not appear that many of the older tractors were being relegated solely to stationary or indoor tasks.

Tractors doing stationary or inside work were much

TABLE II. ROPS Type by Hours of Use*

ROPS status Row % (Column %)	Hours of use −100	100–200	200–400	400+	Total
No ROPS	27.3%	24.6%	27.3%	20.7%	
	(79.9%)	(84.7%)	(61.2%)	(49.7%)	(66.9%)
ROPS	13.9	9.0	35.0	42.2	
	(20.1)	(15.3)	(38.8)	(50.3)	(33.1)
Type of ROPS					
Rollbar	12.7	12.7	35.4	39.2	
	(6.5)	(7.6)	(13.9)	(16.6)	(11.7)
Crushproof cab	17.4	6.1	33.9	42.6	
	(13.0)	(5.3)	(19.4)	(26.2)	(17.1)
Rollbar and cab	3.5	10.3	37.9	48.3	
	(0.7)	(2.3)	(5.5)	(7.5)	(4.3)
Total	22.9	19.5	29.9	27.8	100.00

*n = 673. Chi-square = 62.2; p = 0.001.

TABLE III. Primary Task Performed by Tractor (More than 50% of Time in Operation), by Year of Manufacture*

Task Row % (Column %)	Year of manufacture 1985+	75–84	65–74	64−	Total
Field	15.8%	27.9%	26.5%	29.7%	
	(89.9%)	(96.3%)	(89.2%)	(85.6%)	(90.1%)
Stationary	10.3	6.9	34.5	48.3	
	(3.0)	(1.2)	(6.0)	(7.2)	(4.7)
Inside	21.2	12.1	24.2	42.4	
	(7.1)	(2.5)	(4.8)	(7.2)	(5.3)
Total	15.9	26.1	26.8	31.3	100.0

n = 624. Chi-square = 13.6; p = 0.034.

more likely to be used for multiple activities than were tractors involved in field work. Only 17.4% of tractors doing stationary work were solely devoted to one task (SE = 3.5), as were 28.2% of tractors doing inside work (SE = 5.1). By contrast, 77.6% of tractors doing field work were solely devoted to field work (SE = 1.7). Most tractors used for field activities were only used solely for field activities.

Not surprisingly, ROPS status did vary by type of activity. About 44.5% of total operation time doing field activities was in ROPS-equipped tractors (SE = 2.0), compared to 32.2% for stationary use (SE = 4.0), and 35.6% for inside use (SE = 4.9). Ignoring whether different activities have dissimilar roll-over risk, about 42.7% of all hours of tractor operation was done in ROPS-equipped tractors (SE = 1.9).

Whether a ROPS was a rollbar or cab also varied by activity (Table IV). Tractors used for field activities were the most likely to have a cab. There was little difference between the percent of tractors with rollbars or cabs in the other activities.

TABLE IV. Percentage of Hours of Operation With ROPS, by Task

Tractor activity	Type of ROPS Rollbar (%)	Cab (%)	No ROPS (%)
Field use	14.4	30.1	55.5
Stationary use	16.3	15.9	67.8
Inside use	18.9	16.7	64.4
Total use	14.7	28.0	57.3

Simply accepting this overall calculation of exposure, however, ignores the very different roll-over risks inherent in various farm activities. Stationary tractor uses, for example, where the tractor sits unmoving in one location, so its power takeoff (PTO) can power a silo blower or similar piece of equipment, have little chance of causing a rollover. Indoor uses, such as scraping manure packs or feeding, likely have less of a chance of causing a rollover than many field operations because the tractors generally are driven at much slower speeds and on level surfaces.

If stationary and inside uses are considered to have negligible roll-over risk, the percentage of tractor operation where the operator is at little risk of roll-over injury (due to either the task being performed or having a ROPS) increases to about 51.3% (SE = 1.9), an increase of about 20% over the exposure calculation, which ignored activity differences. This suggests that considering the dissimilar risks inherent in different farm activities does influence our understanding of how much at-risk farm tractor use is done in ROPS-equipped tractors.

Seat Belt Use

Overall, 26.4% of tractors had seat belts (SE = 1.7). Operators reported using these belts about 31.8% of the time, making the effective use rate of seat belts only about 8%. Almost one-half (47.6%) of the operators on seat belt-equipped tractors never use the seat belt, while another 20.7% reportedly always use the seat belt.

Most of the seat belts were on tractors with ROPS. Only 5.6% of the tractors without ROPS were equipped with seat belts (SE = 1.1). By contrast, 68.6% of the tractors with ROPS also had seat belts (SE = 3.1). The tractors without ROPS but with seat belts are cause for concern, because a seat belt would prevent the operator from being thrown free or jumping during a roll-over, their only options for avoiding injury. Seat belts reportedly were used about

TABLE V. Effective ROPS Protection When Considering Seat Belt Use

Tractor activity	Percentage of operation hours protected by ROPS and operator use of seat belts: Assuming all cabs are open (%)	Assuming all cabs are enclosed (%)	ROPS Only (Seat Belts Not Considered) (%)
Field use	7.4	33.9	44.5
Stationary use	4.7	18.5	32.2
Inside use	19.8	31.0	35.6
Total use	8.2	32.5%	42.7

37.5% of the time on these tractors without ROPS, unwittingly placing their operators at greater risk of roll-over injury. (Because of the study design and the fact that respondents' names were unavailable to the researchers, a safety follow-up to warn these operators about the riskiness of their behavior was not possible.)

The survey responses did not indicate whether cabs were open or enclosed, so the effective protection of ROPS with regard to seat belt use had to be alternatively calculated, assuming that all cabs were open (and thus seat belt use is essential for full protection) and then assuming that all cabs were enclosed (and thus making seat belt use less important). The actual effective protection will lie somewhere between these two extremes, depending on what percentage of all cabs actually are enclosed.

When adjusting for seat belt use, both calculations showed effective ROPS protection to be much less than when considering just ROPS status (Table V). Effective protection during field activities, for example, falls somewhere between 8.2% (SE = 1.1) and 33.9% (SE = 1.9), depending on how many cabs are fully enclosed. This compares to 44.5%, if the importance of seat belt use is ignored (SE = 2.0).

DISCUSSION AND CONCLUSIONS

This study makes clear that the aging of older, non-ROPS-equipped tractors will only significantly reduce exposure to roll-over injury when those tractors are retired; the survey responses indicate that older tractors were only slightly less likely to be used primarily for field work than were the newest tractors, suggesting that few older tractors are shifted to other uses as they age. The percentage of older tractors primarily used for field work, for example, was only 4% less than the percentage of newest tractors doing that work. By and large, most aged tractors continue to be operated in many of the more at-risk activities.

The ROPS use rate by hours found in this study is less than that discovered in Myers and Snyders' 1995 national study (42.7% compared to 53.2%). This likely results from the lower average hours of use of tractors with ROPS and higher average hours of use of tractors without ROPS in New York. In addition, this study found a slightly smaller percentage of newer tractors that have ROPS in New York than in their sample. About 31.9% of tractors less than 10 years old had no ROPS, compared to only 16.9% in the Myers and Snyder study. The New York percentage on newer tractors is similar to that in Pennsylvania [Huizinga and Murphy, 1989].

The difference in ROPS coverage may result from New York's different cropping mix than the national average, plus the generally older age of farm buildings in the state. Many older farm buildings never were designed to have the headroom for storing or operating large tractors, in contrast to modern farm buildings. This has an impact on ROPS adoption; in a 1990 study, for example, New York dairy farmers claimed that 69% of the tractors currently without ROPS would no longer be usable for their indoor tasks if they had ROPS [Kelsey et al., 1994].

That about one-third of all the tractors manufactured since 1984 currently have no ROPS is important to consider, because in 1984 tractor manufacturers voluntarily decided to make ROPS standard equipment on all new tractors. This decision has increased the percentage of tractors with ROPS, but the percentage found here suggests that the voluntary approach to getting ROPS on tractors will not be enough for complete ROPS coverage.

The information about seat belt use is disheartening because it suggests that simply focusing on ROPS will not adequately address roll-over injuries. Published data on the injury-preventing effectiveness of ROPS with and without seat belts is lacking, but most of the anecdotal evidence and teaching about ROPS note that a seat belt is necessary to keep the operator within the protective structure during a roll-over. ROPS retrofits could be mandated, but without a concomitant change in seat belt behavior, the policy likely will not be as effective as it could be otherwise. The focus of retrofit policy discussions must include recognition of this barrier to effectiveness, and may have to shift entirely to focusing on retrofitting enclosed cabs or other passive measures that will physically retain the operator within the protective structure in case of rollover.

One limitation of the survey results is that the information on ROPS status and seat belt use was all self-reported. Some respondents may have been less than truthful because the survey was identified as being from an agricultural safety organization. If bias occurred for this reason, however, the respondents likely would have been more likely to exaggerate their use of ROPS and seat belts than to underreport such use. The estimates in this study should therefore be considered the upper limit of ROPS and seat belt use.

Actual ROPS status and seat belt use could be worse than that reported here.

The categorization of tractor activities used in these analyses is not perfect, but it does suggest that additional research into this area would be worthwhile. A more finely delimited set of tractor activities, combined with research-based information on roll-over risk in those specific activities, would permit more accurate estimation of roll-over risk and ROPS protection. The analyses in the current study show that the use of roll-over structures does vary by activity. Measures of the effective coverage of ROPS and policy responses should reflect these differences.

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